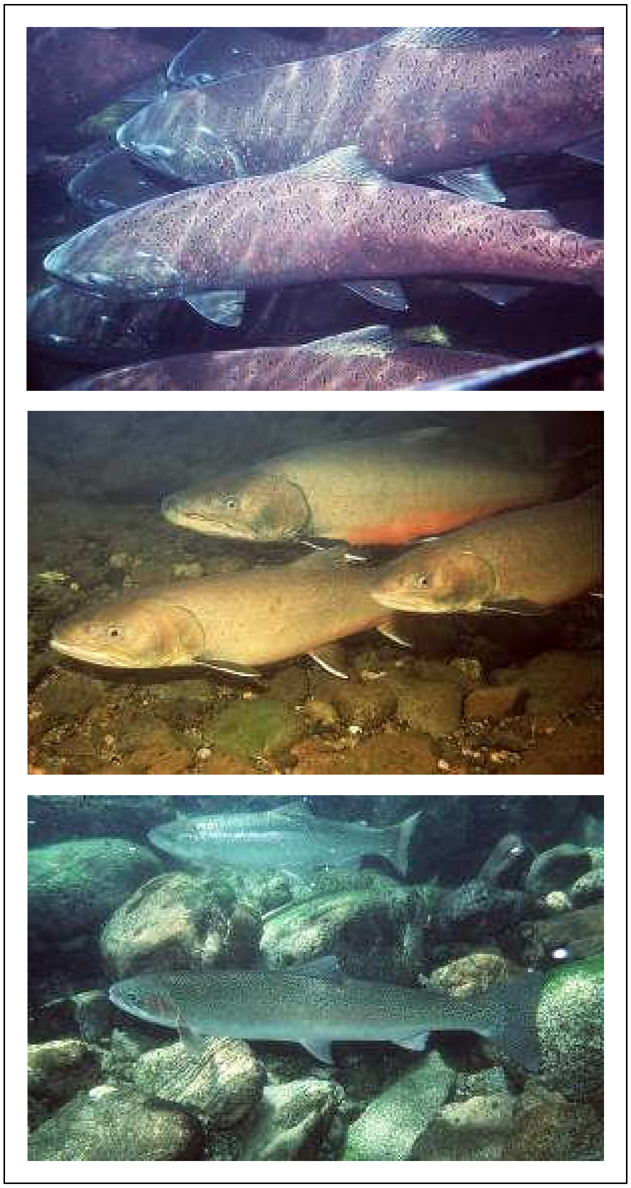

Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan*

August 2007

Upper Columbia Salmon Recovery Board

*This Plan also covers bull trout, which are under the jurisdiction of the U.S. Fish and Wildlife Service. The strategies and actions in this proposed plan are intended as additional recommendations for the draft bull trout recovery plan that was published by the U.S. Fish and Wildlife Service in April 2002.

Coordination with United States Fish and Wildlife Service

Working closely with staff of National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries) and the U.S. Fish and Wildlife Service (USFWS), the Upper Columbia Salmon Recovery Board (UCSRB) developed this plan to support the recovery of spring Chinook salmon, steelhead, and bull trout listed under the Endangered Species Act. NOAA Fisheries has adopted this plan as its recovery plan for the Upper Columbia Spring Chinook and Upper Columbia Steelhead. The UCSRB recognizes that the USFWS listed the bull trout as a threatened species throughout its range in the lower 48 states, not just the portion of bull trout residing in the Upper Columbia area. The UCSRB therefore submits this plan to the USFWS as its recommendation for assisting in the recovery of bull trout in the Columbia River with the understanding that the USFWS will consider these recommendations in its recovery plan for the entire listed species.

Chinook salmon, bull trout, and steelhead photos used courtesy of Dr. Ernest R. Keeley, Idaho State University, Pocatello, Idaho.

Mission Statement:

To restore viable and sustainable populations of salmon, steelhead, and other at-risk species through collaborative, economically sensitive efforts, combined resources, and wise resource management of the Upper Columbia region.

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Acknowledgments

The development of this plan could not have been possible without the dedication and hard work of many people. This plan benefited greatly from the input by local citizens, local, state, and federal agencies, and tribes. Through the efforts by a core group of individuals and coordination with stakeholders, the following individuals and organizations contributed to the completion of this plan.

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Hosting Locations:

Douglas County Public Services Building
City of East Wenatchee, Council Chambers
Chelan County PUD Auditorium
Douglas County PUD Auditorium
Okanogan County PUD Auditorium
Okanogan County Board of County Commissioners Hearing Room
Chelan Fire Station District #7
North Central Washington RC&D Office
Chelan County Planning
City of Leavenworth

Dedication

While countless individuals have participated in the development of this plan, the late Esther Stefaniw, Chelan County Commissioner and one of the founding board members, played an instrumental role in rallying the region around locally led salmon recovery. In the spring of 1999, the first Upper Columbia Salmon Recovery Board meeting was held, and it was here that Esther made her famous proclamation, “If you think that you are a stakeholder, then you are!” She went so far as to bring her neighbors to board meetings so they could learn firsthand about local salmon recovery efforts. Her dedication and spirit brought the Board together and set it on a course for success. Esther demanded from us a commitment to the local process, at the individual citizen level, and never wavered from that ideal. Esther firmly believed that only through a grass-roots process would salmon recovery efforts realize their conservation and economic goals. The State of Washington commended Esther for her efforts to organize the Upper Columbia Salmon Recovery Board. It is the Board’s sincere hope that we have furthered Esther’s ideals and that this plan will be implemented for the good of people and fish in the Upper Columbia region.

The Board hereby dedicates this plan
to the memory and spirit
of our friend

Esther Stefaniw
Chelan County Commissioner (1996-2001)

Executive Summary

The Upper Columbia Salmon Recovery Board (UCSRB) developed this plan for the recovery of Upper Columbia spring Chinook (listed as ***endangered*** on March 24, 1999), Upper Columbia steelhead (listed as ***endangered*** on August 18, 1997; reclassified as ***threatened*** on January 5, 2006; and as a result of a legal challenge, reinstated to ***endangered*** status on June 13, 2007), and bull trout (the coterminous U.S. population was listed as ***threatened*** on November 1, 1999).

The mission for the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan developed by the Upper Columbia Salmon Recovery Board is:

> To restore viable and sustainable populations of salmon, steelhead, and other at-risk species through collaborative, economically sensitive efforts, combined resources, and wise resource management of the Upper Columbia region.

The Board intends to approach salmon recovery efforts in a transparent and evolving process to restore fish populations for ecosystems and people while enhancing the economic viability of the region.

This plan is an outgrowth and culmination of several conservation efforts in the Upper Columbia Basin, including current efforts related to the Endangered Species Act (ESA), state and tribal-sponsored recovery efforts, subbasin planning, and watershed planning.

Use of this Plan

This plan is to be used to guide federal agencies charged with species recovery. In and of itself, this plan is a non-regulatory document. As such, it is not intended to be nor may it serve as a regulatory document forcing landowner action. Any such regulatory actions deemed necessary as a result of this document must be accompanied by a clear legislative mandate to that end.

The plan may be used to inform state and local agency planning and land use actions, but it may not be deemed to place requirements on such entities. The goal of this plan is to offer options for future actions that strive to secure the survival of species. No mandate on state or local agencies may be construed from this plan, and the plan may not be cited as creating a need for new regulatory actions at the state or local level unless clear legislative authority is first adopted.

This plan is limited to address listed salmonid species. If any threatened or endangered species were introduced into an area where it has been designated as extirpated, this population would be treated as an experimental population under Section 10(j) or other mechanisms under ESA and would not increase ESA liabilities for landowners.

Regional Setting

This recovery plan is intended for implementation within the Upper Columbia River Basin, which includes the Columbia River and its tributaries upstream of the confluence of the Yakima River to the base of Chief Joseph Dam. The Upper Columbia Basin consists of six major “subbasins” (Crab, Wenatchee, Entiat, Lake Chelan, Methow, and Okanogan subbasins), several smaller watersheds, and the mainstem Columbia River. This area captures the distribution of Upper Columbia River spring Chinook, steelhead, and bull trout.

Currently, there are three independent populations of spring Chinook within the Upper Columbia Evolutionarily Significant Unit (Wenatchee, Entiat, and Methow) and five steelhead populations (Wenatchee, Entiat, Methow, Okanogan and Crab Creek populations) within the Upper Columbia steelhead Distinct Population Segment (DPS). Spring Chinook in the U.S. portion of the Okanogan subbasin have been extirpated, while Chinook in Canada have been proposed for endangered listing under the "Species at Risk Act." There are three "core" areas supporting bull trout populations (Wenatchee, Entiat, and Methow subbasins) and two areas designated as "unknown occupancy" (Lake Chelan and Okanogan subbasins) in the Upper Columbia Basin.

This plan emphasizes recovery of three spring Chinook populations (Wenatchee, Entiat, and Methow populations), four steelhead populations (Wenatchee, Entiat, Methow, and Okanogan populations), and recovery of bull trout within the Wenatchee, Entiat, and Methow subbasins.

Plan Development

The process of developing this plan began with identification of priority species—spring Chinook, steelhead, and bull trout—based on ESA listings and their population status (abundance, productivity, spatial structure, and diversity). Empirical information, when available, was used to determine current population status and threats. In cases where empirical information was lacking, derived data (from modeling), preliminary analysis, local knowledge or professional judgment (based on literature review or experience with similar conditions or factors) were used to identify threats. Limiting factors were then identified from the threats (both past and present).

Recovery objectives and criteria were identified by the Interior Columbia Basin Technical Recovery Team (ICBTRT) in collaboration with Upper Columbia technical committees. Categories of recovery actions were then recommended that addressed primary limiting factors within each sector (Harvest, Hatcheries, Hydro, and Habitat). In developing the plan it became clear that recovery objectives and criteria could not be met by implementing actions within only one sector (i.e., Habitat). Recovery of listed species requires implementation of actions within all sectors, including actions implemented outside the Upper Columbia Basin (e.g., within the lower Columbia River, estuary, and ocean).

Implementation of specific recovery actions will be coordinated with local stakeholders and jurisdictions that determine the feasibility of recommend actions, including socio-economic interests, benefits, and costs.

Current Status of Listed Populations

Spring Chinook

Spring Chinook begin returning from the ocean in the early spring, with the run into the Columbia River peaking in mid-May. Spring Chinook enter the Upper Columbia tributaries from April through July. After migration, they hold in freshwater tributaries until spawning occurs in the late summer, peaking in mid to late August. Juvenile spring Chinook spend a year in freshwater before migrating to salt water in the spring of their second year of life. Most Upper Columbia spring Chinook return as adults after two or three years in the ocean. Some precocious males, or jacks, return after one winter at sea. A few other males mature sexually in freshwater without migrating to the sea. The run, however, is dominated by four- and five-year-old fish that have spent two and three years at sea, respectively. Fecundity ranges from 4,200 to 5,900 eggs, depending on the age and size of the female.

The risk of extinction over a 100-year period for spring Chinook within the Upper Columbia Basin was determined by following the guidance of the ICBTRT (2004, 2005). Risk of extinction was estimated for abundance/productivity and spatial structure/diversity.

Wenatchee Population

When considering the factors that determine diversity and spatial structure, the Wenatchee spring Chinook population is currently considered to be at a high risk of extinction because of the loss of naturally produced Chinook spawning in tributaries downstream from Tumwater Canyon. In addition, the Wenatchee spring Chinook population is currently not viable with respect to abundance and productivity and has a greater than 25% chance of extinction in 100 years. In sum, the Wenatchee spring Chinook population is not currently viable and has a high risk of extinction.

Entiat Population

When considering the factors that determine diversity and spatial structure, the Entiat spring Chinook population is currently considered to be at high risk. The Entiat spring Chinook population is currently not viable with respect to abundance and productivity and has a greater than 25% chance of extinction in 100 years. In sum, the Entiat spring Chinook population is not currently viable and has a high risk of extinction.

Methow Population

When considering the factors that determine diversity and spatial structure, the Methow spring Chinook population is currently considered to be at a high risk of extinction. Based on abundance and productivity, the Methow spring Chinook population is not viable and has a greater than 25% chance of extinction in 100 years. In sum, the Methow spring Chinook population is not currently viable and has a high risk of extinction.

Okanogan Population

Spring Chinook in the Okanogan subbasin are currently extinct. The Colville Tribes are working to reintroduce spring Chinook into the subbasin. This population would be treated as an experimental population under ESA Section 10(j) or other mechanisms under ESA that would not increase ESA liabilities to landowners.

Steelhead

The life-history pattern of steelhead in the Upper Columbia Basin is complex. Adults return to the Columbia River in the late summer and early fall. Unlike spring Chinook, most steelhead do not move upstream quickly to tributary spawning streams. A portion of the returning run overwinters in the mainstem reservoirs, passing over the Upper Columbia River dams in April and May of the following year. Spawning occurs in late spring of the calendar year following entry into the river. Currently, and for the past 20+ years, most steelhead spawning in the wild are hatchery fish. The effectiveness of hatchery fish spawning in the wild compared to naturally produced spawners is unknown at this time and may be a major factor in reducing steelhead productivity.

Juvenile steelhead generally spend one to three years rearing in freshwater before migrating to the ocean, but can spend as many as seven years in freshwater before migrating. Most adult steelhead return to the Upper Columbia after one or two years at sea. Steelhead in the Upper Columbia have a relatively high fecundity, averaging between 5,300 and 6,000 eggs.

Steelhead can residualize (lose the ability to smolt) in tributaries and never migrate to sea, thereby becoming resident rainbow trout. Conversely, progeny of resident rainbow trout can migrate to the sea and thereby become steelhead. Despite the apparent reproductive exchange between resident and anadromous ***O. mykiss***, the two life forms remain separated physically, physiologically, ecologically, and behaviorally (70 FR 67130). Given this separation, NMFS (70 FR 67130) proposed that the anadromous steelhead populations are discrete from the resident rainbow trout populations. Therefore, this plan only addresses the recovery of anadromous steelhead. Resident rainbow trout are not included in the recovery of steelhead.

The risk of extinction over a 100-year period for steelhead within the Upper Columbia Basin was determined by following the guidance of the ICBTRT (2004b, 2005a). Risk of extinction was estimated for abundance/productivity and spatial structure/diversity.

Wenatchee Population

When considering the factors that determine diversity and spatial structure, the Wenatchee steelhead population is currently considered to be at a high risk of extinction. Based only on abundance and productivity, the naturally produced Wenatchee steelhead population is not viable and has a greater than 25% chance of extinction in 100 years. In sum, the Wenatchee steelhead population is not currently viable and has a moderate to high risk of extinction.

Entiat Population

When considering the factors that determine diversity and spatial structure, the Entiat steelhead population is currently considered to be at a high risk of extinction. Based only on abundance and productivity, the Entiat steelhead population is not viable and has a greater than 25% chance of extinction in 100 years. In sum, the Entiat steelhead population is not currently viable and has a moderate to high risk of extinction.

Methow Population

When considering the factors that determine diversity and spatial structure, the Methow steelhead population is currently considered to be at a high risk of extinction. Based only on abundance and productivity, the Methow steelhead population is not viable and has a greater than 25% chance of extinction in 100 years. In sum, the Methow steelhead population is not currently viable and has a moderate to high risk of extinction.

Okanogan Population

When considering the factors that determine diversity and spatial structure, the Okanogan steelhead population is currently considered to be at a high risk of extinction. Based on abundance and productivity, the Okanogan steelhead population is not viable and has a greater than 25% chance of extinction in 100 years. In sum, the Okanogan steelhead population is not currently viable and has a high risk of extinction.

Bull Trout

Bull trout in the Upper Columbia Basin exhibit both resident and migratory life-history strategies. Resident bull trout complete their entire life cycle in the tributary stream in which they spawn and rear. Migratory bull trout spawn in tributary streams where juvenile fish rear one to four years before migrating to either a lake (adfluvial form) or river (fluvial form). Migrating bull trout have been observed within spawning tributaries as early as the end of June, while spawning occurs in mid-September to late October/early November. Resident and migratory forms may be found together, and either form may give rise to offspring exhibiting either resident or migratory behavior.

The size and age of bull trout at maturity depends upon life-history strategy. Resident fish tend to be smaller than migratory fish at maturity and produce fewer eggs. Bull trout usually reach sexual maturity in four to seven years and may live longer than 12 years. Bull trout spawn in the fall typically in cold, clean, low-gradient streams with loose, clean gravel. Bull trout at all life stages are associated with complex forms of cover including large woody debris, undercut banks, boulders, and pools.

The U.S. Fish and Wildlife Service has not developed guidance for estimating risk of extinction of Upper Columbia bull trout. Therefore, what follows is a summary of the current status of bull trout without a determination of extinction risk.

Wenatchee Core Area

Abundance and productivity of bull trout in the Wenatchee subbasin is based on redd surveys. However, redd survey procedures have changed over time and different streams have different survey periods. Surveys from 2000-2004 were conducted consistently across all populations and redd counts during this period ranged from 309 to 607 in the core area.

For streams with long-term redd counts, numbers of redds have increased over time (e.g., Chiwawa basin). However, there is a fair amount of variability in all the other populations. Number of redds for Little Wenatchee, Nason Creek, Ingalls Creek, and Chiwaukum Creek are very low. Although both migratory and multiple size classes of resident bull trout are present in upper Icicle Creek, spawning areas are currently unknown. No bull trout redd surveys have been conducted in Icicle Creek.

Bull trout currently occur in the Chiwawa River, White River, Little Wenatchee River, Nason Creek, Chiwaukum Creek, Icicle Creek, Peshastin Creek, Negro Creek, and Ingalls Creek drainages. Adfluvial, fluvial, and resident forms of bull trout exist in the Wenatchee subbasin.

Entiat Core Area

Numbers of bull trout redds in the Entiat subbasin have ranged from 10 to 52 redds in the Mad River and 0 to 46 redds in the Entiat River. A large increase in numbers of redds counted in the Entiat River in 2004 resulted from increasing the survey area and changes in survey effort.

Numbers of bull trout redds in the Entiat subbasin have increased since they were first counted in 1989, suggesting an increasing trend in production.

Bull trout occur in both the Mad and Entiat rivers. It is assumed that most of the bull trout in the Entiat subbasin are fluvial fish, with perhaps a resident form in the upper reaches of the Mad

River drainage. Bull trout have been observed in Tillicum and Stormy creeks. Recent studies suggest that bull trout from this core area use the mainstem Columbia River for overwintering habitat and foraging.

Methow Core Area

Bull trout redd surveys in the Methow subbasin began in the early 1990s. Total numbers of redds within the subbasin have ranged from 4 to 195 redds. However, these are not valid estimates of abundance, because not all bull trout spawning streams were surveyed annually, lengths of surveys reaches have changed within a given stream, and survey methods have changed over time. Based on more recent surveys (2000-2004), when survey methods were more similar, redd counts ranged from 127 to 195.

Numbers of redds counted in the Methow subbasin appear to have increased since the mid-1990s. However, this trend is an artifact of changing survey methods. Looking at recent years (2000-2004), when survey methods were similar, there was a fairly stable number of redds ranging from 147 in 2000 to 148 in 2004. Currently, there is insufficient data to establish a trend for the entire core area. In the Twisp and the Upper Methow areas, redd counts are highly variable, but reveal a decreasing trend since 2000.

Currently bull trout occur within the Twisp River, Chewuch River, Lake Creek, Wolf Creek, Early Winters Creek, Upper Methow River, Lost River, Beaver Creek, Gold Creek and Libby Creek, and Goat Creek drainages. Bull trout exist upstream of the anadromous fish barrier on Early Winters Creek, Wolf Creek, Beaver Creek, and the Lost River. The population structure of the Lost River is unknown, but likely contributes to the genetic diversity of the Methow core population. Resident, fluvial, and adfluvial forms still occur in the Methow subbasin.

Limiting Factors and Threats

Some human activities acting in concert with natural occurrences (e.g., drought, floods, landslides, fires, debris flows, and ocean cycles) have impacted the abundance, productivity, spatial structure, and diversity of Upper Columbia spring Chinook salmon, steelhead, and bull trout populations, resulting in these species being listed under the ESA. Coho salmon and some populations of spring Chinook and bull trout have been lost from the region. Lasting effects from some of these early activities may still act to limit fish production in the Upper Columbia Basin. Threats from some current activities are also present in the Upper Columbia Basin.

Populations of spring Chinook and steelhead within the Upper Columbia River Basin were first affected by the intensive commercial fisheries in the lower Columbia River. These fisheries began in the latter half of the 1800s and continued into the 1900s and nearly eliminated many salmon and steelhead stocks. With time, the construction of dams and diversions, some without passage, blocked salmon and steelhead migrations, isolated or fragmented bull trout populations, and killed upstream and downstream migrating fish. Early hatcheries constructed to mitigate for fish loss at dams and loss of spawning and rearing habitat were operated without a clear understanding of population genetics, where fish were transferred without consideration of their actual origin. Although hatcheries were increasing the abundance of stocks, they were probably also decreasing the diversity and productivity of populations they intended to supplement.

Concurrent with these historic activities, human population growth within the basin was increasing and land uses, in many cases encouraged and supported by governmental policy, were in some areas impacting salmon and trout spawning and rearing habitat. In addition, non-native species were introduced by both public and private interests throughout the region that directly or indirectly affected salmon and trout. These activities acting in concert with natural disturbances decreased the abundance, productivity, spatial structure, and diversity of Chinook salmon, steelhead, and bull trout in the Upper Columbia Basin.

Presently, harvest has been greatly reduced from historic levels, dams are being changed and operated in ways that increase passage and reservoir survival, hatcheries are in some cases being managed to address spatial structure and diversity issues, and habitat degradation is being reduced by implementation of recovery projects, voluntary efforts of private landowners, irrigators, and local governments, and improved land management practices on public and private lands. Nevertheless, additional actions are needed within all sectors (Harvest, Hatchery, Hydro, and Habitat) in order for listed stocks in the Upper Columbia Basin to recover.

There are a number of threats that may continue to limit the recovery of ESA-listed fish species in the Upper Columbia Basin. These threats can be organized according to the five categories as set forth in Section 4(a)(1) of the ESA and all apply to this recovery plan:

- The present or threatened destruction, modification, or curtailment of its habitat or range.
- Overutilization for commercial, recreational, scientific, or educational purposes.
- Disease or predation.
- Inadequacy of existing regulatory mechanisms.
- Other natural or human-made factors affecting its continued existence.
- Current threats include:
- The following threats were identified in the Federal Register Rules and Regulation at the time the species were listed. Actions identified within this plan address these threats.

The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range

- Although land and water management activities have improved, factors such as dams, diversions, roads and railways, some aspects of agriculture (including livestock grazing) residential development, and some historic forest management continue to threaten spring Chinook, steelhead, and bull trout and their habitat in some locations in the Upper Columbia Basin.
- Water diversions without proper passage routes disrupt migrations of listed fish species.
- Unscreened diversions trap or divert juvenile spring Chinook, steelhead, and bull trout resulting in reduced survival.
- Hydroelectric passage mortality reduces abundance of migrant spring Chinook, steelhead, and bull trout.
- Sedimentation from land and water management activities is a cause of habitat degradation in some salmon and trout streams.

- Loss of habitat complexity, off-channel habitat, and large, deep pools due to sedimentation and loss of pool-forming structures such as boulders and large woody debris reduces survival of listed fish species and threatens their habitat in some locations in the Upper Columbia Basin.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

- The effects of incidental mortality on naturally produced spring Chinook, steelhead, and bull trout may increase during recreational fishing for hatchery fish or other species.
- Harvest of bull trout because of misidentification continues under existing fishing regulations.
- Incidental harvest mortality in mixed-stock and commercial fisheries contributes to the loss of naturally produced spring Chinook and steelhead.
- Illegal harvest (poaching) continues to threaten listed fish species.

Disease or Predation

- The presence of non-native species has resulted in increased predator populations that prey on listed fish species and/or compete with listed fish.
- Increased predation by northern pikeminnow affects the survival of downstream migrating spring Chinook, steelhead, and bull trout.
- Predation by pinnipeds (marine mammals) and birds are also a threat to spring Chinook and steelhead.

Inadequacy of Existing Regulatory Mechanisms

- The implementation and enforcement of existing Federal and State laws designed to conserve fishery resources, maintain water quality, and protect aquatic habitat have not been entirely successful in preventing past and ongoing habitat degradation.
- Although the Washington State Growth Management Act and Shoreline Management Act have been significantly changed to improve management, conditions and protection efforts for listed species and compliance monitoring (enforcement) have lagged behind because of a lack of political support and funding.
- The extent and distribution of Federal lands limits the ability of the Northwest Forest Plan and PACFISH/INFISH to achieve its aquatic habitat restoration objectives at watershed and river basin scales.
- The "base" State of Washington Forest Practice Rules do not adequately address large woody debris recruitment, tree retention to maintain stream bank integrity and channel networks within floodplains, and chronic and episodic inputs of coarse and fine sediment that maintain habitat that are properly functioning for all life stages of listed fish species.
- The Federal Clean Water Act has not been completely implemented and therefore has not been completely successful in protecting listed fish species, particularly with respect to non-point sources of pollution.

Other Natural or Human-Made Factors Affecting its Continued Existence

- Natural conditions (e.g., fires, floods, droughts, landslides, etc.) can exacerbate the problems associated with degraded and altered aquatic habitats.
- Drought conditions reduce already limited spawning, rearing, and migration habitat.
- Poor ocean conditions (e.g., less upwelling, warm surface waters, etc.) negatively affect spring Chinook and steelhead production.
- The use of non-locally derived broodstock for hatchery programs may negatively affect genetic integrity.
- Introduction of brook trout threatens bull trout through hybridization, competition, and predation.
- The collection of naturally produced spring Chinook and steelhead for hatchery broodstock may harm small or dwindling natural populations if not done with caution.
- Competition, genetic introgression, and disease transmission resulting from hatchery introductions may reduce the productivity and survival of naturally produced spring Chinook and steelhead.

Recovery Goals

Recovery requires reducing or eliminating threats to the long-term persistence of fish populations, maintaining widely distributed and connected fish populations across diverse habitats of their native ranges, and preserving genetic diversity and life-history characteristics. To be consistent with the vision and goals of this plan, listed populations must meet specific ***abundance***, ***productivity***, ***spatial structure***, and ***diversity*** objectives and criteria. This plan refers to these parameters as the four "viable salmonid population" (VSP) parameters.

Because listed anadromous fish species and bull trout have different life-history characteristics, this plan recommends different recovery goals for the different species. The specific goal for spring Chinook and steelhead is:

- **To secure long-term persistence of viable populations of naturally produced spring Chinook and steelhead distributed across their native range.**

Recovery of the Upper Columbia spring Chinook ESU will require the recovery of the Wenatchee, Entiat, and Methow populations. Recovery of the Upper Columbia steelhead DPS will require the recovery of the Wenatchee, Entiat, Methow, and Okanogan populations, but not the Crab Creek population. This plan deviates from the most recent recommendation of the ICBTRT (December 2005) that at least two populations within the ESU and DPS must meet abundance/productivity criteria that represent a 1% extinction risk over a 100-year period. This plan requires that all populations within the spring Chinook ESU and the steelhead DPS (save the Crab Creek steelhead population) meet abundance/productivity criteria that represent 5% extinction risk over a 100-year period.

The specific goal for bull trout is:

- **To secure long-term persistence of self-sustaining, complex, interacting groups of bull trout distributed across the native range of the species.**

This plan recognizes the importance of providing valid metrics for tributary productivity. It is the policy of the UCSRB to emphasize juvenile salmonid productivity within each tributary as the primary indicator of habitat restoration success for each basin in the Upper Columbia. This will be accomplished primarily by evaluating "smolts per spawner" and/or "smolts per redd." Although this plan does not identify specific recovery criteria based on these factors, this will allow a consistent approach to evaluate the level of success for restoration and recovery actions in the Upper Columbia and the quality of habitat in tributaries.

Recovery Objectives

Because spring Chinook and steelhead are currently listed as ***endangered*** under the ESA, this plan identifies two levels of objectives for them. The first identifies objectives related to reclassifying the species as ***threatened*** and the second relate to recovery (delisting).

Spring Chinook and Steelhead Reclassification Objectives

- Increase the abundance and productivity of naturally produced spring Chinook and steelhead within each population in the Upper Columbia ESU to levels that would lead to reclassification of the ESU and DPS as threatened under the ESA.
- Increase the current distribution of naturally produced spring Chinook and steelhead in the Upper Columbia ESU and DPS and conserve genetic and phenotypic diversity.

Spring Chinook and Steelhead Recovery Objectives

- Increase the abundance of naturally produced spring Chinook and steelhead spawners within each population in the Upper Columbia ESU and DPS to levels considered viable.
- Increase the productivity (spawner:spawner ratios and smolts/redds) of naturally produced spring Chinook and steelhead within each population to levels that result in low risk of extinction.
- Restore the distribution of naturally produced spring Chinook and steelhead to previously occupied areas where practical and allow natural patterns of genetic and phenotypic diversity to be expressed.

Bull trout in the Upper Columbia Basin are currently listed as ***threatened*** under the ESA. Therefore this plan only identifies recovery objectives. It is important to note that core populations within the Upper Columbia Basin make up only a portion of the total Columbia Basin population. Therefore, even if the core populations within the Upper Columbia meet recovery objectives and criteria, the population may not be de-listed if other core populations throughout the Columbia Basin do not meet their objectives and criteria.

Bull Trout Recovery Objectives

- Increase the abundance of adult bull trout within each core population in the Upper Columbia Basin to levels that are considered self sustaining.

- Maintain stable or increasing trends in abundance of adult bull trout within each core population in the Upper Columbia River Basin.
- Maintain the current distribution of bull trout in all local populations, restore distribution to previously occupied areas where practical, maintain and restore the migratory form and connectivity within and among each core area, conserve genetic diversity, and provide for genetic exchange.

Recovery Criteria

The following criteria developed for recovery of naturally produced spring Chinook, steelhead, and bull trout address quantitative and qualitative measurements of abundance, productivity, spatial structure, and diversity on a population or core population basis.

Spring Chinook Reclassification Criteria

- Abundance and productivity (based on 8-year geometric mean) of naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations must reach levels that would have less than a 10% risk of extinction over a 100-year period.
- Processes affecting spatial structure must result in at least a ***moderate*** or lower risk assessment for naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations and all factors considered "high" risk would have been addressed.
- Processes affecting diversity will result in at least a ***moderate*** or lower risk assessment for naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations and all factors considered "high" risk would have been addressed.

Spring Chinook Recovery Criteria

- Abundance and productivity (based on 12-year geometric mean) of naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations must reach levels that would have less than a 5% risk of extinction over a 100-year period.
- At a minimum, the Upper Columbia Spring Chinook ESU will have a productivity greater than 1.0 and maintain at least 4,500 naturally produced spawners distributed among the three populations as follows:

Population	Abundance	Productivity (Spawner:Spawner)
Wenatchee	2,000	1.2
Entiat	500	1.4
Methow	2,000	1.2

- Over a 12-year period, naturally produced spring Chinook will use currently occupied spawning areas throughout the ESU according to the following population-specific criteria:

Wenatchee

Naturally produced spring Chinook spawning will occur within four of the five major spawning areas in the Wenatchee subbasin (Chiwawa River, White River, Nason Creek, Little Wenatchee River, or Wenatchee River) and within one minor spawning area downstream from Tumwater Canyon (Chumstick Creek, Peshastin Creek, Icicle Creek, or Mission Creek). The minimum number of naturally produced spring Chinook redds within each major spawning area will be either 5% of the total number of redds within the Wenatchee subbasin or at least 20 redds within each major area, whichever is greater.

Entiat

Naturally produced spring Chinook will spawn within the one major spawning area within the Entiat subbasin.

Methow

Naturally produced spring Chinook spawning will occur within the Twisp, Chewuch, and Upper Methow major spawning areas. The minimum number of naturally produced spring Chinook redds within each major spawning area will be either 5% of the total number of redds within the Methow subbasin or at least 20 redds within each major area, whichever is greater.

- Processes affecting spatial structure will result in a ***moderate*** or lower risk assessment for naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations and all factors considered "high" risk would have been addressed.
- Processes affecting diversity will result in a ***moderate*** or lower risk assessment for naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations and all factors considered "high" risk would have been addressed.

Steelhead Reclassification Criteria

- Abundance and productivity (based on 8-year geometric mean) of naturally produced steelhead with in the Wenatchee, Entiat, Methow, and Okanogan populations must reach levels that would have less than a 10% risk of extinction over a 100-year period.
- Processes affecting spatial structure must result in at least a **moderate** or lower risk assessment for naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations and all factors considered "high" risk will have been addressed.
- Processes affecting diversity will result in at least a **moderate** or lower risk assessment for naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations and all factors considered "high" risk will have been addressed.

Steelhead Recovery Criteria

- Abundance and productivity (based on 12-year geometric mean) of naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations must reach levels that would have less than a 5% risk of extinction over a 100-year period.

- At a minimum, the Upper Columbia Steelhead DPS will have a productivity greater than 1.0 and maintain at least 3,000 spawners distributed among the four populations as follows:

Population	Abundance	Productivity (Spawner:Spawner)
Wenatchee	1,000	1.1
Entiat	500	1.2
Methow	1,000	1.1
Okanogan	500[1]	1.2

- Over a 12-year period, naturally produced steelhead will use currently occupied spawning areas throughout the DPS according to the following population-specific criteria:

Wenatchee

Naturally produced steelhead spawning will occur within four of the five major spawning areas in the Wenatchee Subbasin (Chiwawa River, Nason Creek, Icicle Creek, Peshastin Creek, or Chumstick Creek). The minimum number of naturally produced steelhead redds within four of the five major spawning areas will be either 5% of the total number of redds within the Wenatchee population or at least 20 redds within four of the five major areas, whichever is greater.

Entiat

Naturally produced steelhead will spawn within the two major spawning areas within the Entiat subbasin (Middle Entiat and Mad rivers). The minimum number of naturally produced steelhead redds within the two major spawning areas will be either 5% of the total number of redds within the Entiat population or at least 20 redds within major areas, whichever is greater.

Methow

Naturally produced steelhead spawning will occur within three of the four major spawning areas (Twisp, Chewuch, Beaver, or Upper Methow). The minimum number of naturally produced steelhead redds within each major spawning area will be either 5% of the total number of redds within the Methow subbasin or at least 20 redds within each major area, whichever is greater.

Okanogan

Steelhead spawning will occur within the two major spawning areas (Salmon and Omak Creeks) and within at least two of the five minor spawning areas (Ninemile, Whitestone, Bonaparte, Antoine, or Loup Loup). The minimum number of naturally produced

[1] The Interior Columbia Basin Technical Recovery Team has determined that 500 naturally produced steelhead adults will meet the minimum abundance recovery criteria within the U.S. portion of the Okanogan subbasin. If the Canadian portion of the Okanogan subbasin is included, the minimum abundance recovery criteria would be 1,000 naturally produced steelhead adults.

steelhead redds within the major spawning areas will be either 5% of the total number of redds within the Okanogan subbasin or at least 20 redds within each area, whichever is greater.

- Processes affecting spatial structure will result in a ***moderate*** or lower risk assessment for naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations and all factors considered "high" risk would have been addressed.
- Processes affecting diversity will result in a ***moderate*** or lower risk assessment for naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations and all factors considered "high" risk would have been addressed.

Bull Trout Recovery Criteria

- The abundance of Upper Columbia bull trout will increase and maintain a 12-year geometric mean of 4,144-5,402 spawners, distributed among the three core areas as follows:

Population	Abundance
Wenatchee	1,612-2,257
Entiat	298-417
Methow	1,234-1,728[2]

- The trend in numbers of bull trout redds (an index of numbers of spawners) within each population in the core areas (Wenatchee, Entiat, and Methow) is stable or increasing over a 12-year period.
- Bull trout will use spawning areas throughout the Upper Columbia Basin according to the following population-specific criteria:

  Wenatchee

  Bull trout spawning will occur within the seven interconnected areas (Chiwawa, White, Little Wenatchee, Nason, Icicle, Chiwaukum, and Peshastin), with 100 or more adults spawning annually within three to five areas.

  Entiat

  Bull trout spawning will occur within the two interconnected areas (Entiat and Mad), with 100 or more adults spawning annually in both areas.

  Methow

  Bull trout spawning will occur within the ten interconnected areas (Gold, Twisp, Beaver, Chewuch, Lake Creek, Wolf, Early Winters, Upper Methow, Goat, and Lost), with 100 or more adults spawning annually within three to four areas.

- The migratory form of bull trout and connectivity within and among core areas must be present.

[2] This criterion does not include bull trout in the Lost River drainage.

Strategy for Recovery

This plan recommends recovery actions for <u>all</u> sectors (Harvest, Hatchery, Hydro, and Habitat) that affect populations of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. Several ongoing processes, including the redevelopment of the biological opinion for the Federal Columbia River Power System (FCRPS) and ***U.S. v. Oregon***, are expected to produce new or amended strategies and actions. Some of the recovery actions recommended in this plan were developed in other forums or processes (e.g., Public Utility District Habitat Conservation Plans) and are incorporated with little or no modification. Several have already been implemented to the benefit of one or more of the viable salmonid population parameters (abundance, productivity, spatial structure, and diversity) of populations in the Upper Columbia Basin.

Identified in this plan are **306** recovery actions to be implemented within the Upper Columbia Basin. By sector, there are 87 harvest actions, 50 hatchery actions, 16 hydro project actions, and 153 habitat actions. In addition, there are **188** monitoring and research actions, which, when broken down by sector is 55 harvest actions, 76 hatchery actions, 8 hydro project actions, and 49 habitat actions. One or more actions are associated with each of the following objectives within each sector.

All the recommended recovery objectives and actions identified in this plan may be modified in response to monitoring, research, and adaptive management and as determinations made in other processes such as the FCRPS Biological Opinion, ***U.S. v Oregon***, and hatchery reform programs. Any modification, especially those that change the regulatory environment or impose additional costs or restrictions on private property and water rights, shall be submitted for public review and comment by local governments and stakeholders, and approved by the UCSRB before implementation.

Harvest

Harvest objectives for treaty and non-treaty salmon and steelhead fisheries in the Columbia River Basin are set by the applicable state, tribal, and federal agencies. Fishery objectives from McNary Dam to the mouth of the Columbia River (fishing zones 1-6) are established by state, tribal, and federal parties in ***U.S. v Oregon***. In developing management plans under ***U.S. v Oregon***, the parties recognize the necessity of managing the fisheries to provide spawning escapement to the various tributary production areas, including the Upper Columbia tributaries covered in this plan. At the same time, they seek to provide meaningful treaty and non-treaty fishing opportunities in zones 1-6, targeting the more productive natural and hatchery stocks, and, where possible, allow fish to pass through to provide tributary fishing opportunities.

The following objectives for harvest apply not only to the Upper Columbia Basin, but also include the entire Columbia River. This plan will strengthen the likelihood that all actions and mitigation associated with harvest throughout the Columbia River are consistent with recovery of Upper Columbia spring Chinook, steelhead, and bull trout. These objectives are intended to reduce threats associated with harvest.

Short-Term Objectives

- Use selective harvest techniques to constrain harvest on naturally produced fish at the currently reduced rates in the Upper Columbia Basin.

- Use selective harvest techniques to preserve fishery opportunities in the Upper Columbia Basin that focus on hatchery produced fish that are not needed for recovery.
- Recommend that parties of ***U.S. v Oregon*** incorporate Upper Columbia viable salmonid population criteria when formulating fishery plans affecting Upper Columbia spring Chinook and steelhead.
- Increase effective enforcement of fishery rules and regulations.
- Appropriate co-managers/fisheries management agencies should work with local stakeholders to develop tributary fisheries management goals and plans.

Long-Term Objectives

- Provide opportunities for increased tributary harvest consistent with recovery.
- Incorporate Upper Columbia viable salmonid population criteria when formulating fishery plans affecting Upper Columbia spring Chinook and steelhead.

Research and Monitoring Objectives

- Research and employ best available technology to reduce incidental mortality of non-target fish in selective fisheries.
- Monitor the effects of incidental take on naturally produced populations in the Upper Columbia Basin.
- Improve estimates of harvested fish and indirect harvest mortalities in freshwater and ocean fisheries.
- Initiate or continue monitoring and research to improve management information, such as the timing of the various run components through the major fisheries.

This plan balances these harvest objectives with the federal government's trust obligations to Native Americans and integrates efforts from the following harvest programs: Pacific Fishery Management Council, the Pacific Salmon Commission, and the Columbia River mainstem and tributary fisheries.

Hatcheries

This plan recognizes that hatchery strategies and actions have been reviewed and considered in several ongoing processes. The following objectives for hatchery programs apply to both federal and state-operated facilities in the Upper Columbia Basin and are intended to be consistent with these ongoing processes. The identified objectives are intended to be consistent with other plans and should reduce the threats associated with hatchery production in the Upper Columbia Basin while meeting other obligations. Actions and mitigation associated with hatcheries throughout the Upper Columbia River Basin should not preclude the recovery of Upper Columbia spring Chinook, steelhead, and bull trout. Additionally, future hatchery facilities will support recovery goals, and minimize and mitigate any impacts (including objectives within other sectors).

Short-Term Objectives

- Continue to use artificial production to maintain critically depressed populations in a manner that is consistent with recovery and avoids extinction.
- Use artificial production to seed unused, accessible habitats.
- Use artificial production to provide for tribal and non-tribal fishery obligations as consistent with recovery criteria.
- Use harvest or other methods to reduce the proportion of hatchery-produced fish in naturally spawning populations.
- To the extent possible use local broodstocks in hatchery programs.
- To the extent possible, integrate federal, state, and tribal-operated hatchery programs that use locally derived stocks.[3]

Long-Term Objectives

- Phase out the use of out-of-basin stock in the federal programs at Leavenworth and Entiat National Fish Hatcheries if continued research indicates that the programs threaten recovery of listed fish and those threats cannot be minimized through operational or other changes.
- Strive to make ongoing hatchery programs consistent with recovery.
- Provide for tribal and non-tribal fishery obligations.
- Use harvest or other methods to reduce the proportion of hatchery produced fish in naturally spawning populations.
- Manage hatcheries to achieve sufficient natural productivity and diversity to de-list populations and to avert re-listing of populations.

Research and Monitoring Objectives

- Employ the best available technology to monitor the effects of hatchery releases on natural populations and production.
- Develop marking programs to assure that hatchery produced fish are identifiable for harvest management, escapement goals, and reproductive success studies.
- Evaluate existing programs and redesign as necessary so that artificial production does not pose a threat to recovery.
- Integrate and coordinate monitoring activities between federal, state, and tribal programs.

[3] Because state and federal hatchery programs have different objectives and obligations, the programs cannot be fully integrated. However, they can develop common broodstock protocols and production levels that optimize recovery of naturally produced fish.

- Examine the reproductive success of naturally and hatchery produced spring Chinook and steelhead spawning in the wild.
- Examine steelhead kelt reconditioning and their reproductive success.
- Continue studies to assess the effects of the coho reintroduction program.
- Examine the interactions (competition and predation) between naturally and hatchery produced steelhead.
- Continue to examine residualism of hatchery produced steelhead.
- Examine the feasibility of reintroducing bull trout (including ESA status of introduced stock) into the Chelan and Okanogan subbasins.
- Examine the feasibility (including ESA status of introduced stock) of reintroducing spring Chinook into the Okanogan subbasin.

This plan recognizes the need to balance hatchery recovery objectives with legal obligations and mandates under Habitat Conservation Plans, the Mitchell Act, federal government and tribal agreements, Hatchery and Genetic Management Plans, ***U.S. v. Oregon,*** and relicensing agreements.

Hydro Projects

Upper Columbia ESU and DPS migrate through four federally owned projects and three to five projects owned by public utility districts (PUDs). The four federally owned projects include McNary, John Day, The Dalles, and Bonneville dams, power plants, and reservoirs in the lower Columbia River. These projects are part of the FCRPS. Projects owned and operated by public utility districts include Wells (Douglas County PUD), Rocky Reach and Rock Island (Chelan County PUD), and Wanapum and Priest Rapids dams (Grant County PUD). These projects are licensed by the Federal Energy Regulatory Commission.

This plan recognizes that hydro strategies and actions have been reviewed and considered in several ongoing processes, including FCRPS Section 7 consultations (for the lower four federal dams on the Columbia River). The following objectives are intended to be consistent with these processes; however, they apply primarily to the projects owned by the PUDs. These objectives are consistent with the Anadromous Fish Agreement and Habitat Conservation Plans (HCPs), Priest Rapids Salmon and Steelhead Settlement Agreement, and Section 7 Consultations. This plan strengthens the likelihood that all actions and mitigation associated with hydro projects throughout the Columbia River are consistent with recovery of Upper Columbia spring Chinook, steelhead, and bull trout. These objectives are intended to reduce the threats associated with hydroelectric development in the Upper Columbia Basin.

Short-Term Objectives

- Continue the actions identified in the Anadromous Fish Agreement and HCPs that will achieve no net impact for Upper Columbia steelhead and spring Chinook.
- Implement the actions identified in the Settlement Agreement and Section 7 Consultation with Grant PUD that will improve spring Chinook and steelhead survival.

- Implement the actions identified in the U.S. Fish and Wildlife Service biological/conferencing opinion with Douglas and Chelan PUDs that will improve conditions for Upper Columbia bull trout.
- Implement the actions identified in the Lake Chelan Hydroelectric Project relicensing agreement that will provide suitable spawning habitat for steelhead in the tailrace and lower Chelan River (downstream from the natural fish barriers).
- Strive to build hydroelectric dams proposed for construction in the future in the Upper Columbia Basin that have no negative effect on spring Chinook, steelhead, and bull trout viable salmonid population parameters.
- Encourage the implementation of actions for federal hydroelectric projects identified in the remanded Federal Columbia River Power System biological opinion.

Long-Term Objectives

- Provide upstream and downstream passage for juvenile/smolt and adult life stages.
- Implement the actions identified in the Lake Chelan Comprehensive Fishery Management Plan to determine the feasibility and possible reintroduction of bull trout into the basin.
- Achieve no-net-impact on species covered under the Anadromous Fish Agreement, HCPs, and Section 7 Consultations.
- Maintain suitable subadult and adult bull trout rearing and passage conditions in the mainstem Upper Columbia River.
- Maintain suitable spawning habitat for steelhead in the lower Chelan River and tailrace.

Research and Monitoring Objectives

- Determine baseline survival estimates for juvenile spring Chinook, steelhead, and bull trout as they pass hydroelectric projects on the Upper Columbia River.
- Evaluate effects of hydroelectric projects on adult passage of spring Chinook, steelhead, and bull trout.
- Evaluate if passage through hydroelectric projects affect spawning success or fitness of spring Chinook, steelhead, and bull trout.
- Evaluate effectiveness of predator control programs.

Most of these objectives are consistent with the legal mandates of the HCPs, Section 7 Consultations, and relicensing agreements. The primary objective of the HCPs is to achieve no-net-impact. If met, this objective would equate to a net productivity equivalent to the productivity that could be attained if these projects did not exist. The HCPs intend to meet no-net-impact primarily through mainstem survival objectives for juvenile and adult salmonids, and through off-site mitigation with hatchery and tributary habitat improvements. The goal is to achieve combined adult and juvenile survival of 91% per project. The remaining 9% will be compensated through hatchery (7%) and tributary (2%) activities.

Habitat

The following objectives for habitat restoration apply to all streams that currently support or may support (in a restored condition) spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. These objectives are consistent with subbasin plans, watershed plans, the Upper Columbia Biological Strategy, Habitat Conservation Plans, and relicensing agreements, and are intended to reduce threats to the habitat needs of the listed species. Because maintaining existing water rights are important to the economy of landowners within the Upper Columbia Basin, this plan will not ask individuals or organizations to affect their water rights without empirical evidence as to the need for the recovery of listed species. To the extent allowed by law, landowners will be adequately compensated for implementing recovery actions. In addition, any land acquisition proposal in this plan will be based on the concept of no net loss of private property ownership, such as conservation easements, transfer of development rights, and other innovative approaches. This plan will strengthen the likelihood that all actions and mitigation associated with habitat throughout the Columbia River are consistent with recovery of Upper Columbia spring Chinook, steelhead, and bull trout. These objectives will be implemented within natural, social, and economic constraints. Local habitat groups (in cooperation with local landowners) will prioritize and coordinate the implementation of "specific" habitat actions within specific stream areas.

Short-Term Objectives

- Protect[4] existing areas where high ecological integrity and natural ecosystem processes persist.
- Restore connectivity (access) throughout the historic range where feasible and practical for each listed species.
- Where appropriate, establish, restore, and protect stream flows (within the natural hydrologic regime and existing water rights) suitable for spawning, rearing, and migration (based on current research and modeling).
- Protect and restore water quality where feasible and practical within natural constraints.
- Increase habitat diversity in the short term by adding instream structures (e.g., large woody debris, rocks, etc.) where appropriate.[5]
- Protect and restore riparian habitat along spawning and rearing streams and identify long-term opportunities for riparian habitat enhancement.

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[4] Protect or protection in this plan refers to ***all*** actions that safeguard required habitat features of listed species. This plan does not recommend land acquisition, unless "no net loss" of the tax base of the county in which the land is being sold is accomplished.

[5] This plan recommends the use of instream structures (such as boulders and LWD) as an immediate, short-term action to increase habitat diversity. These structures can be used while other actions are implemented to restore proper channel and riparian function (i.e., natural watershed processes). The manual addition of instream structures is usually not a long-term recovery action and should not be used in place of riparian or other restoration activities that promote reestablishment of natural watershed processes. However, if recovery of natural watershed processes cannot be achieved, the use of instream structures is a reasonable option.

- Protect and restore floodplain function and reconnection, off-channel habitat, and channel migration processes where appropriate and identify long-term opportunities for enhancing these conditions.
- Restore natural sediment delivery processes by improving road network, restoring natural floodplain connectivity, riparian health, natural bank erosion, and wood recruitment.
- Replace nutrients in tributaries that formerly were provided by salmon returning from the sea.
- Reduce the abundance and distribution of non-native species that compete and interbreed with or prey on listed species in spawning, rearing, and migration areas.

Long-Term Objectives

- Protect areas with high ecological integrity and natural ecosystem processes.
- Maintain connectivity through the range of the listed species where feasible and practical.
- Maintain suitable stream flows (within natural hydrologic regimes and existing water rights) for spawning, rearing, and migration.
- Protect and restore water quality where feasible and practical within natural constraints.
- Protect and restore off-channel and riparian habitat.
- Increase habitat diversity by rebuilding, maintaining, and adding instream structures (e.g., large woody debris, rocks, etc.) where long-term channel form and function efforts are not feasible.
- Reduce sediment recruitment where feasible and practical within natural constraints.
- Reduce the abundance and distribution of non-native species that compete and interbreed with or prey on listed species in spawning, rearing, and migration areas.

Administrative/Institutional Objectives

- Maximize restoration efficiency by concentrating habitat actions in currently productive areas with significant scope for improvement and areas where listed species will benefit.
- Develop incentive and collaborative programs with local stakeholders and land owners to enhance and restore habitat within productive areas.
- Strive to secure compliance with Federal, State, and local regulatory mechanisms designed to conserve fishery resources, maintain water quality, and protect aquatic habitat.
- Counties will continue to consider recovery needs of salmon and trout in comprehensive land-use planning processes.

- Provide information to the public on the importance of "healthy"[6] streams and the potential effects of land and water management activities on the habitat requirements of listed species.

- Until recovery is achieved, improve or streamline the permitting process for conducting research and monitoring on ESA-listed species and for implementing restoration actions.

- Develop, maintain, and provide a comprehensive inventory of habitat projects and their costs and benefits (effectiveness) to the public annually.

Research and Monitoring Objectives

- Monitor the effectiveness of each "class" of habitat action implemented in the Upper Columbia Basin on listed species and community structure.

- Accurately monitor trends in abundance, productivity (including smolts/redd), spatial structure, and diversity at the population and subpopulation scale.

- Assess stream flows (within the natural hydrologic regime and existing water rights) suitable for spawning, rearing, and migration (based on current research and modeling).

- Implement current monitoring protocols and continue to develop standardized monitoring methods.

- Examine relationships between habitat and biological parameters at coarse (landscape) and fine (stream segment) scales.

- Update, revise, and refine watershed and salmonid performance assessment tools (e.g., Ecosystem Diagnosis and Treatment analysis) to adaptively manage the implementation and prioritization strategy.

- Examine the effects of non-native species on listed species.

- Assess abundance and consumption rates of non-native fish that feed on listed species.

- Conduct channel migration studies within each subbasin to identify priority locations for protection and restoration.

- Examine fluvial geomorphic processes within each subbasin to assess how these processes affect habitat creation and loss.

- Inventory and assess fish passage barriers and screens within each subbasin.

- Conduct hydrologic assessments to better understand water balance and surface/groundwater relations within the subbasins (similar to studies conducted in the Methow by the USGS) and relationships to salmonid utilization and survival.

This plan recognizes that at some point the implementation of habitat actions will provide little benefit to the listed species because the habitat has achieved its greatest productivity potential

[6] "Healthy" is a relative term and is used in this plan to mean the habitat conditions necessary to sustain the listed species indefinitely.

within natural, social, and economic constraints. That is, at some point in the future, habitat improvements through protection and restoration will have a limited effect on fish habitat. This plan promotes an end point of habitat improvements that when met will conclude the responsibility of landowner action to improve or protect habitat, regardless of the status of the listed species.

Integration of Actions

The results of preliminary analyses indicate that the implementation of recommended actions in this Plan will move the listed fish species toward recovery. This will occur if actions are implemented within all sectors (Harvest, Hatchery, Hydro, and Habitat). Recovery cannot be achieved by implementing actions within only one sector (e.g., Habitat). Recovery will also require the implementation of actions outside the Upper Columbia Basin (i.e., in the lower Columbia River, estuary, and ocean).

Recovery actions recommended in this plan should significantly improve the abundance and productivity of naturally produced spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. Preliminary analysis suggests that the implementation of recommended recovery actions within all sectors may increase the survival of spring Chinook populations from 99-198%, while steelhead population survivals may increase from 85-226%. There are currently no estimates for bull trout. The amount of survival improvement depends on the specific population and the "intensity" at which recommended actions are implemented.

Implementation of recovery actions within the hatchery and habitat sector should also improve the spatial structure and diversity of the Upper Columbia populations. Implementing actions recommended within the hatchery sector should reduce threats to and improve opportunities for meeting diversity requirements.

Time and Cost Estimates

The ESA section 4(f)(1) requires that the recovery plan include ''estimates of the time required and the cost to carry out those measures needed to achieve the Plan's goal and to achieve intermediate steps toward that goal'' (16 U.S.C. 1533[f][1]). The Upper Columbia Plan contains an extensive list of actions that need to be undertaken to recover spring Chinook and steelhead; however, there are many uncertainties involved in predicting the course of recovery and in estimating total costs. Such uncertainties include biological and ecosystem responses to recovery actions as well as long-term and future funding. The Upper Columbia Plan states that if its recommended actions are implemented, recovery of the spring Chinook salmon ESU and the steelhead DPS is likely to occur within 10 to 30 years. The cost estimates cover work projected to occur within the first 10-year period. Before the end of this first implementation period, specific actions and costs will be estimated for subsequent years, to achieve long-term goals and to proceed until a determination is made that listing is no longer necessary.

The estimated cost of restoring habitat for spring Chinook, steelhead, and bull trout in the Upper Columbia Basin is at least $296 million over the first 10-year period. This estimate includes expenditures by local, Tribal, State, and Federal governments and private business and individuals in implementing both capital projects and non-capital work. Although these costs are attributed to spring Chinook, steelhead, and bull trout conservation, other species will also benefit.

There are no estimated costs associated with hatchery programs because these programs are funded to achieve specific program objectives, which may change based on monitoring and evaluation. The cost estimate does not include expenses associated with implementing actions within the lower Columbia River, in the estuary, within the Federal Columbia River Power System, or the cost of implementing measures in the Public Utility District Habitat Conservation Plans and Settlement Agreements. Cost estimates for these items are included in two modules that NMFS developed because of the regional scope and applicability of the actions. These modules are incorporated into the Upper Columbia Plan by reference and are available on the NMFS Web site: www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other-Documents.cfm. The hydropower cost estimates will be updated over time, as the section 7 consultation on the remanded 2004 FCRPS BiOp is completed. The estuary recovery costs could be further refined following public comment on the ESA recovery plan for the three listed lower Columbia ESUs and one listed Lower Columbia steelhead DPS in 2007. There are virtually no estimated costs for recovery actions associated with harvest to report at this time. This is because no actions are currently proposed that go beyond those already being implemented through ***U.S. v. Oregon*** and other harvest management forums. In the event that additional harvest actions are implemented through these forums, those costs will be added during the implementation phase of this recovery plan. All cost estimates will be refined and updated over time.

The Plan estimates it may cost a total of $10 million to cover agency and organization staffing costs during the first 10 years of plan implementation ($1 million/year), and it is conceivable that this level of effort will need to continue for the Plan’s duration. Also, continued actions in the management of habitat, hatcheries, and harvest, including both capital and non-capital costs, will likely warrant additional expenditures beyond the first 10 years. Although it is not practicable to accurately estimate the total cost of recovery, it appears that most of the costs will occur in the first 10 years. Annual costs are expected to be lower for the remaining years, thus the total for the entire period (years 11-30) may possibly range from $150 million to $200 million.

Funding Strategy

It is uncertain exactly how recovery will be funded in the Upper Columbia Basin. Habitat Conservation Plans and binding mitigation agreements help guarantee that some programs (e.g., state-run mitigation hatchery programs, tributary habitat fund, etc.) have secure funding and will continue operating into the future. However, these programs fall short of funding the total needs of this plan. Additional funding from the following sources will be required to implement this recovery plan.

- The Washington Salmon Recovery Funding Board.
- Public Utility District funds.
- The Bonneville Power Administration (BPA) Fish and Wildlife Program.
- The Federal Columbia River Power System Biological Opinion.
- Appropriations from the Washington State Legislature for state agency budgets (WDFW, WDOE, Conservation Districts).
- Pacific Coast Salmon Recovery Fund (NMFS).

- Appropriations from the U.S. Congress for federal agency (USACE, USFWS, USGS, USFS, NRCS, BOR, and BLM).
- Local government mechanisms funded through state legislative appropriations.
- Other nongovernmental organizations such as the National Fish and Wildlife Foundation, Regional Fishery Enhancement Groups, the Bonneville Environmental Foundation, and the Bullitt Foundation.
- Voluntary projects funded through public and private partnerships.

Because of limited resources, recommended actions will be funded according to a prioritization framework that is based on a balance between biological benefit of the action, and the cost and feasibility of implementing the action. Projects that address primary limiting factors, have high biological benefit, are relatively inexpensive, and are feasible to implement will receive highest funding priority.

Implementation and Coordination

The UCSRB is the coordinating body for the plan and it is their responsibility to make sure the plan is implemented in a voluntary manner. An Implementation Team, composed of a Leader, three Lead Entity representatives (one from each County), the Upper Columbia Regional Technical Team, local, State, Federal, and Tribal resource management agencies and others including local stakeholders, will be responsible for implementing the plan, tracking progress, identifying milestones and benchmarks, and sequencing tasks. The Implementation Team will be involved in all issues related to recovery actions, and will work within the framework of the UCSRB, ***U.S. v Oregon***, Habitat Conservation Plans for the Public Utility Districts, Biological Opinion and Anadromous Fish Agreement, Section 7 consultations, the Mitchell Act, Hatchery and Genetic Management Plans, and federal trust responsibilities to the tribes. The Implementation Team will work closely with local habitat groups, which will be responsible for identifying specific habitat restoration actions and coordinating activities within their respective subbasins. All proposed recovery actions will be coordinated with local stakeholder input and local stakeholders will be included in the development of any of the planning processes that may affect their interests.

Monitoring and Adaptive Management

The beneficial actions identified in this plan are believed to represent a sound approach based on available information and tools, and they address the range of known threats. However, uncertainty exists for many actions because of insufficient information. This plan does not assume risk-free actions with perfectly predictable results. Therefore, this plan will monitor[7] or assess the outcomes of different recovery actions. The plan is "adaptive" in the sense that it will take this information, combined with cost and benefit estimates, and re-evaluate priorities and reasonable actions. The intent is to use the information as a means of selecting what actions will be sufficient for recovery. This plan is a "living document" that will be updated as new information becomes available. All significant modifications, especially those that change the

[7] Monitoring will include implementation, status/trend, and effectiveness monitoring.

regulatory environment or impose additional costs or restrictions on private property and water rights, will be submitted for public review and comment by local governments and stakeholders, and approved by the UCSRB before implementation.

Assurances

Assurances are needed that good-faith recovery efforts, which are consistent with this recovery plan and are based on the best scientific information available, will reduce the risk that the public would be prosecuted for a take of listed species. In other words, if an entity has corrected problems (threats and limiting factors) that have been identified as detrimental to listed species, there must be a point at which they are no longer responsible for salmonid population problems. Currently, assurances are legally guaranteed only under Section 4, Section 7, and Section 10 of the ESA. The UCSRB encourages the federal agencies to explore additional opportunities for assurances. A legally binding definition of discharge of responsibility for impacts to spring Chinook, steelhead, and bull trout populations would increase voluntary participation in recovery planning and implementation.

Estimated Date of Recovery

The time necessary to achieve reclassification for spring Chinook and steelhead and recovery of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin depends on the status of the fish species, factors affecting their viability, implementation and effectiveness of recovery actions, and responses to recovery actions. A large amount of work within all sectors is needed to recover the species. If the actions recommended in this plan are implemented, recovery of the three listed species should occur within 10 to 30 years.

1 Introduction

1.1 Definition of a Recovery Plan
1.2 Organization of Plan
1.3 Regional Setting
1.4 Current Conditions
1.5 Desired Outcome
1.6 Overall Strategy to Recovery
1.7 Relationship to Other Recovery Activities
1.8 Coordination and Public Involvement

The National Oceanographic Atmospheric Administration Fisheries (NOAA Fisheries) issued a rule listing Upper Columbia River Steelhead (***Oncorhynchus mykiss***) as endangered under the Endangered Species Act (ESA) on August 18, 1997 (62 FR 43937). On January 5, 2006, NOAA Fisheries reclassified the Upper Columbia River Steelhead Distinct Population Segment (DPS) as threatened (50 FR 834), based in part on the agency's application of the ESA Hatchery Listing Policy (70 FR 123). On June 13, 2007, the U.S. District Court set aside that ESA Hatchery Listing Policy as contrary to the ESA. Consequently, the 2006 listing was invalidated and the endangered status of the Upper Columbia Steelhead DPS reinstated (Trout Unlimited et al. v. Lohn). The Upper Columbia River Steelhead DPS occupies the Columbia River and its tributaries between the Yakima River and Chief Joseph Dam. On March 24, 1999, NOAA Fisheries listed the Upper Columbia River Spring-run Chinook Salmon (***O. tshawytscha***) as endangered (64 FR 14307). The Upper Columbia River Spring-run Chinook ESU occupies the Columbia River and its tributaries between Rock Island Dam and Chief Joseph Dam.

The U.S. Fish and Wildlife Service (USFWS) issued a final rule listing the Columbia River and Klamath River populations of bull trout (***Salvelinus confluentus***) as threatened under the ESA on June 10, 1998 (63 FR 31647). The USFWS considers the Columbia River population as one of five distinct population segments (DPS) (i.e., they meet the joint policy of the USFWS and NOAA Fisheries regarding the recognition of distinct vertebrate populations). The USFWS issued another final rule coterminously listing the bull trout in all DPSs as threatened on November 1, 1999 (64 FR 58910). This recovery plan addresses the recovery of bull trout in the Upper Columbia Basin, encompassing the basin upstream of the confluence of the Yakima River to Chief Joseph Dam, including the mainstem Columbia River and all of its associated tributaries. This geographic area is referred to as the Upper Columbia Recovery Unit in the Bull Trout Draft Recovery Plan (USFWS 2002). Bull trout in the Upper Columbia constitute one portion of the total Columbia River population.

The Upper Columbia Salmon Recovery Board (UCSRB)[8] developed this plan for the recovery of endangered spring Chinook and endangered steelhead and threatened bull trout in the Upper Columbia River Basin (commonly called the Upper Columbia Region or Upper Columbia Basin). This plan is an outgrowth and culmination of several conservation efforts in the Upper Columbia Basin including efforts related to the ESA, state-sponsored recovery efforts, subbasin planning, watershed planning, and tribal recovery.

[8] The UCSRB consists of Chelan, Douglas, and Okanogan counties, the Confederated Tribes of the Colville Indian Reservation, and the Yakama Nation.

Watershed planning began when the 1998 Washington State Legislature passed House Bill (HB) 2514, codified into RCW 90.82, to set a framework for addressing the state's water resources issues. In 2001, HB 1336 amended the law. Currently RCW 90.82 states:

> The legislature finds that the local development of watershed plans for managing water resources and for protecting existing water rights is vital to both state and local interests. The local development of these plans serves vital local interests by placing it in the hands of people: Who have the greatest knowledge of both the resources and the aspirations of those who live and work in the watershed; and who have the greatest stake in the proper, long-term management resources. The development of such plans serves the state's vital interests by ensuring that the state's water resources are used wisely, by protecting existing water rights, by protecting instream flows for fish and by providing for the economic well-being of the state's citizenry and communities. Therefore the legislature believes it necessary for units of local government throughout the state to engage in orderly development of these watershed plans.

The purpose of the 1998 Watershed Management Act (WMA) is to provide a framework for local government, interest groups, and citizens to identify and solve water-related issues collaboratively in each of the 62 Water Resource Inventory Areas (WRIAs) of Washington State. Water quantity is a required element of the plan, with water quality, stream flows, habitat, and storage as optional elements to be included. Watershed plans have been completed in the Wenatchee, Entiat, Methow, Foster Creek, and Moses Coulee WRIAs and adopted respectively by Chelan, Okanogan, and Douglas counties. Portions of these plans are integral parts of the recovery plan.

Recently, the Northwest Power and Conservation Council (NPCC; formerly the Northwest Power Planning Council) adopted a revised Fish and Wildlife Program for the Columbia River Basin with the intent that the program will be more comprehensive than, but complimentary to, regional, state, county, and tribal efforts. Their revised program calls for an ecosystem-based approach for planning and implementing fish and wildlife recovery. This effort resulted in subbasin plans. Pertinent information from both subbasin plans and watershed plans formed the basis for much of this recovery plan. Other species, including resident, migrant, and anadromous species are expected to benefit from this plan.

1.1 Definition of a Recovery Plan

As outlined in Section 4(f)(1) of the ESA, a recovery plan is defined as follows:

The Secretary shall develop and implement plans (hereafter in this subsection referred to as "recovery plans") for the conservation and survival of endangered species and threatened species listed pursuant to this section, unless he finds that such a plan will not promote the conservation of the species. The Secretary, in development and implementing recovery plans, shall, to the maximum extent practicable-

> ***(A) give priority to those endangered species or threatened species, without regard to taxonomic classification, that are most likely to benefit from such plans, particularly***

those species that are, or may be, in conflict with construction or other forms of economic activity;

(B) incorporate in each plan-

(i) a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;

(ii) objective, measurable criteria which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list; and

(iii) estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

This document is designed to be a roadmap showing a possible path to the recovery of salmonids in the Upper Columbia. While it contains much of the available science, it is not intended to be the definitive method or means of recovery. This plan is to be used to guide federal agencies charged with species recovery in their actions. In and of itself, this plan is a non-regulatory document. As such, it is not intended to be nor may it serve as a regulatory document forcing landowner action. Any such regulatory actions deemed necessary as a result of this document must be accompanied by a clear legislative mandate to that end.

The plan may be used to inform state and local agency planning and land use actions, but it may not be deemed to place requirements on such entities. The goal of this plan is to offer options for future action to enhance the survival of species. No mandate on state or local agencies may be construed from this plan, and the plan may not be cited as creating a need for new regulatory actions at the state or local level unless clear legislative authority is first adopted.

This plan is limited to address listed salmonid species. If any threatened or endangered species were introduced into an area where it has been designated as extirpated, this population would be treated as an experimental population (ESA Section 10(j) or other mechanisms under ESA), which would not increase ESA liabilities for landowners.

1.2 Organization of Plan

This plan, the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan, describes a process and recommends actions to remove or minimize the threats to spring Chinook and steelhead long-term survival and reverse their decline within the Upper Columbia Basin. This plan is also expected to benefit other sensitive or at-risk species.

1.2.1 Executive Summary

The Executive Summary provides a succinct description of the recovery plan. It identifies the problem, clearly states the goal and scope of the plan, summarizes the strategies, and outlines the recommended actions and commitments needed for recovery of the listed species.

1.2.2 Section 1 (Introduction)

The Introduction provides general background information, including a brief description of the Upper Columbia Basin, current conditions of the listed species and their habitats, desired outcomes from implementing the plan, the approach to developing recovery strategies and actions, the relationship of this plan to other recovery activities, public participation in the development of this plan, and who was involved in developing this plan.

1.2.3 Section 2 (Species Status)

This section briefly describes the current and historical status of Upper Columbia spring Chinook, steelhead, and bull trout. It focuses on four Viable Salmonid Population (VSP) parameters: abundance, productivity, spatial structure, and diversity (McElhany et al. 2000). Historical distribution, habitat use, and production potential within the Upper Columbia Basin have been estimated using Ecosystem Diagnostic and Treatment (EDT) analysis (see Okanogan, Methow, and Entiat subbasin plans); quantitative habitat analysis (QHA) (see Wenatchee and Upper Middle Mainstem subbasin plans); and using an analysis commonly referred to as the Intrinsic Potential Analysis (NWFSC 2004) (see NOAA Fisheries Northwest Fisheries Science Center (NWFSC)). This section also reviews community structure within the Upper Columbia Basin. Section 2 provides only a very brief discussion on species status. A more detailed discussion can be found in watershed plans and subbasin plans.

1.2.4 Section 3 (Factors for Decline)

This section briefly describes the major factors that led to the decline of Upper Columbia spring Chinook, steelhead, and bull trout. This section also identifies the major threats to recovery of the three species. The reader should consult watershed plans and subbasin plans for a detailed description of factors causing decline of these and other species.

1.2.5 Section 4 (Recovery Criteria)

This section identifies the objectives and targets that must be met for recovery of the ESU, DPS, and bull trout. This section identifies the goals, objectives, and criteria for recovery, outlines desired future conditions and recovery targets for abundance, productivity, spatial structure, and diversity, and also identifies a timeframe for opportunities and goals. The Interior Columbia Basin Technical Recovery Team (ICBTRT)[9] has developed recommendations for biological criteria for population and ESU-level viability (criteria that indicate when populations or ESUs and DPSs have a high probability of persistence into the future). Recommendations submitted by the ICBTRT to NOAA Fisheries are included in this plan (McElhany et al. 2000; ICBTRT 2004a).

[9] The ICBTRT consists of representatives from NOAA Fisheries, Columbia River Inter-Tribal Fish Commission, U.S. Fish and Wildlife Service, Idaho Department of Fish and Game, Oregon Department of Fish and Wildlife, Washington Department of Fish and Wildlife, the University of Montana, and the University of Washington.

1.2.6 Section 5 (Recovery Program)

This section of the plan identifies the recommended actions that are needed to achieve recovery of Upper Columbia ESA-listed spring Chinook, steelhead and bull trout. Actions are recommended and prioritized for each "H" sector (Harvest, Hatchery, Hydropower, and Habitat) and for each listed population, but are not prioritized across H's. This section also describes the interaction of actions and what changes in VSP parameters can be expected for each population (and ESU) if actions are implemented. Within this section local government programs and policies are examined and compared with possible effects to the VSP parameters. Finally, this section identifies performance measures, responsible parties, compliance, coordination, and commitments.

1.2.7 Section 6 (Social/Economic Considerations)

The plan will include coarse-scale cost estimates for the suite of actions and cost effectiveness[10] of some actions.

1.2.8 Section 7 (Relationship to Other Efforts)

This section describes how the plan relates to other efforts that intend to help restore fish populations and/or habitat in the Upper Columbia River Basin. For example, this section identifies how this plan meshes with NOAA Fisheries Biological Opinions, the U.S. Fish and Wildlife Service (USFWS) Bull Trout Draft Recovery Plan and Biological Opinions, the mid-Columbia Habitat Conservation Plans (HCPs), watershed plans and subbasin plans, and other conservation efforts. Each of these includes its own conservation efforts in varying stages of development and implementation. This plan builds upon the foundation established by these conservation plans and adopts portions of those plans where appropriate.

1.2.9 Section 8 (Plan Implementation)

Parties to this plan recognize that the plan can succeed only if local, state, and federal interests take ownership of it and are involved in implementation and adaptive management. This section describes how, when, and by whom the recommended actions will be implemented and monitored. Because there is some uncertainty associated with some actions, this section will identify those uncertainties and describe how they will be addressed. The plan stresses the importance of adaptive management[11] and provides a mechanism for monitoring the progress of the plan and refining the plan over time. In addition, this section will describe how the plan will

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[10] Cost effectiveness refers to the relationship between costs and potential benefits (biological and social).

[11] Adaptive management applies the concept of experimentation to design and implementation of natural resource plans and policies (Lee 1993). As stated in Lee (1993), "***Adaptive management encourages deliberate design of measures. This assures that both success and failures are detected early and interpreted properly as guidance for future action. Information from these evaluations should enable planners to estimate the effectiveness of protection and enhancement measures on a systemwide basis. Measures should be formulated as hypotheses. Measures should make an observable difference. Monitoring must be designed at the outset. Biological confirmation*** [plus social acceptance] ***is the fundamental measure of effectiveness.***" (See Section 8.)

involve the public during implementation and how it will seek broad support. Finally, this plan will link specific actions to responsible parties and funding sources.

1.3 Regional Setting

This recovery plan is intended for implementation within the Upper Columbia River Basin, which includes the Columbia River and its tributaries upstream of the confluence of the Yakima River to the base of Chief Joseph Dam (**Figure 1.1**). Implementation of recovery actions outside the Upper Columbia Basin (i.e., out-of-subbasin hydro, harvest, and estuary actions) are incorporated in this plan by reference and managed in other forums such as ***U.S. v. Oregon***, the Lower Columbia River Estuary Partnership, and the FCRPS. This area forms part of the larger Columbia Basin Ecoregion (Omernik 1987). The Wenatchee, Entiat, and Chelan subbasins are in the Northern Cascades Physiographic Province, and the Okanogan and Methow subbasins are in the Okanogan Highlands Physiographic Province. The geology of these provinces is somewhat similar and very complex, developed from marine invasions, volcanic deposits, and glaciation. The river valleys in this region are deeply dissected and maintain low gradients except in headwaters. The climate includes extremes in temperatures and precipitation, with most precipitation falling in the mountains as snow. Melting snowpack, groundwater, and runoff maintain stream flows in the area. Because a large portion of the Upper Columbia Basins is publicly owned, management of public lands to improve forest and ecosystem health could have direct and indirect benefits to the listed species.

The Upper Columbia Basin consists of six major "subbasins" (Crab, Wenatchee, Entiat, Lake Chelan, Methow, and Okanogan subbasins), several smaller watersheds, and the mainstem Columbia River (**Figure 1.1**). This area captures the distribution of Upper Columbia River spring Chinook, steelhead, and bull trout. The ICBTRT[12] identified independent populations of spring Chinook and steelhead within the Upper Columbia River Basin (ICBTRT 2003).

The ICBTRT recognized three extant, independent populations of spring Chinook within the Upper Columbia ESU (Wenatchee, Entiat, and Methow), with one extirpated stock of spring Chinook identified in the Okanogan subbasin. While Chinook also rear in some of the smaller tributaries to the Columbia River, the particular life-history type (spring or summer)[13] is unknown.

The ICBTRT recognizes five steelhead populations within the Upper Columbia DPS (Wenatchee, Entiat, Methow, Okanogan and Crab Creek populations). Steelhead also exist within smaller tributaries to the Columbia River, such as Squilchuck, Stemilt, Colockum, Tarpiscan, Tekison, Quilomene/Brushy, and Foster creeks, and the Chelan River tailrace. Steelhead in these smaller tributaries are not separate populations, but are included in the closest

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[12] The ICBTRT was convened by NOAA Fisheries to provide technical guidance and recommendations relating to the recovery of salmon and steelhead in the interior Columbia Basin.

[13] Spring Chinook are also referred to as "early run," "stream-type," or "stream-annulus" Chinook, while summer Chinook are also referred to as "late-run," "ocean-type," or "ocean-annulus" Chinook. Very simply, spring Chinook enter the Columbia River earlier than summer Chinook, they spawn earlier and higher in watersheds than do summer Chinook, and they tend to rear within tributary streams or lakes (Lichatowich 1999) for one year before migrating to tthe sea as smolts in the spring. In this document we identify Chinook as either "spring" or "summer" fish.

upstream population. For example, Squilchuck, Stemilt, Colockum, Tarpiscan, Tekison, and Quilomene/Brushy are all part of the Wenatchee steelhead population. A detailed description of small tributaries to the Columbia River can be found in the Upper Middle Mainstem subbasin plan (2004).

The USFWS (2002) has identified three "core" areas supporting bull trout populations (Wenatchee, Entiat, and Methow subbasins) and two areas designated as "unknown occupancy" (Lake Chelan and Okanogan subbasins)[14]. The USFWS has also identified "local" populations within each of the three core areas.

1.3.1 Wenatchee Subbasin

The Wenatchee subbasin is located in north-central Washington and lies entirely within Chelan County. The subbasin consists of about 854,000 acres. About 90% of the subbasin is in public ownership. The remaining 10% is privately owned and is primarily within the valley bottoms. The subbasin consists of nine primary watersheds: Mission, Peshastin, Chumstick, Icicle, Chiwaukum, and Nason creeks, the Chiwawa, White, and Little Wenatchee rivers (**Figure 1.2**), and two mainstem Wenatchee River "watersheds:" the lower and upper Wenatchee River (the upper river includes Lake Wenatchee). Spring Chinook, steelhead, and bull trout spawn and rear in the subbasin. A more detailed description of the Wenatchee Subbasin can be found in the Wenatchee Subbasin Plan (2005).

1.3.2 Entiat Subbasin

The Entiat subbasin is located in north-central Washington and lies entirely within Chelan County. The subbasin consists of about 298,000 acres. About 91% of the subbasin is in public ownership. The remaining 9% is privately owned and is primarily within the valley bottoms. The subbasin consists of two primary watersheds: Entiat and Mad rivers (**Figure 1.3**). Spring Chinook, steelhead, and bull trout spawn and rear in the Entiat subbasin. A more detailed description of the Entiat Subbasin can be found in the Entiat WRIA 46 Management Plan (CCCD 2004) and the Entiat Subbasin Plan (2004).

1.3.3 Lake Chelan Subbasin

The Lake Chelan subbasin is located in north-central Washington and lies entirely within Chelan County (**Figure 1.1**). The subbasin consists of 599,905 acres. About 87% of the subbasin is in public ownership. The remaining 13% is privately owned. The most prominent feature of the subbasin is Lake Chelan, which occupies about 50 miles of the 75-mile-long basin. The majority of inflow to Lake Chelan is from two major tributaries, the Stehekin River (65%) and Railroad Creek (10%). About 50 small streams provide the remaining 25% of the inflow. Because of the shape of the valley, most tributaries are relatively steep and short. Lake Chelan drains into the 4.1-mile-long Chelan River. Presently, nearly all the flow from Lake Chelan is diverted through a penstock, which passes the water through the Lake Chelan powerhouse located near the mouth of the river. Steelhead spawn and rear in the Chelan tailrace. No anadromous fish enter Lake Chelan because natural barriers prevent their upstream migration in the Chelan River. Although

[14] "Occupancy unknown" is defined as areas where bull trout existed historically but their population status is currently unknown (USFWS 2002).

bull trout historically occurred in the subbasin, they have not been observed in the subbasin for several decades. Adult bull trout have occasionally been observed in the Chelan tailrace. A more detailed description of the Lake Chelan subbasin can be found in the Lake Chelan Subbasin Plan (2004).

1.3.4 Methow Subbasin

The Methow subbasin is located in north-central Washington and lies entirely within Okanogan County. The subbasin consists of about 1,167,764 acres. About 89% of the subbasin is in public ownership. The remaining 11% is privately owned and is primarily within the valley bottoms. The subbasin consists of ten primary watersheds: Early Winters Creek, Upper Methow, Lost, Middle Methow, Chewuch, Twisp, Beaver Creek, Gold Creek, Libby Creek, and the Lower Methow rivers (**Figure 1.4**). Spring Chinook, steelhead, and bull trout spawn and rear in the Methow subbasin. A more detailed description of the Methow subbasin can be found in the Methow Watershed Plan (2004) and Methow Subbasin Plan (2005).

1.3.5 Okanogan Subbasin

The Okanogan subbasin is the third largest of the Columbia River subbasins. Originating in British Columbia, the Okanogan subbasin enters the Columbia River between Wells Dam and Chief Joseph Dam. The subbasin consists of about 5,723,010 acres. About 74% of the subbasin is in British Columbia and 26% is in Washington State. The portion within Washington State lies entirely within Okanogan County. About 41% is in public ownership, 21% is in Tribal ownership, and the remaining 38% is privately owned and is primarily within the valley bottoms. There are three major watersheds within the subbasin in the State of Washington (Similkameen, Omak, and Salmon; **Figure 1.5**). The Similkameen River, located primarily in Canada, contributes 75% of the flow to the Okanogan River. Steelhead spawn and rear in the Okanogan subbasin. The tribes are in the process of introducing an experimental population of spring Chinook into the subbasin. Presence of bull trout in the Okanogan subbasin is unknown. A more detailed description of the Okanogan subbasin in the U.S. can be found in the Okanogan Watershed Plan (in development) and Okanogan Subbasin Plan (2005) and in Canada in Rae (2005).

1.3.6 Crab Creek Subbasin

The Crab Creek subbasin is located in central Washington within portions of Douglas, Lincoln, Adams, Grant, and Spokane counties (**Figure 1.1**). Considered one of the longest ephemeral streams in North America, Crab Creek flows southwest for about 140 miles, draining into the Columbia River near the town of Schwana, five miles downstream from Wanapum Dam. The subbasin consists of about 3,261,720 acres, most of which are used to raise crops. Anadromous salmonids, including steelhead and summer Chinook use only the lower portion of Crab Creek. These fish are known to occur as far upstream as Red Rock Coulee. Unlike historical conditions, the lower portion of Crab Creek currently has permanent stream flows, because of the Columbia Basin Project.

Although the ICBTRT identified steelhead in Crab Creek as an independent population within the Upper Columbia DPS, this plan will only generally address recovery of steelhead in Crab Creek. This decision is based on the following information.

- The decision by the ICBTRT to designate steelhead in Crab Creek as an independent population occurred too late for the Upper Columbia Salmon Recovery Board (UCSRB) to seek participation by the appropriate entities and stakeholders.
- There remains uncertainty about the genetics of steelhead and resident rainbow in Crab Creek.
- The contribution of steelhead to the historic steelhead-rainbow population is uncertain, but it is thought to be less than other steelhead-rainbow populations in the Interior Columbia Basin.
- There is uncertainty regarding water regimes and historic connectivity between the resident portion of the population in the upper watershed and the anadromous portion in the lower watershed.
- It is possible that the steelhead population was not viable historically because of environmental conditions (e.g., intermittent stream flows and high water temperatures).
- It is possible that steelhead in Crab Creek are dependent on resident forms and strays from other populations.

This plan recognizes that the Upper Columbia Steelhead DPS would be at a lower risk of extinction with a viable Crab Creek population. However, given the uncertainty of consistent stream flows and the assumption that the resident component of the population was the primary driver in the viability of the historic population, this plan concludes that the other populations of steelhead in the Upper Columbia were not and are not dependent upon the Crab Creek population to be a viable DPS. Therefore, recovery of the DPS can be achieved without the recovery of steelhead in Crab Creek.

1.4 Current Conditions

Current conditions in the Upper Columbia Basin are described in detail in watershed plans and subbasin plans. A summary of historic and current conditions of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin can be found in Section 2. What follows is a very brief summary of findings by NOAA Fisheries and the USFWS during their status reviews at the time of listing and more recent information contained in the watershed and subbasin plans.

1.4.1 Spring Chinook

At the time of listing (1999), spring Chinook in the Upper Columbia Basin ESU exhibited very low abundance (64 FR 14307). At that time, redd counts were declining severely and individual populations within the ESU were small, with none averaging more than 150 adults annually. Trends were mostly downward and a few local populations exhibited rates of decline exceeding 20% per year. Since 2000, adult spring Chinook numbers have increased in the Upper Columbia Basin (see Section 2).

1.4.2 Steelhead

At the time of the initial listing (1997 when the steelhead—then ESU, now DPS—was listed as ***endangered***), naturally produced steelhead in the Upper Columbia exhibited low abundance, both in absolute numbers and in relation to numbers of hatchery fish throughout the region (62 FR 43937). At that time, trends in natural steelhead abundance had declined or remained relatively constant in the ESU and natural adult replacement ratios were low (e.g., 0.25 and 0.30 for Entiat and Wenatchee steelhead, respectively), indicating that the populations were not self-sustaining. Since 2000, adult steelhead numbers have increased in the Upper Columbia Basin (see Section 2). In January 2006, the DPS was reclassified as ***threatened,*** primarily because the hatchery programs in the Upper Columbia Basin collectively mitigate the immediacy of extinction risk. However, in June 2007, a federal judge set aside NMFS' Hatchery Listing Policy, ruling that it was not valid to count the hatchery component of this steelhead DPS in determining their status under the Endangered Species Act. The decision reinstated the ***endangered*** status of the Upper Columbia Steelhead DPS. The naturally produced component of steelhead is at a high risk over the long term (100 years) because of low productivity.

1.4.3 Bull Trout

At the time of listing (1998), bull trout abundance in the Upper Columbia Basin was relatively low, with the exception of the Lake Wenatchee subpopulation, which was considered "strong" and increasing or stable (63 FR 31647). Most of the subpopulations exhibited "depressed" or unknown trends and consisted of a single life-history form. Bull trout are designated as "occupancy unknown" in the Okanogan and Lake Chelan subbasins. The USFWS Draft Recovery Plan indicates that bull trout in the Wenatchee, Entiat, and Methow core areas persist at low abundance. Bull trout populations from each of the core areas in the Upper Columbia basin are known to use the mainstem Columbia River (USFWS 2002). Currently the USFWS is developing a five-year review of the status of bull trout since listing.

1.4.4 Harvest

Restrictive fisheries currently prevent large numbers of Upper Columbia Basin spring Chinook, steelhead, and bull trout from being harvested. A federally established limit of 5% incidental take of naturally produced spring Chinook and steelhead in the Lower Columbia River was set in 2004 for non-tribal fisheries. Tribal fisheries in Zone 6 (a 130-mile treaty Indian commercial fishery between Bonneville Dam and McNary Dam) harvest an additional incidental take of 5-7%. The ESA listing precludes a directed fishery on naturally produced spring Chinook or steelhead in the Upper Columbia Basin. There is, however, a directed fishery on hatchery-origin steelhead, with the intent to remove excess hatchery steelhead. There is also a fishery on bull trout in the Lost River within the Methow Subbasin. This was established under a 4d Rule for sport fishing regulations (63 FR 31647). The UCSRB has a firm commitment to pursue and support all possible fishing opportunities (sport and tribal) in the Upper Columbia consistent with meeting ESA obligations for listed populations.

1.4.5 Hatcheries

There are 12 hatcheries or artificial production programs in the Upper Columbia Basin operated by the USFWS, Washington Department of Fish and Wildlife (WDFW) and the Confederated Tribes of the Colville Indian Reservation (Colville Tribes) that produce spring Chinook and steelhead (see Section 5.3). These programs annually release about four million spring Chinook in the Entiat, Methow, Okanogan, and Wenatchee subbasins and nearly one million steelhead in the Methow, Okanogan, and Wenatchee subbasins. At the time of listing, NOAA Fisheries included spring Chinook produced at state hatcheries in the ESU, excluding the Ringold Hatchery, because they were derived from endemic stock. They did not include spring Chinook produced at federal hatcheries (Winthrop, Entiat, and Leavenworth hatcheries)[15] in the ESU, because these fish are a mixture of Upper Columbia and Snake River populations. Starting in 2000, Winthrop National Fish Hatchery changed their production stock to be the listed component, while changes in operations at the other two federal facilities are being discussed. Currently, these two other hatcheries raise out-of-basin Carson spring Chinook stocks[16]. Spring Chinook produced at the Winthrop National Fish Hatchery are comprised of Methow Composite stock, which is included in the Upper Columbia ESU. Steelhead produced at the Wells and Eastbank hatcheries and the Winthrop National Fish Hatchery[17] are included in the Upper Columbia Basin steelhead DPS. NOAA Fisheries has concluded that locally derived fish produced in hatcheries are essential for recovery of both the ESU and DPS. Although there is no artificial propagation of bull trout in the Upper Columbia Basin, artificial propagation may be necessary for recovery of the Upper Columbia population (i.e., for Lake Chelan and Okanogan subbasins).

1.4.6 Hydropower

The existence and operation of the Columbia River Hydrosystem[18] presents passage obstacles to both adult and juvenile migrants. Populations of spring Chinook and steelhead in the Okanogan and Methow subbasins must pass through nine dams, populations in the Entiat subbasin must pass through eight dams, and those in the Wenatchee subbasin pass through seven dams. Upper Columbia migrant bull trout also move through the mainstem dams (Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells dams). Recently, Chelan and Douglas Public Utility Districts HCPs and Settlement Agreements (Grant Public Utility District) were signed by NOAA Fisheries, Washington Department of Fish and Wildlife (WDFW), USFWS, Colville Tribes, and the Yakama Nation. The primary goal of the HCPs and Settlement Agreement is to achieve "No Net Impact" (NNI)[19] of the Wells, Rocky Reach, and Rock Island hydroprojects on all anadromous salmonids. The major focus in implementation to achieve the goal of "no-net impact" is through mainstem Columbia River passage survival (adult and juvenile). "Unavoidable mortality" at the dams will be mitigated through artificial production and tributary enhancement. Cooney et al. (2001) estimated that survival would increase 16-25% for steelhead and 21-35% for spring Chinook with the implementation of the mid-Columbia HCPs (see Section 5.4). Federal projects also contribute to the loss of Upper Columbia spring Chinook,

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[15] Federal hatcheries were developed as part of the mitigation for Grand Coulee Dam (Bryant and Parkhurst 1950).

[16] Although the Entiat and Leavenworth hatcheries may move away from out-of-basin stocks, fish produced in these hatcheries are not listed and therefore do not currently contribute to the recovery of listed stocks.

[17] Although steelhead produced at the Winthrop National Fish Hatchery are listed, they are 100% fin-clipped and harvestable.

[18] The Columbia River Hydropower System downstream from Chief Joseph Dam consists of non-federal facilities owned and operated by Public Utility Districts (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids dams) and federal facilities operated by the Army Corps of Engineers and Bureau of Reclamation (McNary, The Dalles, John Day, and Bonneville dams).

[19] If met, this would equate to a net productivity equivalent to the productivity that could be attained if these projects did not exist.

steelhead, and bull trout. The 2004 Federal Columbia River Power System Biological Opinion, currently in remand, identifies actions to mitigate for the effects of federal hydropower facilities.

1.4.7 Habitat

Human activities acting in concert with natural occurrences (e.g., floods, drought, fires, wind, volcanism, ocean cycles, etc.) within the Upper Columbia Basin have impacted habitat conditions (habitat diversity and quantity, connectivity, and riparian function) and compromised ecological processes. Habitat within many of the upper reaches of most subbasins is in relatively pristine condition. Water quality and quantity have also been affected by land-use and management activities. Loss of large woody debris and floodplain connectivity have reduced overwinter habitat for salmon, steelhead, and bull trout in the larger rivers (i.e., Wenatchee, Entiat, Methow, and Okanogan rivers). Fish management, including introductions and persistence of non-native species continues to affect habitat in some locations (e.g., presence of brook trout in bull trout habitat).

The implementation of several programs and projects that regulate land-use activities on public and private lands have improved habitat conditions (but have not been quantified) over the last decade in the Upper Columbia Basin. Improved farm and ranch practices and numerous voluntary restoration and protection projects have occurred throughout the region. While difficult to quantify, the cumulative effects are important to salmon and trout recovery. Counties continue to protect and enhance critical areas, including salmon and trout habitat through the Growth Management Act and the Shoreline Management Act and their associated administrative codes and local land-use regulations. The Forest Service, the largest landowner in the Upper Columbia Basin, manages spawning and rearing streams through several programs including the Northwest Forest Plan and the PACFISH/INFISH[20] Strategy. WDFW and the Department of Natural Resources also own land in the Upper Columbia Basin and have modified and continue to modify land management practices to improve habitat conditions. The fact remains that habitat improvements are still needed to improve populations of listed species.

1.5 Desired Outcome

Defining recovery goals and criteria begins with a vision statement for the Upper Columbia recovery region. The vision statement provides the context within which recovery goals and criteria are set and strategies and actions are identified. The vision for the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan developed by the Upper Columbia Salmon Recovery Board (UCSRB) is:

> ***Develop and maintain a healthy ecosystem that contributes to the rebuilding of key fish populations by providing abundant, productive, and diverse populations of aquatic species that support the social, cultural, and economic well being of the communities both within and outside the recovery region.***

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[20] PACFISH is the Interim Strategy for Managing Anadromous Fish-producing Watersheds in Eastern Oregon and Washington, and Portions of California. INFISH is the Interim Strategy for Managing Fish-producing Watersheds in Eastern Oregon and Washington, Idaho, Western Montana, and Portions of Nevada.

This vision statement includes: (1) meeting recovery goals established for listed populations of spring Chinook, steelhead, and bull trout, (2) achieving sustainable harvests of key species within the recovery region and the Columbia River following recovery, (3) realizing these objectives while recognizing that agriculture and urban development are beneficial to the health of the human environment within the recovery region, (4) continue harvest (tribal and non-tribal) according to existing harvest management processes during the recovery period, and (5) implementing a road map of non-regulatory, voluntary measures that is not intended to override anyone's authority over habitat, hydropower, hatcheries, and harvest.

Recovery of listed populations is based on achieving recovery goals. Because listed anadromous fish species and bull trout have different life-history characteristics (see Section 2), this plan identified different recovery goals for the different species.

The specific goal for spring Chinook and steelhead is:

- **To secure long-term persistence of viable populations of naturally produced spring Chinook and steelhead distributed across their native range.**

Recovery of the spring Chinook ESU will require the recovery of the Wenatchee, Entiat, and Methow populations (ICBTRT 2005). Recovery of the Upper Columbia steelhead DPS will require the recovery of the Wenatchee, Entiat, Methow, and Okanogan populations, but not the Crab Creek population (ICBTRT 2005).

The specific goal for bull trout is:

- **To secure long-term persistence of self-sustaining, complex, interacting groups of bull trout distributed across the native range of the species.**

In summary, recovery requires reducing threats to the long-term persistence of fish populations, maintaining widely distributed and connected fish populations across diverse habitats of their native ranges, and preserving genetic diversity and life-history characteristics (components of VSP). To be consistent with the vision and goals of this plan, listed populations, ESU, and DPS must meet specific criteria associated with each VSP parameter and the goals and objectives identified in the USFWS Draft Bull Trout Recovery Plan. Specific criteria associated with each parameter are identified in Section 4.

This plan recognizes the importance of providing valid metrics for Upper Columbia tributary productivity. It is the policy of the UCSRB to emphasize juvenile salmonid productivity within each tributary as the primary indicator of habitat restoration success for each basin in the Upper Columbia. In addition to evaluating productivity for the entire life cycle (spawner to spawner ratios), this plan looks to identify a measure that focuses on effects of tributary habitat on juvenile salmonid survival, without the confounding effects of mortality outside the subbasin (commonly referred to as out-of-subbasin effects[21]). This will be accomplished primarily by evaluating "smolts per spawner" and/or "smolts per redd." Although this plan does not identify specific recovery criteria based on these factors, this will allow a consistent approach to evaluate

[21] Out-of-subbasin effects (OOSE) include mortality associated with federally owned hydropower projects in the lower Columbia River, mortality in the estuary and ocean, and mortality associated with fisheries (directed and incidental harvest) (Toole et al. 2005).

the level of success for restoration and recovery actions in the Upper Columbia and the quality of habitat in tributaries.

1.5.1 Abundance

This plan will identify actions that if implemented should result in population abundances (or effective population sizes) large enough to have a high probability of surviving environmental variation observed in the past and expected in the future, to be resilient to environmental and anthropogenic disturbances, to maintain genetic diversity, and to support or provide ecosystem functions. In this plan, abundance is expressed as the 12-year geometric mean[22] abundance of naturally produced adult fish on spawning grounds. The 12-year period falls within the recommended guidance of the ICBTRT (8-20 years) and represents two to three generations for spring Chinook and steelhead. The geometric mean provides a better indicator of central tendency than the arithmetic mean, which is often skewed by uncommon large and small returns. For spring Chinook and bull trout, abundance will be based on redd counts. Because of a lack of long-term redd counts, abundance for steelhead will be based on inter-dam counts and radio-telemetry studies.

1.5.2 Productivity

This plan envisions that naturally produced, Upper Columbia spring Chinook and steelhead will support net replacement rates of 1:1 or higher, expressed as the 12-year geometric mean recruits per spawner.[23] This means that on average one or more offspring returns for every fish that spawns. Populations with growth rates greater than one are resilient to negative environmental conditions and can quickly rebound from low abundances. Thus, productivity rates at relatively low numbers of spawners (<500-2000 adults) will need to be considerably higher than one to allow the populations to rapidly return to abundance target levels. It is assumed that all historic populations had high productivity when populations were well below carrying capacity. This plan combines abundance and productivity together using the viability curve concept provided by the ICBTRT (see Section 4).

As noted above, this plan recognizes the importance of juvenile productivity within tributaries as an indicator of habitat restoration success. This will be accomplished by evaluating “smolts per spawner” or “smolts per redd.” Although this plan does not identify recovery criteria based on smolts per redd, it does allow for a consistent approach to evaluating restoration actions in tributaries.

Because of a lack of information on the population dynamics of bull trout in the Upper Columbia Basin, productivity will be estimated from temporal trends in redd counts. Recovery is expressed as a stable or increasing trend over a twelve-year period.

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[22] Because population growth is a multiplicative process, the geometric mean gives a better estimate of average population growth than does the arithmetic mean (Gotelli and Ellison 2004). The geometric mean is calculated as the antilogarithm of the arithmetic mean of the logarithms of the data.

[23] The use of smolts/redd would result in a greater precision in the estimate of productivity. This increased precision may affect the timeframe to determine recovery.

1.5.3 Spatial Structure

This plan will identify actions that if implemented should vastly improve widespread or complex spatial structures of naturally produced spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. This will be accomplished by not destroying habitat (or their functions) at rates faster than they are created or restored, by not artificially increasing or decreasing natural rates of straying, by maintaining suitable habitats (major and minor spawning areas; see Section 4) even if they contain no ESA-listed species, by maintaining and increasing source populations[24], and by addressing man-made (artificial) barriers to fish migration and movement.

1.5.4 Diversity

Actions implemented under this plan will maintain both phenotypic (morphology, behavior, and life-history traits) and genotypic (genetic) within-population diversity. This will be accomplished by carefully managing and/or minimizing factors (e.g., introduction of non-native species, artificial propagation, hydropower reservoir effects, man-made barriers, and harvest pressures) that alter variation in traits such as run timing, age structure, size, fecundity, morphology, behavior, and molecular genetic characteristics.

In some cases, the mixing of hatchery fish (or excessive numbers of out-of-basin stocks) with naturally produced fish on spawning grounds can actually decrease genetic diversity within a population (Hallerman 2003). According to the ICBTRT (2005a), diversity of naturally produced populations, ESUs and DPSs can decrease because of hatchery adaptations of domestication, losses of genetic variability through supportive breeding, and erosion of natural population structure through homogenization. Recovery actions should be designed to reduce domestication and homogenization, and prevent gene flow rates greater than natural levels.

Importantly, historic (pre-development) diversity cannot be measured for any populations within the Upper Columbia Basin. Because spatial structure is the physical process that drives diversity, the two (spatial structure and diversity) are very difficult to separate (ICBTRT 2004). Therefore, following the recommendations of the ICBTRT (2004b), this plan will evaluate spatial structure and diversity together.

1.6 Overall Strategy to Recovery

This plan is based on the best empirical information currently available and professional judgment. In order to keep this plan simple and succinct, other documents have been referenced, and tangential or irrelevant information reduced to a minimum. For those interested in detailed information, please refer to the reference section of this document for a list of source materials. This plan is based on the information in those documents and some expanded analyses (e.g., EDT analysis for the Wenatchee Subbasin). The logic path used to develop the plan is shown in **Figure 1.6** and discussed briefly below.

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[24] This will follow the concept of metapopulation theory. A metapopulation is an interacting network of local populations with varying frequencies of migration and gene flow among them. Multiple local populations distributed and interconnected throughout a watershed provide a mechanism for spreading risk from stochastic events (USFWS 2002).

The process of developing this plan began with identification of priority or focal species—spring Chinook, steelhead, and bull trout—based on ESA listings. Next, "independent" and "core" populations were identified based on the work of the ICBTRT (2003) and USFWS (2002) and the spatial structure of each population was then divided into geographic assessment units. Current and historical conditions of each population were described, with emphasis on VSP parameters (described above and in Section 4), and limiting factors that led to the decline of each population in the Upper Columbia Basin were identified. Appropriate actions were then selected that addressed limiting factors or threats[25] to listed fish populations in the Upper Columbia Basin.

Recommended actions addressed the most important limiting (primary) factor(s) and threats within each assessment unit and population. For each H (Harvest, Hatcheries, Hydropower, and Habitat), actions were linked to specific limiting factors. Using All H Analyzer, empirical and derived data, public input, and professional judgment, an assessment was completed of the cumulative effects of recovery actions integrated across the Hs and across populations. Importantly, actions will be coordinated with local stakeholders and jurisdictions that determined the feasibility of the recommended actions.

The process for selecting actions differed for each of the four Hs. Harvest actions were selected based on the best available science and from frameworks of legal authorities (e.g., ***U.S. v Oregon***). Hatchery actions were selected based on the best available science and from existing hatchery and genetic management plans (HGMPs), Biological Opinions, and the HCPs. Hydropower actions were selected primarily from existing HCPs and other processes (e.g., 2004 Federal Columbia River Power System Biological Opinion). Habitat actions were selected from other plans (e.g., NPCC subbasin plans, watershed plans, Wy-Kan-Ush-Mi Wa-Kish-Wit [Spirit of the Salmon], The Tribal Fish Recovery Plan and the USFWS Bull Trout Draft Recovery Plan), EDT analysis, public input, and the best available science. Habitat actions identified in this plan will be refined based on input from local landowners and land managers. The last step in the process compared the benefits in VSP parameters associated with the recommended actions to the recovery criteria outlined by ICBTRT (2004b) and the USFWS (2002).

It is important to note that the list of recommended actions identified in this plan represent the first step of recovery implementation. The beneficial actions identified in this plan are believed to represent a sound approach based on available information and tools, and they address the range of known threats. However, uncertainty exists for many actions because of insufficient information.[26] This plan does not assume risk-free management actions with perfectly predictable results. Therefore, this plan will monitor or assess the outcomes of different recovery actions. The plan is "adaptive" in the sense that it will take this information, combined with cost estimates, and re-evaluate priorities and reasonable actions. The intent is to use the information as a means of selecting what actions will be sufficient for recovery. This plan is a "living

[25] Limiting factors and threats represent two different things. Limiting factors represent the environmental condition (e.g., warm water temperatures) that negatively affects the abundance, productivity, and survival of a population. Threats, on the other hand, represent the actions that cause limiting factors (e.g., removal of stream side vegetation, which reduces stream shading and increases stream temperatures).
[26] Uncertainty of outcomes arises from a lack of knowledge about the ecological and social processes that affect fish as well as from stochastic (random) events.

document" that will be updated as new information becomes available. All significant modifications, especially those that change the regulatory environment or propose additional costs or restrictions on private property and water rights, shall be submitted for public review and comment by local governments and stakeholders, and approved by the UCSRB before implementation.

1.7 Relationship to Other Recovery Activities

There are a number of conservation and watershed planning efforts in varying stages of development and implementation that directly or indirectly protect or improve the viability of naturally produced spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. These efforts each have unique attributes, but may not meet all statutory requirements for the contents of recovery plans, as described in section 4(f)(1)(B) of the ESA including:

> (i) a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species; (ii) objective, measurable criteria, which, when met, would result in a determination, in accordance with the provisions of this section, that the species be removed from the list; and (iii) estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal.

Efforts currently being developed or implemented in the Upper Columbia Basin are identified in Section 7.

1.8 Coordination and Public Involvement

The three counties in the Upper Columbia Salmon Recovery Board developed similar public participation plans that are customized for the unique qualities of each county. These plans are designed to allow the community to learn about, and participate in, the processes to discuss documents and activities and elicit feedback from stakeholders regarding the design and implementation of the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. Methods for soliciting public involvement may include, but are not limited to, public meetings, open houses, workshops, informational sessions, brochures, advisory committees, use of websites, and of course the documents themselves. Each county shares resources, ideas, and some of the regional commonalities to provide a coordinated and cost-effective means of public participation.

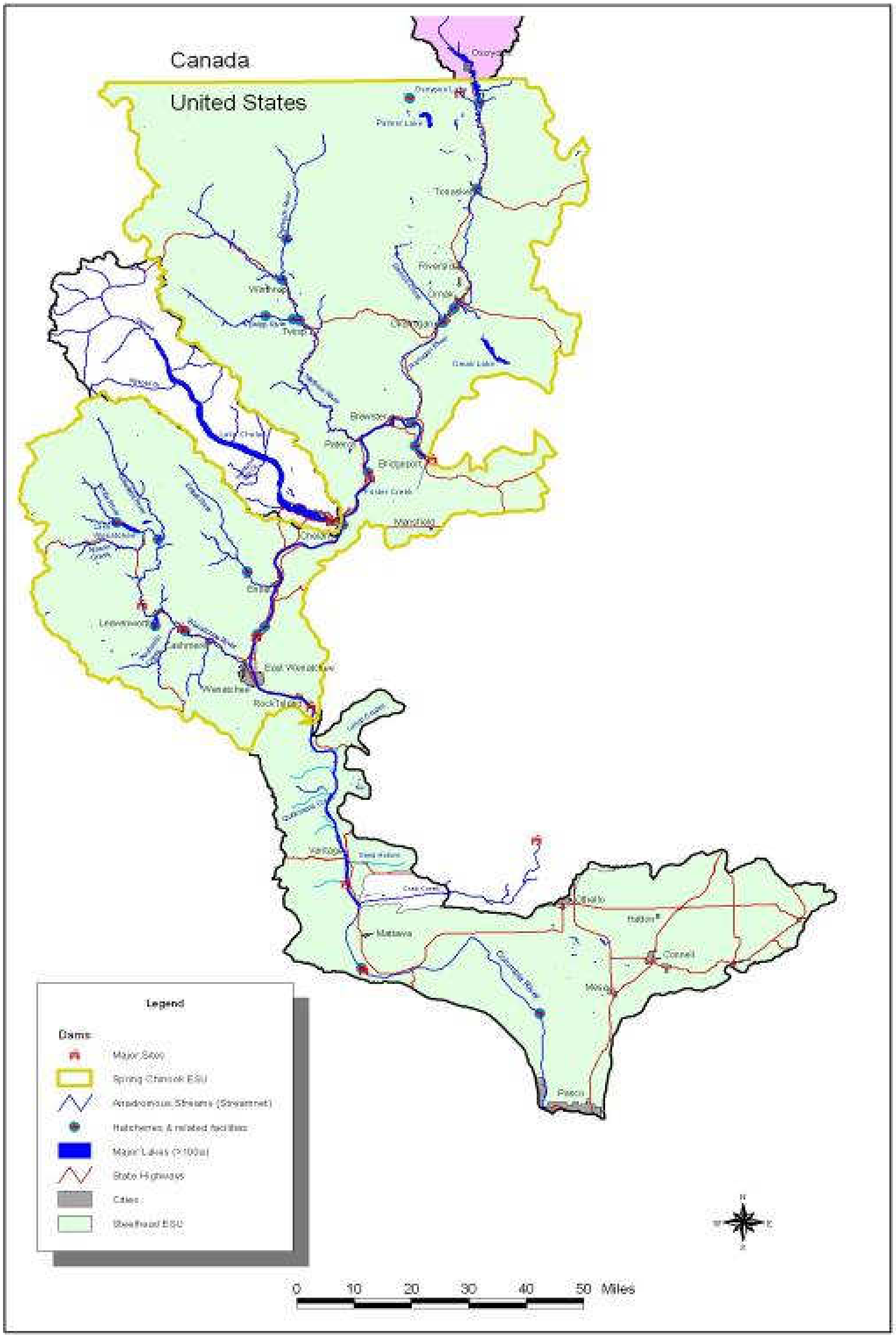

Figure 1.1 Subbasins and major tributaries within the Upper Columbia River Subbasin

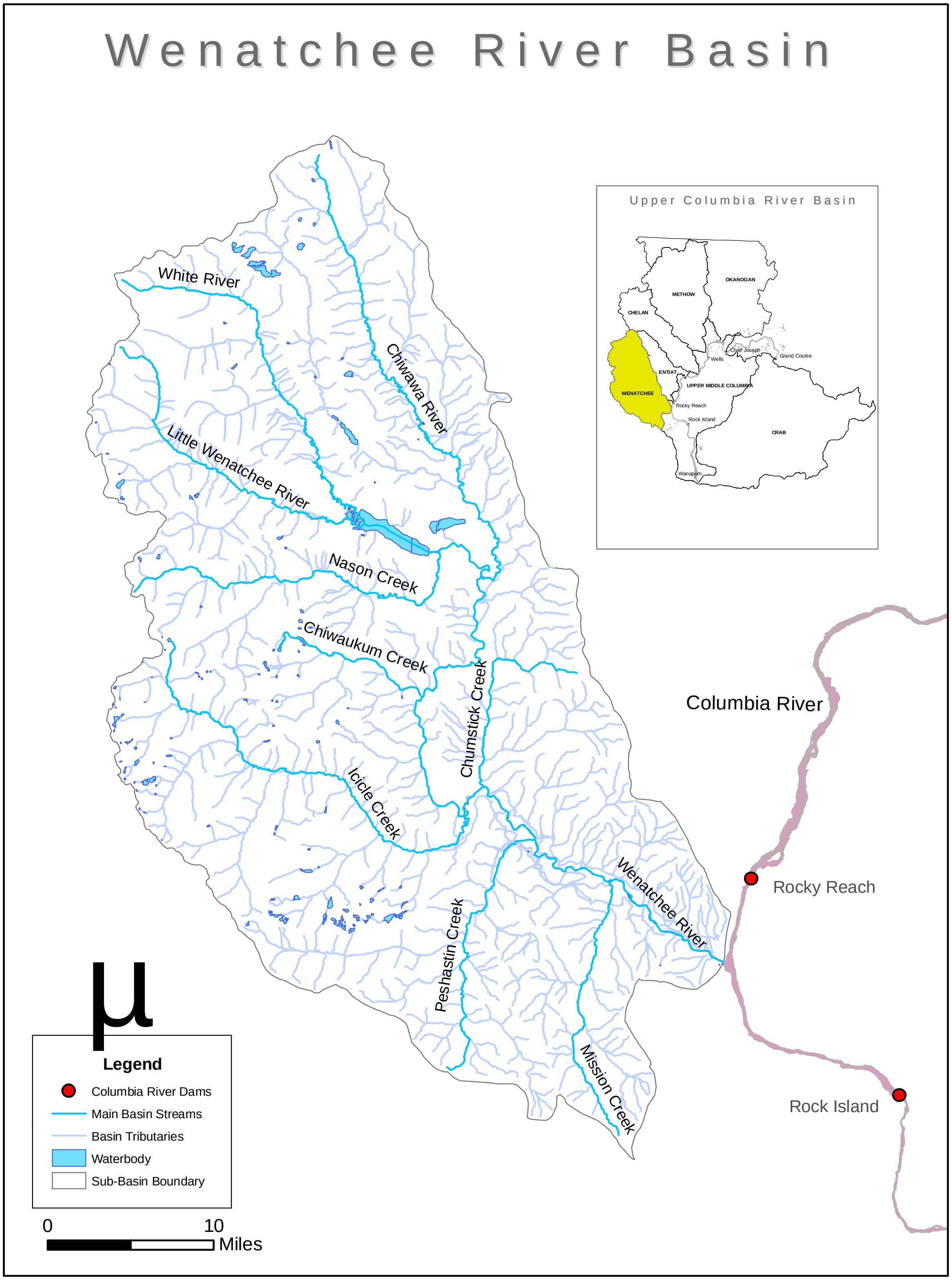

Figure 1.2 Major tributaries within the Wenatchee subbasin

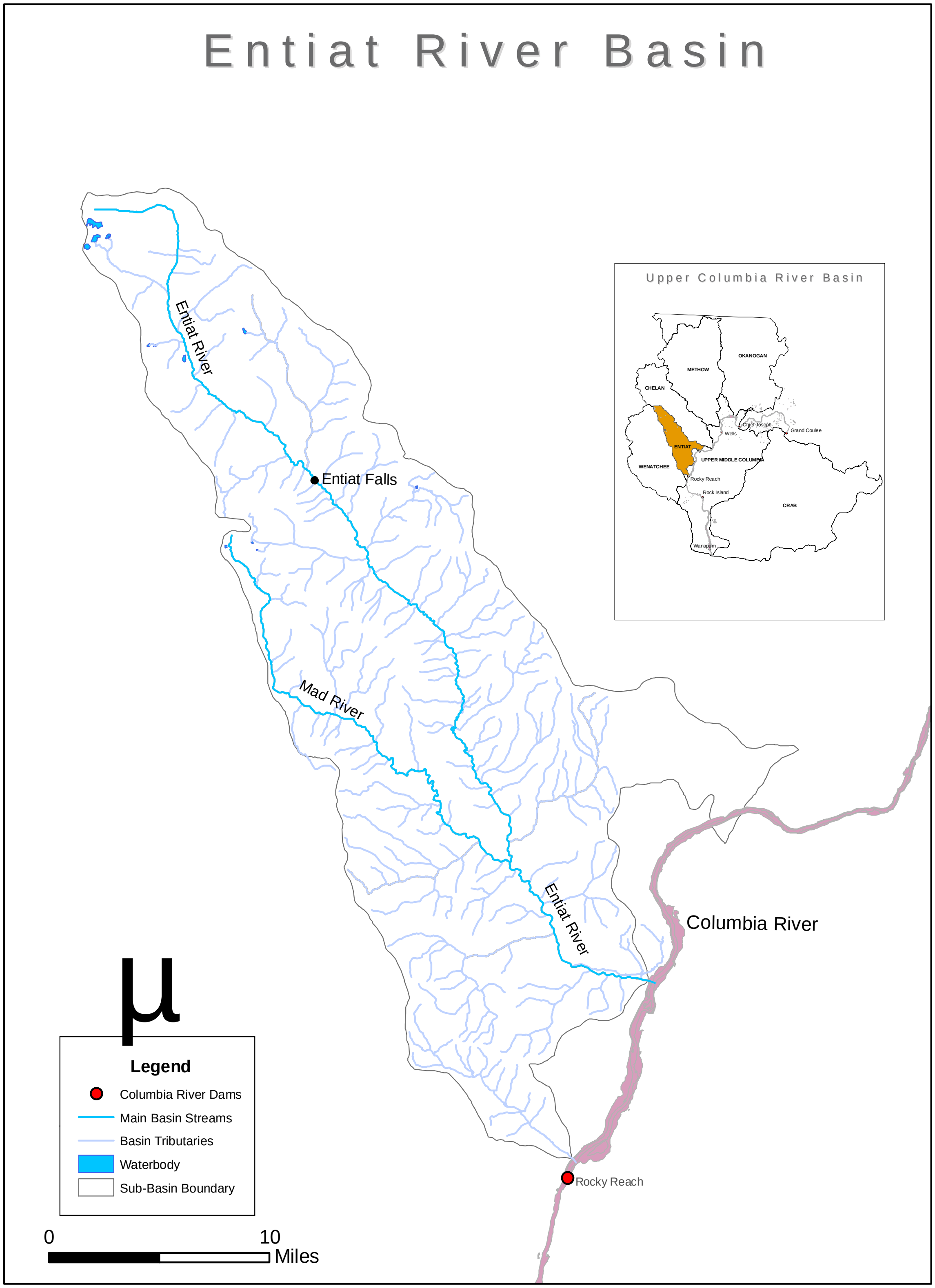

Figure 1.3 Major tributaries within the Entiat subbasin

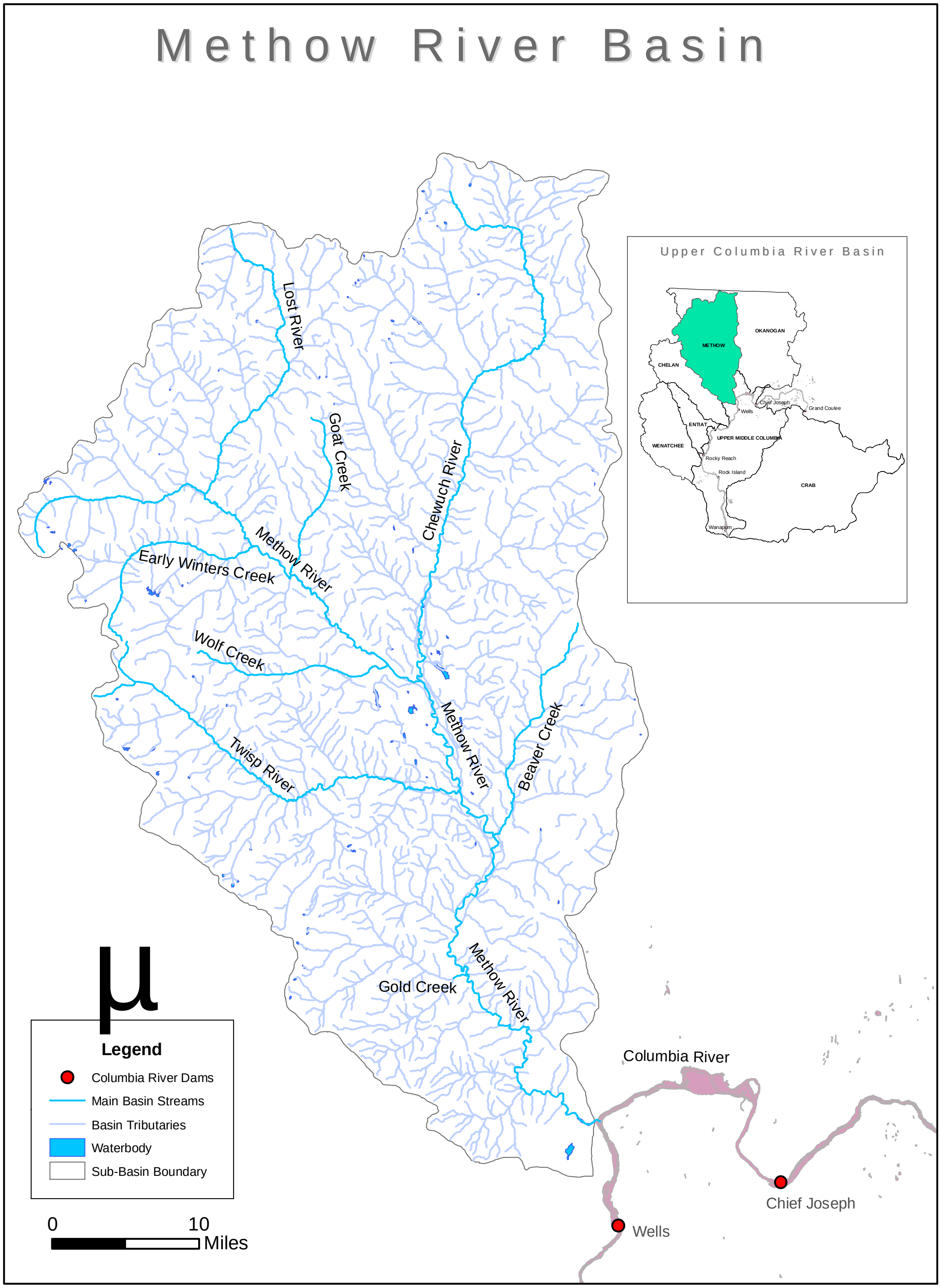

Figure 1.4 Major tributaries within the Methow subbasin

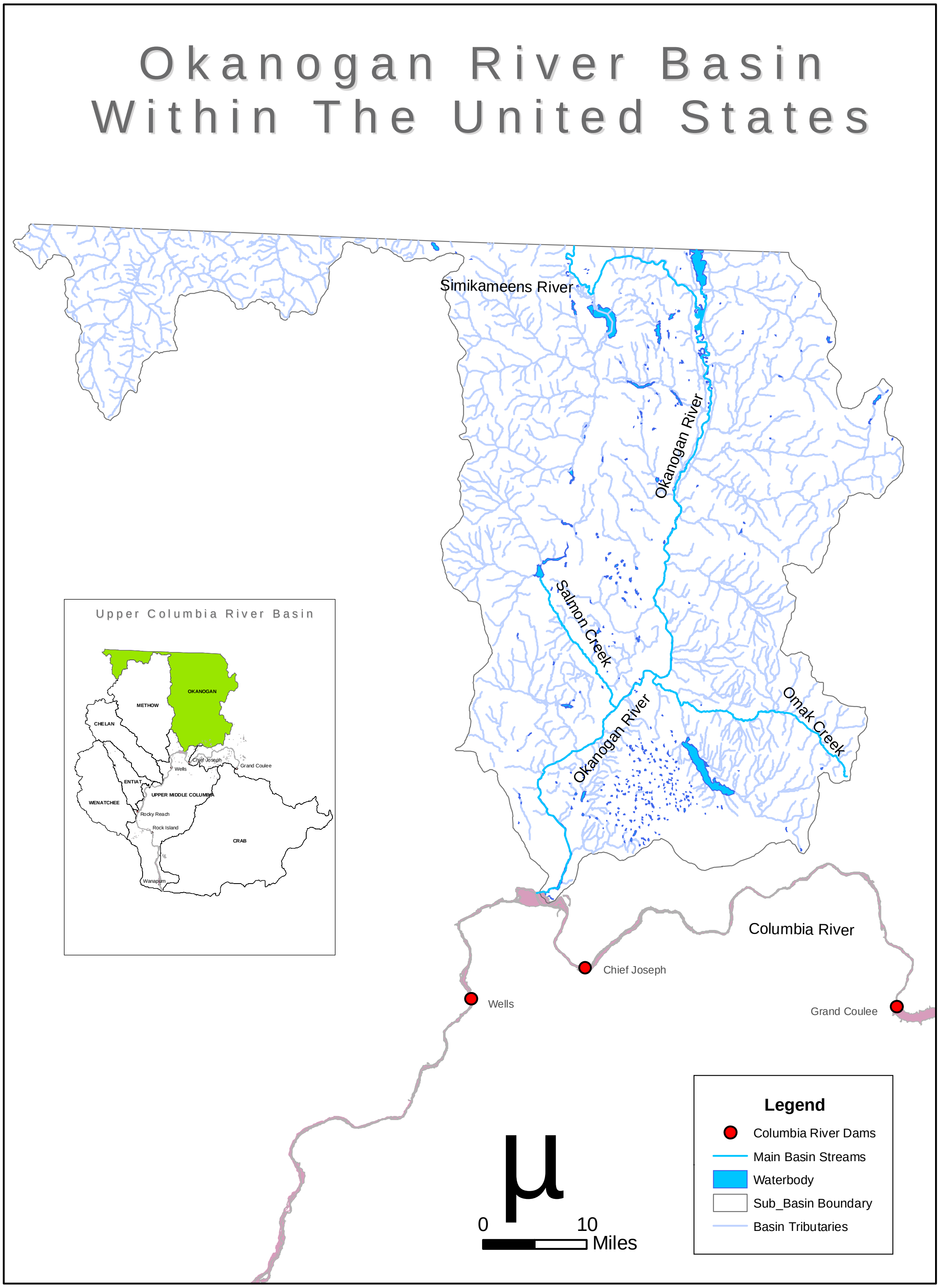

Figure 1.5 Major tributaries within the Okanogan subbasin

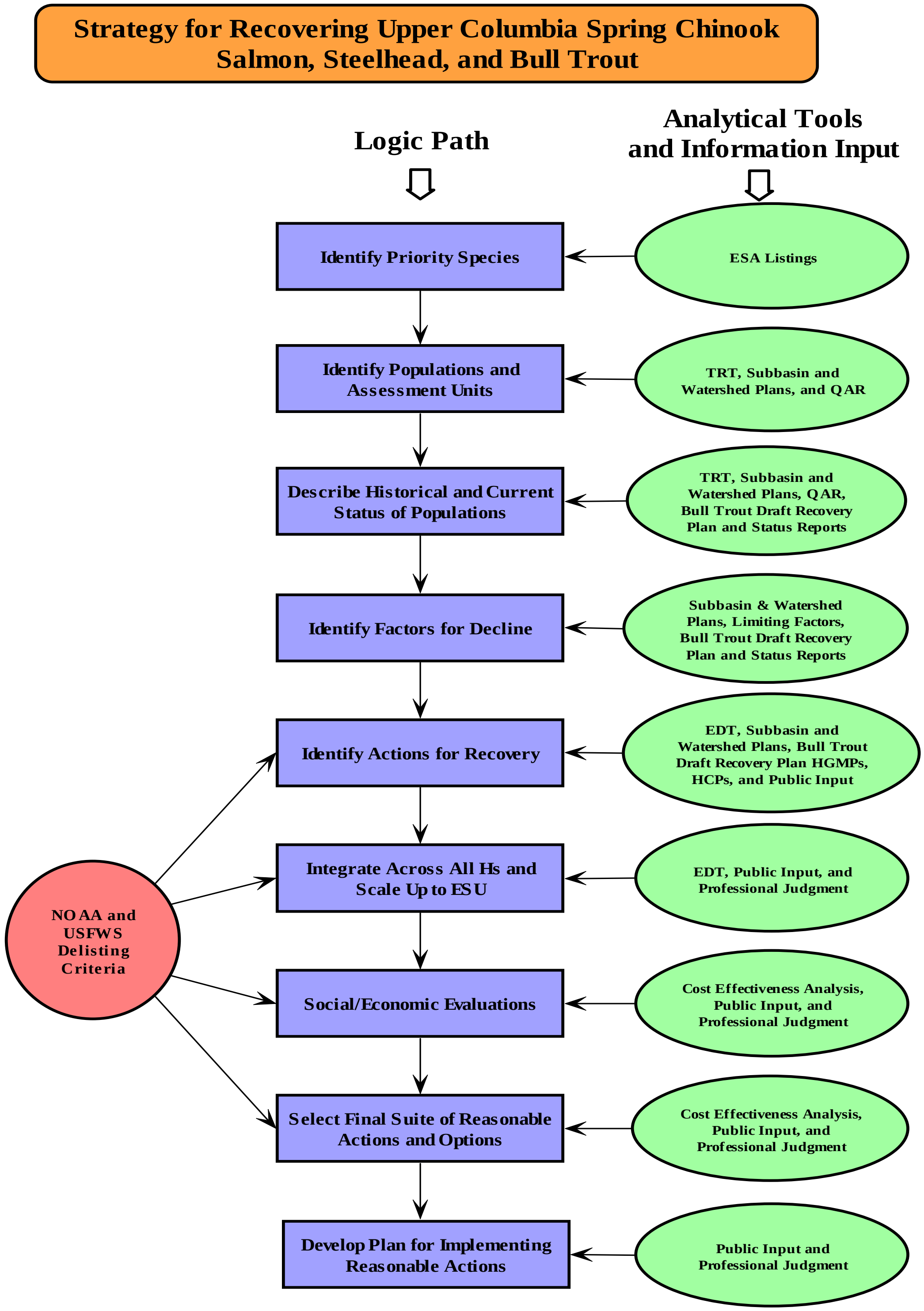

Figure 1.6 Logic path, analytical tools, and information sources used to develop the Upper Columbia Basin recovery plan

2 Species Status

2.1 Identification of Priority Species
2.2 Community Structure
2.3 Population Characteristics and Life Histories

This section briefly describes the community structure, current and historical population structure and life histories of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. Data are available and presented in this section going back as far as 1960. Because variability in climate and ocean conditions can have very long cycle times, it is difficult to assess long-term variability in salmonid population structure in the Upper Columbia with high precision, given the limited number of years for which data are available. This section describes current and historic population structure by addressing the VSP parameters, abundance, productivity, spatial structure, and diversity, for each species and population. Readers can find a more detailed discussion on species status in the Upper Columbia Basin NPCC subbasin plans, watershed plans, and the USFWS Bull Trout Draft Recovery Plan.

2.1 Identification of Priority Species

2.1.1 Method for Selecting Priority Species

This recovery plan focuses on spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. These species were selected based on their status under the ESA. Upper Columbia spring Chinook and steelhead are listed as endangered under the ESA, while bull trout are listed as threatened.

2.1.2 General Life Histories of Priority Species

Spring Chinook

Spring Chinook in the Upper Columbia Basin have similar life-history characteristics to spring Chinook runs originating in the Snake River system (Chapman et al. 1995). Adults begin returning from the ocean in the early spring, with the run into the Columbia River peaking in mid-May. Spring Chinook enter the Upper Columbia tributaries from April through July. After migration, they hold in freshwater tributaries until spawning occurs in the late summer, peaking in mid to late August. Juvenile spring Chinook spend a year in freshwater before migrating to salt water in the spring of their second year of life. Most Upper Columbia spring Chinook return as adults after two or three years in the ocean. Some precocious males, or jacks, return after one winter at sea. A few other males mature sexually in freshwater without migrating to the sea. However, four and five year old fish that have spent two and three years at sea, respectively, dominate the run. Fecundity ranges from 4,200 to 5,900 eggs, depending on the age and size of the female.

Steelhead

The life-history pattern of steelhead in the Upper Columbia Basin is complex (Chapman et al. 1994). Adults return to the Columbia River in the late summer and early fall. Unlike spring Chinook, most steelhead do not move upstream quickly to tributary spawning streams (K. Williams, personal communication). A portion of the returning run overwinters in the mainstem reservoirs, passing over the Upper Columbia River dams in April and May of the following year. Spawning occurs in the late spring of the calendar year following entry into the river. Currently, and for the past 20+ years, most steelhead spawning in the wild are hatchery fish. Juvenile steelhead generally spend one to three years rearing in freshwater before migrating to the ocean, but have been documented spending as many as seven years in freshwater before migrating (Peven 1990; Mullan et al. 1992). Most adult steelhead return to the Upper Columbia after one or two years at sea. Steelhead in the Upper Columbia have a relatively high fecundity, averaging between 5,300 and 6,000 eggs (Chapman et al. 1994).

Steelhead can residualize (lose the ability to smolt) in tributaries and never migrate to sea, thereby becoming resident rainbow trout. Conversely, progeny of resident rainbow trout can migrate to the sea and thereby become steelhead. Despite the apparent reproductive exchange between resident and anadromous ***O. mykiss***, the two life forms remain separated physically, physiologically, ecologically, and behaviorally (70 FR 67130). Steelhead differ from resident rainbow physically in adult size and fecundity, physiologically by undergoing smoltification, ecologically in their preferred prey and principal predators, and behaviorally in their migratory strategy. Given these differences, NMFS (70 FR 67130) proposed that the anadromous steelhead populations are discrete from the resident rainbow trout populations. Therefore, this plan only addresses the recovery of anadromous steelhead. Resident rainbow trout are not included in the recovery of steelhead.

Bull Trout

Bull trout in the Upper Columbia Basin exhibit both resident and migratory life-history strategies (USFWS 2002). Some of the populations also exhibit such strategies as every year and every other year spawning as well as offsetting migration periods. Bull trout migrate to spawning areas as well as rearing/feeding areas (Kelly-Ringel, USFWS, personal communication). Migrations may occur between core areas and within the Columbia River (BioAnalysts 2002, 2003). Resident bull trout complete their entire life cycle in the tributary stream in which they spawn and rear. Migratory bull trout spawn in tributary streams where juvenile fish rear one to four years before migrating to either a lake (adfluvial form) or river (fluvial form). Migrating bull trout have been observed within spawning tributaries as early as the end of June, while spawning occurs in mid-September to late October/early November. Resident and migratory forms may be found together, and either form may give rise to offspring exhibiting either resident or migratory behavior (Rieman and McIntyre 1993).

The size and age of bull trout at maturity depends upon life-history strategy. Resident fish tend to be smaller than migratory fish at maturity and produce fewer eggs. BioAnalysts (2002) compared a sample of resident and fluvial fish from the Methow subbasin and found that the fluvial fish were two to three times larger than resident fish of the same age. Bull trout usually reach sexual maturity in four to seven years and may live longer than 12 years (Fraley and Shepard 1989; Williams and Mullan 1992). Repeat-spawning frequency and post-spawning mortality are not well documented in the Upper Columbia Basin.

Bull trout distribution is limited by water temperature above 15°C, which may partially explain their patchy distribution within a watershed (Fraley and Shepard 1989; Rieman and McIntyre 1995; Dunham et al. 2003). Bull trout spawn in the fall typically in cold, clean, low-gradient streams with loose, clean gravel (Fraley and Shepard 1989; Rieman and McIntyre 1993). Bull trout at all life stages are associated with complex forms of cover including large woody debris, undercut banks, boulders, and pools (Fraley and Shepard 1989; Watson and Hillman 1997; Rich et al. 2003). Bull trout exhibit some differences from salmon in that they are in the habitat in the Upper Columbia Basin year round and can remain in the gravel for up to 220 or more days (USFWS 1998). They are susceptible to competition by other non-native char such as brook trout and lake trout.

2.1.3 Other Species of Importance

Other species of importance within the Upper Columbia Basin include summer Chinook, sockeye salmon (***O. nerka***), Pacific lamprey (***Lampetra tridentata***), white sturgeon (***Acipenser transmontanus***), and westslope cutthroat trout (***O. clarki lewisi***). Currently, Pacific lamprey and westslope cutthroat are designated as species of concern (USFWS 2005). NOAA Fisheries reviewed the status of summer Chinook and sockeye salmon and concluded that their relative abundances did not warrant listing and that they do not appear to be endangered in the future (59 FR 48855; 63 FR 11751). NOAA Fisheries did suggest, however, that the two populations of sockeye within the Upper Columbia Basin should be monitored because of their potential to become threatened (64 FR 14528). The USFWS reviewed the status of westslope cutthroat and determined that they were not warranted for listing (68 FR 46989); however, they are still designated as species of concern. Recovery actions identified under this plan are expected to benefit all these species, as well as spring Chinook, steelhead, and bull trout.

2.2 Community Structure

Spring Chinook, steelhead, and bull trout share the aquatic environment with several other fish species in the Upper Columbia Basin. Available information (summarized in Hillman 2000; Duke Engineering 2001; subbasin plans 2005) indicates that about 41 species of fish occur within the Upper Columbia Basin (from the mouth of the Yakima River upstream to Chief Joseph Dam) (Appendix A). This is an underestimate because several species of cottids (sculpins)[27] live there. Of the fishes in the basin, 15 are cold-water species, 18 are cool-water species, and 8 are warm-water species. Most of the cold-water species are native to the area; only five were introduced (brown trout (***Salmo trutta***), brook trout (***S. fontinalis***), lake whitefish (***Coregonus clupeaformis***), lake trout (***S, namaycush***), and Atlantic salmon (***S. salar***)). Four of the 18 cool-water species are introduced (pumpkinseed (***Lepomis gibbosus***), walleye (***Stizostedion vitreum***), yellow perch (***Perca flavescens***), and smallmouth bass (***Micropterus dolomieu***)), while all warm-water species in the Upper Columbia Basin are introduced.

Anadromous species within the upper basin include spring and summer Chinook salmon, coho salmon (***O. kisutch***), sockeye salmon, steelhead, and Pacific lamprey. White sturgeon, which may have been anadromous historically, are present as a resident population. These fish are rarely detected migrating upstream at Upper Columbia River dams.

About half of the resident species in the upper basin are piscivorous (eat fish) (Appendix A). Ten cold-water species, seven cool-water species, and five warm-water species are known to eat fish.

[27] At least three species of sculpins have been identified in the Upper Columbia Basin. They include Prickly sculpin (***Cottus asper***), torrent sculpin (***C. rhotheus***), and shorthead sculpin (***C. confuses***).

About 59% of these piscivores are exotics. Before the introduction of exotic species, northern pikeminnow (***Ptychocheilus oregonensis***), sculpin (***Cottus*** spp.), white sturgeon, bull trout[28], rainbow trout, cutthroat trout, and burbot (***Lota lota***) were the primary piscivores in the region (Li et al. 1987; Poe et al. 1994). Presently, burbot are rare in the upper basin (Dell et al. 1975; Burley and Poe 1994) and probably have little effect on the abundance of ESA-listed species in the region. The status of white sturgeon in the Upper Columbia Basin is mostly unknown, although their numbers appear to be quite low (DeVore et al. 2000).

2.3 Population Characteristics and Life Histories

2.3.1 Levels of Population Structure

Before describing the population structure of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin, it is important to define the different levels of population structure. Various terms have been used to define levels of population structure or ecological types. Brannon et al. (2002) stated that population structure is defined by the life-history strategies that have evolved to maximize fitness under varying environmental conditions within geographic ranges. Identified below are the levels of population structure used in this plan.

Distinct Population Segment

As amended in 1978, the ESA allows listing of distinct population segments (DPSs) of vertebrates as well as named species and subspecies. However, the ESA did not provide specific guidance on what constituted a DPS, and thus created some ambiguity (Platts et al. 1993). Because of this ambiguity, NOAA Fisheries and the USFWS created a policy in 1996 to recognize and define DPSs in relation to ESA listings (61 FR 4722). Because NOAA Fisheries had established a policy in 1991 that defined species under the ESA (56 FR 58612) for Pacific salmonids, it maintained its delineation for the ESA that a population segment would be a DPS if it were an ESU.

The USFWS requested that NMFS consider departing from use of the ESU Policy and evaluate ***O. mykiss*** population risk status through the DPS Policy. The major difference between the two policies is that under the ESU Policy, one delineation of whether a population is distinct is that they are "reproductively isolated" from other population segments. Within the DPS Policy, there only needs to be "marked separation" to satisfy population distinctiveness.

Evolutionarily Significant Units

Waples (1991) defined ESUs as the determining population structure for delineating whether a "species" should be listed under the ESA. An ESU is a population (or group of populations) that (1) is reproductively isolated from other related population units and (2) represents an important component in the evolutionary legacy of the species. ESUs may contain multiple populations that

[28] The recovery of ESA-listed species that prey on other ESA-listed species (e.g., bull trout that prey on juvenile spring Chinook and steelhead) may appear to be counter productive. However, the recovery levels established in this plan for bull trout will not prevent the recovery of the other listed species. The three ESA-listed species evolved together in the Columbia Basin and their niches are sufficiently segregated to prevent one species from driving the others to extinction. Large bull trout are generalists and will not prey exclusively on spring Chinook and steelhead.

are connected by some degree of migration, and hence may have broad geographic areas, transcending political borders. Determining exactly what the evolutionary significance of a population is may be difficult.

Independent Populations

Following McElhany et al. (2000), the ICBTRT (2003) defined independent populations, as:

> …a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season. For our purposes, not interbreeding to a 'substantial degree' means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame.

Core Areas

The USFWS (2002) defined a core area to be the closest approximation of a biologically functioning unit that reflects the metapopulation structure of bull trout as described by Dunham and Rieman (1999). That is, within the metapopulation or core areas, local populations are expected to function as one demographic unit. Thus, a core area may consist of one or more local populations. Rieman and Allendorf (2001) have suggested that between 5 and 10 populations are necessary for a bull trout metapopulation to function effectively. Core areas are not necessarily synonymous with independent populations. Bull trout may be grouped so that they share genetic characteristics as well as management jurisdictions (USFWS 2002). The USFWS is in the process of collecting and analyzing genetic data from all three core areas in the Upper Columbia. The results may clarify the extent of interbreeding between local populations and core areas.

As noted earlier, this recovery plan will focus on actions that, if implemented, should improve the VSP parameters of ESA-listed species at the "population" and "core area" level.

2.3.2 Historic Population Characteristics

Chapman (1986) stated that large runs of Chinook and sockeye, as well as smaller runs of coho, steelhead, and chum (***O. keta***) historically (pre-development) returned to the Columbia River. Chum used the lower Columbia River. Based on the peak commercial catch of fish in the lower Columbia River and other factors, such as habitat capacity, Chapman (1986) estimated pre-development run sizes of about 588,000 spring Chinook, 3.7 million summer Chinook, 554,000 steelhead, over 2.6 million sockeye, 618,000 coho, and 748,000 chum for the entire Columbia Basin. Spring Chinook, summer Chinook, steelhead, sockeye, and coho were relatively abundant in Upper Columbia River tributary streams before extensive resource exploitation (e.g., harvest, logging, mining, dams and diversions, and agriculture) in the 1860s. By the 1880s, the expanding salmon canning industry and the rapid growth of the commercial fisheries in the lower Columbia River had heavily depleted the mid- and upper-Columbia River spring and summer Chinook runs (McDonald 1895), and eventually steelhead, sockeye, and coho (Mullan 1984, 1986, 1987; Mullan et al. 1992). It was estimated that at the time Grand Coulee Dam was built that 85 to 90%

of the fish counted at Rock Island Dam from 1933-1937 originated from spawning areas upstream from Grand Coulee Dam (Calkins et al. 1939).

Upper Columbia Spring Chinook

The Upper Columbia spring Chinook ESU includes three extant populations (Wenatchee, Entiat, and Methow), as well as one extinct population in the Okanogan subbasin (ICBTRT 2003).

Wenatchee

Abundance

Mullan et al. (1992) estimated that the total historic Chinook run to the Wenatchee was about 41,000 fish. It is unknown what fraction of this estimate represents spring Chinook.

Productivity

While there are no quantitative data on historic productivity in the Wenatchee subbasin, it is a basic assumption of defining a viable population that the population growth rate was greater than 1.0, meaning that on average more than one offspring returned for every fish that spawned (ICBTRT 2004b). Populations with growth rates greater than 1.0 are resilient to negative environmental conditions and can quickly rebound from low abundances. The ICBTRT (2005a) assumed that all historic populations had productivities of 1.0 or greater when populations were well below carrying capacity, and, even at high densities, expressed long-term mean returns-per-spawner greater than 1.0.

Spatial structure and diversity

Fulton (1968) described the distribution of spring Chinook in the Wenatchee subbasin as most of the main river; portions of the Chiwawa, Little Wenatchee, and White rivers, and Nason, Icicle, and Peshastin creeks. Salmonscape (http://wdfw.wa.gov/mapping/salmonscape/) and the intrinsic productivity analysis (NWFSC 2004) suggests that spring Chinook also occurred in Mission and Chiwaukum creeks.

Entiat

Abundance

Mullan et al. (1992) estimated that the total Chinook run in the Entiat was 3,400 historically. Because summer Chinook probably did not use the Entiat (Fish and Hanavan 1948; Mullan 1987), the entire estimate probably represents the historic abundance of spring Chinook.

Productivity

While there are no quantitative data on historic productivity in the Entiat subbasin, it is a basic assumption of defining a viable population that the population growth rate was greater than 1.0, meaning that on average more than one offspring returned for every fish that spawned (ICBTRT 2004b).

Spatial structure and diversity

Fulton (1968) identified most of the mainstem Entiat as habitat for spring Chinook, noting that steep gradients of tributaries prevented salmon use there. Salmonscape and the intrinsic productivity analysis (NWFSC 2004) indicate that spring Chinook also used the lower five miles of the Mad River.

Methow

Abundance

The historic estimate for Chinook within the Methow subbasin was estimated by Mullan et al. (1992) as just over 24,000 fish. It is unclear whether summer Chinook occupied the Methow River (Mullan 1987), thus a large fraction of this estimate was probably spring Chinook.

Productivity

While there are no quantitative data on historic productivity in the Methow subbasin, it is a basic assumption of defining a viable population that the population growth rate was greater than 1.0, meaning that on average more than one offspring returned for every fish that spawned (ICBTRT 2004b).

Spatial structure and diversity

Fulton (1968) described the historic distribution of spring Chinook in the Methow subbasin as the mainstem Methow River and larger tributaries, including the lower portion of the Twisp River and the mainstream of the Chewuch River to a point 52 km upstream from the mouth. Fulton (1968) also mentioned that the Chewuch River had the largest spring Chinook run of any single stream upstream from Rocky Reach Dam. Salmonscape also includes Gold, Wolf, and Early Winters creeks and the Lost River as potential historic habitat for spring Chinook.

Okanogan

Abundance

Although spring Chinook occurred in the Okanogan subbasin historically (Vedan 2002), there are no estimates of their abundance in the subbasin. Their abundance was likely small, however, because of a lack of suitable habitat in the Okanogan subbasin.[29] An assumption by the ICBTRT (2003) is that all historic populations consisted of at least 500 fish. Therefore, this plan assumes that the Okanogan had the capacity for at least 500 spring Chinook.[30]

Productivity

While there are no quantitative data on historic productivity in the Okanogan subbasin, it is a basic assumption of defining a viable population that the population growth rate was greater than 1.0, meaning that on average more than one offspring returned for every fish that spawned (ICBTRT 2004b).

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[29] Williams (personal communication) speculates that spring Chinook spawned and reared only in the Canadian portion of the Okanogan subbasin.

[30] The minimum abundance criterion of 500 fish per population is based on theoretical and limited empirical information provided by the ICBTRT. The use of this criterion in the Upper Columbia Basin has not been demonstrated with empirical data. Therefore, this criterion may change as more information is gathered (through monitoring) within the Upper Columbia Basin.

Spatial structure and diversity

Craig and Suomela (1941) contain affidavits that indicate spring Chinook historically used Salmon Creek and possibly Omak Creek. In 1936, spring Chinook were observed in the Okanogan River upstream from Lake Osoyoos by Canadian biologists (Gartrell 1936).[31] Vedan (2002) contains information suggesting that spring Chinook historically entered Okanogan Lake and ascended upstream past Okanogan Falls. Spring Chinook in the Okanogan subbasin may have exhibited a lake-rearing life-history trait (S. Smith, personal communication).

There is no evidence that spring Chinook (or steelhead) used the Similkameen River upstream from falls that lay at the present site of Enloe Dam (Chapman et al. 1995). Cox and Russell (1942) state:

> From testimony of a Mr. McGrath at Nighthawk, who had been in that country over 40 years, we learned that before any power dam was built (Enloe Dam), the 15' to 20' natural falls already mentioned prevented salmon ascending any farther. He had often fished the river at Nighthawk but had never heard of a salmon being seen or caught above the natural falls. He stated that the Indians came in to fish at these falls each summer...Therefore, we conclude that this power dam did not interfere with any salmon runs...

Accounts from Native American oral tradition (i.e., the story of coyote) suggest that salmon never passed upstream of the falls, and the Native people of the Similkameen valley never sought to have fish passage there, further confirming that anadromous fish never passed the falls (Vedan 2002). The lack of anadromous fish upstream from the falls is further supported by the work of Copp (1998), who researched the plant and animal resources of the Similkameen drainage and concluded that anadromous fish did not occur in the Canadian portion of the Similkameen drainage.

Upper Columbia Steelhead

The Upper Columbia steelhead DPS includes five extant populations (Wenatchee, Entiat, Methow, Okanogan, and Crab Creek[32]) (ICBTRT 2003). Calkins et al. (1939) estimated that 85-90% of the Chinook, steelhead, and sockeye counted at Rock Island Dam in the 1930s were destined for areas upstream of Grand Coulee Dam. Other estimates are available from Scholz et al. (1985).

Small Tributaries of the Columbia River

Howell et al. (1985) noted that several smaller tributaries of the Columbia River, such as Squilchuck, Stemilt, Colockum, Tarpiscan, Brushy, Tekison, Foster, and Quilomene creeks,

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[31] Gartrell (1936) contains the only reference that we found to spawning by spring-run Chinook salmon in the main Okanogan River. We regard this information cautiously.

[32] As noted in the Section 1, this plan does not address specific recovery actions for the Crab Creek steelhead population.

potentially produced steelhead, but never in great numbers.[33] Steelhead probably also used Crab Creek (see Upper Middle Mainstem Subbasin Plan 2004 and Crab Creek Subbasin Plan 2005).

Wenatchee

Abundance

Mullan et al. (1992; their table 5) estimated that the steelhead run to the Wenatchee was about 7,300 fish.

Productivity

While there are no quantitative data on historic productivity in the Wenatchee subbasin, it is a basic assumption of defining a viable population that the population growth rate was greater than 1.0, meaning that on average more than one offspring returned for every fish that spawned (ICBTRT 2004b).

Spatial structure and diversity

Fulton (1970) identified lower Mission, Peshastin, Icicle, Chiwaukum, Chumstick, Beaver, and Nason creeks, and the Wenatchee, Chiwawa, Little Wenatchee, and White rivers as historical steelhead habitat. Salmonscape also included Derby Creek, and numerous small tributaries, within the above-mentioned watersheds as historical steelhead habitat.

Entiat

Abundance

Mullan et al. (1992; their table 5) estimated that the historic run of steelhead in the Entiat was 500 fish.

Productivity

While there are no quantitative data on historic productivity in the Entiat subbasin, it is a basic assumption of defining a viable population that the population growth rate was greater than 1.0, meaning that on average more than one offspring returned for every fish that spawned (ICBTRT 2004b).

Spatial structure and diversity

Fulton (1970) listed the mainstem Entiat and Mad rivers as historical steelhead streams. Salmonscape also includes the lower portions of Mud, Potato, Stormy, Tillicum, and Roaring creeks.

Methow

Abundance

Mullan et al. (1992; their table 5) estimated that the historic run of steelhead in the Methow was about 3,600 fish.

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[33] Steelhead in small tributaries downstream from the Wenatchee River are part of the Wenatchee steelhead population (ICBTRT 2004).

Productivity

While there are no quantitative data on historic productivity in the Methow subbasin, it is a basic assumption of defining a viable population that the population growth rate was greater than 1.0, meaning that on average more than one offspring returned for every fish that spawned (ICBTRT 2004b).

Spatial structure and diversity

Fulton (1970) lists the mainstem, Twisp, and Chewuch rivers, and lower Beaver Creek as historic steelhead habitat. WDF/WDW (1992) also listed Gold, Wolf, and Early Winters creeks, and the Lost River, as historic steelhead habitat. Salmonscape includes Little Bridge, Lake, Eightmile, South Fork Gold, Libby, Smith Canyon, Black Canyon, Bear, and Goat creeks as historical steelhead streams. Williams (personal communication) noted that steelhead also occur in the lower portions of Cub, Falls, Twentymile, Boulder, South, Crater, War, Andrews, West and East Forks of Buttermilk, Rattlesnake, Reynolds, Robinson, Eureka, and Monument creeks.

Okanogan

Abundance

Numbers of steelhead are not available for the Okanogan subbasin. Mullan et al. (1992) indicated that steelhead in the Okanogan subbasin were not abundant, and that Salmon Creek and the lower Similkameen River (downstream of Enloe Falls) were the most probable steelhead producing streams in the subbasin. An assumption by the ICBTRT (2003) is that all historic populations consisted of at least 500 fish.

Productivity

While there are no quantitative data on historic productivity in the Okanogan subbasin, it is a basic assumption of defining a viable population that the population growth rate was greater than 1.0, meaning that on average more than one offspring returned for every fish that spawned (ICBTRT 2004b).

Spatial structure and diversity

Fulton (1970) identified Omak and Salmon creeks as steelhead-producing streams, and the upper Similkameen, but that is questioned based on uncertainty of fish being able to ascend Enloe Falls before construction of Enloe Dam at that site (Chapman et al. 1994). Steelhead also ascended the Okanogan River into Canada (Vedan 2002).

Upper Columbia Bull Trout

The Upper Columbia bull trout recovery area includes three core areas (Wenatchee, Entiat, and Methow), the mainstem Columbia River, and two areas designated as “unknown occupancy” (Lake Chelan and Okanogan) (USFWS 2002).

Wenatchee

Abundance

There are no estimates of the historical abundance of bull trout in the Wenatchee subbasin.

Productivity

There are no data available to describe historical production of bull trout in the Wenatchee subbasin. It is assumed that bull trout historically maintained stable trends over time.

Spatial structure and diversity

It is believed that bull trout historically occurred throughout most drainages within the Wenatchee subbasin. They occurred within the Chiwawa, White, Little Wenatchee, Nason, Chiwaukum, Icicle, and Peshastin Creek drainages and in the Wenatchee River (USFWS 2002). There is no evidence that they occurred in the Chumstick or Mission Creek drainages. All life-history forms (resident, fluvial, and adfluvial) occurred in the Wenatchee subbasin historically (USFWS 2002; K. Williams, personal communication).

Entiat

Abundance

There are no estimates of the historical abundance of bull trout in the Entiat subbasin.

Productivity

There are no data available to describe historical production of bull trout in the Entiat subbasin. It is assumed that bull trout historically maintained stable trends over time.

Spatial structure and diversity

Bull trout historically occurred in the Entiat River upstream to Entiat Falls[34] and in the Mad River. Both resident and fluvial forms of bull trout probably occurred in the Entiat subbasin (USFWS 2002).

Methow

Abundance

There are no estimates of the historical abundance of bull trout in the Methow subbasin.

Productivity

There are no data available to describe historical production of bull trout in the Methow subbasin. It is assumed that bull trout historically maintained stable trends over time.

Spatial structure and diversity

Historically, bull trout occurred throughout most of the subbasin including Gold, Wolf, Early Winters, Trout, Beaver, Lake, Buttermilk, and Goat creeks, and the Twisp, Chewuch, Upper Methow, and Lost rivers (USFWS 2002). Based on habitat conditions, they may have also occurred in Little Bridge, Eightmile, Libby, Smith Canyon, Black Canyon, and Bear creeks. Both resident, fluvial, and adfluvial forms of bull trout occurred in the Methow Basin historically (USFWS 2002).

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[34] It is unknown if bull trout existed upstream from the falls. Currently, numerous non-native brook trout exist upstream from the falls.

Lake Chelan

Abundance

There are no estimates of the historical abundance of bull trout in the Lake Chelan subbasin.

Productivity

There are no data available to describe historical production of bull trout in the Lake Chelan subbasin. It is assumed that bull trout historically maintained stable trends over time.

Spatial structure and diversity

It is quite likely that resident life-history types as well as known adfluvial bull trout occurred historically in the Lake Chelan subbasin. Based on summaries in Brown (1984), adfluvial bull trout historically occurred in the Stehekin drainage and its major tributaries, Bridge, Flat, Agnes, Blackberry, and Company creeks. Other streams that may have supported bull trout at least in their deltas included Mitchell, Gold, Grade, Safety Harbor, Prince, Fish, Four Mile, Railroad, Deep Harbor, Big, Little Big, Twentyfive Mile, and First creeks (Brown 1984). The adfluvial component has not been observed since 1951 (Brown 1984) and the status of the resident form is unknown. Fluvial bull trout have been observed in the lower Chelan River (BioAnalysts, Inc. 2003).

Okanogan

Abundance

There are no estimates of the historical abundance of bull trout in the Okanogan subbasin.

Productivity

There are no data available to describe historical production of bull trout in the Okanogan subbasin. It is assumed that bull trout historically maintained stable trends over time.

Spatial structure and diversity

The historical distribution of bull trout in the Okanogan subbasin is not well known. It is believed that they occurred in at least Salmon and Loup Loup creeks (Fisher and Wolf 2002; Williams, personal communication) and in the Okanogan River.[35] It is possible that both resident and migrant (fluvial and adfluvial) forms occurred in the Okanogan subbasin.

2.3.3 Current Population Characteristics

This section describes the current abundance, productivity, spatial structure, and diversity of each population within the Upper Columbia Basin. Some VSP parameters, such as returns per spawner, are not available for recent years because not all fish from recent spawning

[35] The Omak Chronicle (Vol. 4, No. 25, Nov. 7, 1913) reports P. Umbrite landing some “extra nice big Dolly Varden trout” from the bridge in Omak. The Chronicle also reports that O. E. Bisher landed “two fine specimens of the Dolly Varden trout” from the Okanogan River. An angler reported capturing an adult bull trout near the town of Mallot in early spring 2003 (C. Fisher, personal communication, Colville Tribes).

escapements have returned from the ocean. This section relies heavily on the information provided by NOAA Fisheries (T. Cooney, NOAA Fisheries, personal communication) and the Bull Trout Draft Recovery Plan (USFWS 2002).

This plan reports the 12-year geometric mean for abundance and productivity as the appropriate interval to measure current status of spring Chinook and steelhead. The twelve-year period falls within the recommended guidance of the ICBTRT (8-20 years) and represents two to three generations for spring Chinook and steelhead. The geometric mean provides a better indicator of central tendency than the arithmetic mean, which is often skewed by uncommon large and small returns. The geometric mean for productivity (returns per spawner) must be back calculated, based on run reconstruction, for five years previous to the most recent abundance estimate.

Upper Columbia Spring Chinook

Current (from 1960 to present) abundance and production for each population of spring Chinook in the Upper Columbia Basin were based on spawner estimates (spawning escapements) and returns per spawner (spawner to spawner return rates), respectively. Spawning escapement was based on numbers of redds, expanded by an estimated fish/redd ratio of 2.2 fish/redd.[36] Returns from each brood-year spawning escapement were estimated by run reconstruction based on age composition. Year-specific age-composition estimates were obtained from spawning ground surveys, tributary fishery samples, or corresponding hatchery returns. Returns from each spawning escapement were estimated by summing up the subsequent returns from each spawning escapement across the appropriate range of future years. See NOAA Fisheries website http://www.nwr.noaa.gov/Salmon-Recovery-Planning/index.cfm for a description of analytical methods, assumptions, and results.

Wenatchee

Abundance

From 1960 to 2003, abundance of age 3+ spring Chinook in the Wenatchee subbasin ranged from 51 to 6,718 fish (**Table 2.1**, **Figure 2.1**).[37] During this period the 12-year geometric mean of spawners in the subbasin ranged from 383 to 3,449 adults (**Table 2.1**, **Figure 2.1**). The geometric mean at the time of listing (1999) was 417 spawners.

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[36] The number of adult fish per redd is calculated at the number of adult fish returning to the spawning grounds divided by the number of redds that they construct. The reason that the number per redd is often greater than 2 (one male and one female) is because some of the adults that return to the spawning grounds do not spawn (i.e., they die before spawning). Thus, the ratio provides an estimate of pre-spawn mortality. The ratio is useful in estimating total spawning escapement if only the number of redds is known (total escapement = ratio x number of redds).

[37] Out-of-basin Carson stock spawn primarily in Icicle Creek. Fish that spawned in Icicle Creek were not included in the abundance estimates. Any out-of-basin fish that spawned in other areas within the subbasin were included in the estimates, because there was no way to remove them from the returns.

Productivity

During the period 1960 to 1999, returns per spawner for spring Chinook in the Wenatchee subbasin ranged from 0.06 to 4.59 (**Table 2.1**,**Figure 2.1**). The 12-year geometric mean of returns per spawner during this period ranged from 0.31 to 1.19 (**Table 2.1**, **Figure 2.1**). The geometric mean at the time of listing (1999) was 0.74.

WDFW has estimated the freshwater productivity (smolts per redd) of spring Chinook in the Wenatchee subbasin for the period 1992-2002 (WDFW, unpublished data). Numbers of smolts and redds were estimated at three different spatial scales: Wenatchee subbasin, area upstream from Tumwater Canyon, and the Chiwawa basin. The geometric mean for the Chiwawa was 364 smolts/redd. The geometric mean for the area upstream of Tumwater Canyon was 250 smolts/redd, while the geometric mean for the total Wenatchee subbasin was 197 smolts/redd (**Figure 2.2**). These estimates are not independent, because estimates for the Chiwawa basin are included in the estimate for the area upstream from Tumwater Canyon, which are included in the total Wenatchee subbasin estimate. Habitat downstream of Tumwater Canyon is less productive than the upper watershed.

Spatial structure and diversity

Spring Chinook currently spawn and rear in the upper main Wenatchee River upstream from the mouth of the Chiwawa River, overlapping with summer Chinook in that area (Peven 1994). The primary spawning areas of spring Chinook in the Wenatchee subbasin include Nason Creek and the Chiwawa, Little Wenatchee, and White rivers (**Figure 2.3**). During high abundance years, such as 2001, spring Chinook also spawn in Chiwaukum Creek. Beginning in 2001, the USFWS and the Yakama Nation (YN) planted Leavenworth (Carson stock) adult spring Chinook into Peshastin Creek. The outplanting was part of a study to determine if hatchery adult plants could be used to restore the spring Chinook population in Peshastin Creek. The last outplanting is scheduled for 2005. These fish are not part of the ESU. Spawning in Icicle Creek is from out-of-basin (non-listed) spring Chinook released from the Leavenworth National Fish Hatchery (Chapman et al. 1995).

After 1850, the diversity of the Wenatchee population was likely reduced because of hatchery programs, commercial harvest, and habitat degradation. The diversity of the Wenatchee population was also reduced in part because of the Grand Coulee Fish Maintenance Project (GCFMP) and hydropower development. The continued release of out-of-basin spring Chinook from the Leavenworth National Fish Hatchery may have some effect on the diversity of spring Chinook in the Wenatchee subbasin. Tagging studies indicate that stray rates are generally low (<1%) (Pastor 2004).[38] Recently, based on expanded carcass recoveries from spawning ground surveys (2001-2004), the straying from Leavenworth National Fish Hatchery and other out-of-basin facilities has accounted for 3-27% of the natural spawner composition upstream from Tumwater Canyon despite the low percentage of the Leavenworth National Fish Hatchery population historically detected straying.

The Wenatchee spring Chinook population is currently distributed across four interconnected spawning watersheds (Chiwawa, Nason, White, and Little Wenatchee), which increases

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[38] It should be noted that efforts to recover tags on spawning grounds varied prior to 1993.

population diversity. However, compared to the historical condition, the current distribution of naturally produced spring Chinook in the Wenatchee subbasin is reduced because of the loss of naturally produced fish spawning in tributaries downstream from Tumwater Canyon.

When considering the 9 factors (and 12 metrics identified in ICBTRT 2005a and shown in Appendix B) that determine diversity and spatial structure, the Wenatchee spring Chinook population is currently considered to be at a high risk of extinction (**Table 2.2**). Two metrics that kept the population from achieving a low risk rating were: (1) Chiwawa hatchery fish (local origin stock) have averaged more than 30% of total spawners and more than 10% of the spawner composition in other non-target major spawning areas and (2) there is a high proportion (3-27%) of out-of-basin hatchery produced fish from the Leavenworth National Fish Hatchery on spawning grounds (Appendix B). Based only on abundance and productivity, the Wenatchee spring Chinook population is not viable and has a greater than 25% chance of extinction in 100 years (**Figure 2.4**). Combining all VSP parameters together (using method described in ICBTRT 2005a), the Wenatchee spring Chinook population is not currently viable and has a high risk of extinction (**Table 2.3**).[39]

Entiat

Abundance

From 1960 to 2003, abundance of age 3+ spring Chinook in the Entiat subbasin ranged from 18 to 1,197 fish (**Table 2.1**; **Figure 2.5**).[40] During this period the 12-year geometric mean of spawners in the subbasin ranged from 90 to 490 adults (**Table 2.1**; **Figure 2.5**). The geometric mean at the time of listing (1999) was 92 spawners.

Productivity

During the period 1960 to 1999, returns per spawner for spring Chinook in the Entiat subbasin ranged from 0.16 to 4.72 (**Table 2.1**; **Figure 2.5**). The 12-year geometric mean of returns per spawner during this period ranged from 0.41 to 1.12 (**Table 2.1**; **Figure 2.5**). The geometric mean at the time of listing (1999) was 0.76. Presently there are too few data to estimate tributary productivity (smolts/redd) for Entiat spring Chinook. When more data are available, this plan will estimate tributary productivity of Entiat spring Chinook.

Spatial structure and diversity

Hamstreet and Carie (2003) described the current spawning distribution for spring Chinook in the Entiat subbasin as the Entiat River (river mile 16.2 to 28.9) and the Mad River (river mile 1.5-5.0) (**Figure 2.6**). The original diversity of the Entiat population was reduced because of hatchery practices, past harvest, hydropower development including dams that blocked passage

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[39] Risk of extinction based on the four VSP parameters was based on guidance from the ICBTRT (2005a).

[40] Out-of-basin, hatchery produced spring Chinook return to the Entiat subbasin. Some of these fish contribute to the spawning population. There is presently no way to remove these spawners from the estimated returns. The degree of introgression of out-of-basin stock with naturally produced fish remains questionable.

into the Entiat River, habitat degradation, and releases of out-of-basin stock[41] from the Entiat National Fish Hatchery.[42] The Entiat River has a history of impoundments from the late 1880s through the first half of the 1900s. The U.S. Bureau of Fisheries surveys in the 1930s noted that three dams without fish passage remained on the Entiat River (Bryant and Parkhurst 1950). Because of its small size (relative to other subbasins in the Upper Columbia) and natural barriers, the Entiat subbasin offers limited numbers of suitable habitat areas for spring Chinook. Therefore, this population would naturally be at a higher risk than other populations in the Upper Columbia because of the naturally limited size of spawning and rearing habitat.

When considering the 9 factors (and 12 metrics identified in ICBTRT 2005 and shown in Appendix B) that determine diversity and spatial structure, the Entiat spring Chinook population is currently considered to be at a high risk of extinction (**Table 2.2**). Two factors contributed to this high-risk rating and both were related to the Entiat National Fish Hatchery propagating out-of-basin spring Chinook (Appendix B). Based only on abundance and productivity, the Entiat spring Chinook population is not viable and has a greater than 25% chance of extinction in 100 years (**Figure 2.7**). Combining all VSP parameters together (using method described in ICBTRT 2005), the Entiat spring Chinook population is not currently viable and has a high risk of extinction (**Table 2.3**).

Methow

Abundance

From 1960 to 2003, abundance of age 3+ spring Chinook in the Methow subbasin ranged from 33 to 9,904 adults (**Table 2.1**; **Figure 2.8**).[43] During this period the 12-year geometric mean of spawners in the subbasin ranged from 480 to 2,231 adults (**Table 2.1**; **Figure 2.8**). The geometric mean at the time of listing (1999) was 480 spawners.

Productivity

During the period 1960 to 1999[44], returns per spawner for spring Chinook in the Methow subbasin ranged from 0.05 to 5.21 (**Table 2.1**; **Figure 2.8**). The 12-year geometric mean of returns per spawner during this period ranged from 0.41 to 1.02 (**Table 2.1**; **Figure 2.8**). The geometric mean at the time of listing (1999) was 0.51. Presently there are too few data to

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[41] The fish at the Entiat National Fish Hatchery at the time of listing originated from "Carson stock," which were derived from the collection of co-mingled spring Chinook trapped annually between 1955 and 1964 at Bonneville Dam. Recent genetic information indicates that these fish are a mix of Upper Columbia and Snake River populations (Pastor 2004).

[42] Tagging studies indicate that about 6% of the spring Chinook produced at the Entiat National Fish Hatchery stray into other areas (Pastor 2004). During low natural return years, strays of out-of-basin fish can make up a substantial proportion of naturally spawning fish (Hamstreet and Carie 2003).

[43] Estimates of spawners, returns, and their geometric means of Methow spring Chinook do not include fish returning in 1996 or 1998 because all returns in these years were captured at Wells Dam and used in the hatchery program. Carson origin fish have undoubtedly been added into the number of returns, since not all hatchery fish have been marked (until recent releases). It is not possible to separate Carson fish from the returning population.

[44] The series only goes to 1999 because not all fish produced from parents that spawned after 1999 have returned from the ocean.

estimate tributary productivity (smolts/redd) for Methow spring Chinook. When more data are available, this plan will estimate tributary productivity of Methow spring Chinook.

Spatial structure and diversity

Spring Chinook currently spawn in the mainstem Methow River and the Twisp, Chewuch, and Lost drainages (Scribner et al. 1993; Humling and Snow 2004). A few also spawn in Gold, Wolf, and Early Winters creeks (**Figure 2.9**). The original diversity of the Methow population was reduced because of man-made barriers near the confluence, early 1900s hatchery practices, the GCFMP, past harvest, hydropower development, habitat degradation, and the release of out-of-basin stock from the Winthrop National Fish Hatchery.[45] The USFWS transitioned from the release of out-of-basin stock to the listed stock from 2000 to 2006 (B. Cates, personal communication, USFWS). The population is currently distributed across three major watersheds (Twisp, Chewuch, and Upper Methow), which increases population diversity and reduces risk from catastrophic events.

When considering the 9 factors (and 12 metrics identified in ICBTRT 2005 and shown in Appendix B) that determine diversity and spatial structure, the Methow spring Chinook population is currently considered to be at a high risk of extinction (**Table 2.2**; Appendix B). Two factors contributed to this high-risk rating: (1) there is very little divergence occurring within the population; and (2) out-of-basin Carson stock were propagated in the past and the genetic legacy of these out-of-basin fish is still significant in fish used in the state and federal hatchery programs (Appendix B). Based only on abundance and productivity, the Methow spring Chinook population is not viable and has a greater than 25% chance of extinction in 100 years (**Figure 2.4**). Combining all VSP parameters together (using method described in ICBTRT 2005), the Methow spring Chinook population is not currently viable and has a high risk of extinction (**Table 2.3**).

Okanogan

Abundance

Currently, there are no naturally produced Spring Chinook in the Okanogan subbasin. A recent run of the Ecosystem Diagnosis and Treatment (EDT) model predicted that a viable population of spring Chinook cannot be maintained currently because of in-basin and out-of-basin factors (see Section 3.7 and Okanogan Subbasin Plan 2005).

Productivity

There is presently no production of spring Chinook in the Okanogan subbasin.

Spatial structure and diversity

Spring Chinook do not naturally occur within the Okanogan subbasin. In 2002, the USFWS released out-of-basin, Carson-stock spring Chinook smolts and fry into Omak Creek. As noted

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[45] As noted earlier, the fish at the Winthrop National Fish Hatchery at the time of listing originated from "Carson stock," which were derived from the collection of about 500 co-mingled spring Chinook trapped annually between 1955 and 1964 at Bonneville Dam. Recent genetic information indicates that these fish are a mix of Upper Columbia and Snake River populations (Pastor 2004).

earlier, these fish are not part of the ESU. Salmon Creek probably has the greatest habitat potential in the U.S. portion of the Okanogan subbasin (Okanogan Subbasin Plan 2005).

Upper Columbia Steelhead

Current (from 1960s to present) abundance and productivity for each population of steelhead in the Upper Columbia Basin were based on annual dam counts and returns per spawner (spawner to spawner return rates), respectively. Abundance was based on annual dam counts, not redd counts, because redd counts were not routinely conducted for steelhead until recently (2001). The total return from each spawning year was reconstructed by breaking each year's return down into components by age and summing those components by brood year (across return years). Annual return estimates were partitioned by age using age estimates obtained from the Wells and Priest Rapids sampling programs. Only anadromous steelhead were included in estimation of VSP parameters.[46] See Appendix C for a detailed description of the steelhead run reconstruction.

Wenatchee

Abundance

Between 1967 and 2003, escapement of naturally produced steelhead in the Wenatchee subbasin ranged from 70 to 2,864 (**Table 2.4**; **Figure 2.10**). During this same time period, the 12-year geometric mean ranged from 185 to 919 adults. The geometric mean at the time of listing (1997) was 793 (**Table 2.4**; **Figure 2.10**).

Productivity

The return per spawner of Wenatchee steelhead (and the Entiat, Methow, and Okanogan populations) depends on how effective hatchery-produced spawners have been in producing future spawners (recruits). Two scenarios are described that are based on the assumptions that (1) hatchery fish are equally as effective in producing returning spawners as naturally produced steelhead, and (2) that hatchery fish contribute no returning spawners (see Appendix C for details). Also, as noted in Appendix C, as spawning ground surveys and subsequent information (e.g., hatchery-naturally produced composition, hatchery spawner egg voidance, etc.) increase, it will be important to reevaluate the information and methodologies presented here.

Assuming that hatchery fish are as effective as naturally produced steelhead, the return per spawner ranged from 0.05 to 0.79 (**Table 2.4**). The 12-year geometric mean for this scenario ranged from 0.18 to 0.32. The geometric mean at the time of listing (1997) was 0.25.

If hatchery fish do not contribute to returning adults, then the return per spawner ranged from 0.13 to 4.73 (**Table 2.4**). The 12-year geometric mean for this scenario ranged from 0.71 to 1.96. The geometric mean at the time of listing (1997) was 0.81. The "true" productivity of Wenatchee steelhead lies somewhere between this scenario and the scenario that hatchery produced steelhead are as effective as naturally produced steelhead.

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[46] Resident rainbow trout are not included in VSP estimates for reason given in Section 2.1.

Spatial structure and diversity

Steelhead currently spawn and rear in the Wenatchee River between 37 Tumwater Canyon and Nason Creek, the Chiwawa River, and in Nason, Icicle, Peshastin, Chumstick, and Mission creeks (**Figure 2.13**). Steelhead may also spawn and rear in the Little Wenatchee and White rivers and Chiwaukum Creek. The diversity of the Wenatchee population was reduced because of past harvest and hatchery practices, hydropower development, and habitat degradation. The Wenatchee steelhead population is currently distributed across several interconnected spawning watersheds (Chiwawa, Nason, Icicle, Peshastin, Chumstick, and Mission), which increases population diversity.

When considering the 9 factors (and 12 metrics identified in ICBTRT 2005 and shown in Appendix B) that determine diversity and spatial structure, the Wenatchee steelhead population is currently considered to be at a high risk of extinction (**Table 2.2**). The high rating was based primarily on the proportion of natural spawners that consist of hatchery-produced fish (Appendix B). The high proportion results from collecting broodstock at Dryden Dam, rather than within specific spawning tributaries. Based only on abundance and productivity, the Wenatchee steelhead population is not viable and has a greater than 25% chance of extinction in 100 years (**Figure 2.14**). Combining all VSP parameters together (using method described in ICBTRT 2005), the Wenatchee steelhead population is not currently viable and has a moderate to high risk of extinction (**Table 2.5**).

Entiat

Abundance

Between 1967 and 2003, escapement of naturally produced steelhead in the Entiat subbasin ranged from 9 to 366 (**Table 2.4**; **Figure 2.15**). During this same time period, the 12-year geometric mean ranged from 24 to 118 adults. The geometric mean at the time of listing (1997) was 101 (**Table 2.4**; **Figure 2.15**).

Productivity

Assuming that hatchery fish are as effective as naturally produced steelhead, the return per spawner ranged from 0.05 to 0.79 (**Table 2.4**). The 12-year geometric mean for this scenario ranged from 0.18 to 0.32. The geometric mean at the time of listing (1997) was 0.25.

If hatchery fish do not contribute to returning adults, then the return per spawner ranged from 0.13 to 4.73 (**Table 2.4**). The 12-year geometric mean for this scenario ranged from 0.71 to 1.96. The geometric mean at the time of listing (1997) was 0.81. The “true” productivity of Entiat steelhead lies somewhere between this scenario and the scenario that hatchery produced steelhead are as effective as naturally produced steelhead.

Spatial structure and diversity

Steelhead currently spawn and rear in the mainstem Entiat River and from RM 0.5 discontinuously upstream to RM 28. Spawning and rearing in the Mad River occurs from RM 1.3 to RM 7.2 (**Figure 2.16**). Tributary use has been documented in lower Tillicum, Roaring, Stormy creeks. The upstream extent of steelhead in Roaring Creek is unknown.

The original diversity of the Entiat population was reduced because of the past harvest, hydropower development including dams that blocked passage into the Entiat River, habitat degradation, hatchery practices, and the GCFMP. Because of its small size (relative to other subbasins in the Upper Columbia) and natural barriers, the Entiat subbasin offers limited numbers of suitable habitat patches for steelhead. We note that the Entiat population was probably always at an intermediate to high risk because of its small size, low capacity to produce steelhead, and simple spatial structure.

When considering the 9 factors (and 12 metrics identified in ICBTRT 2005 and shown in Appendix B) that determine diversity and spatial structure, the Entiat steelhead population is currently considered to be at a high risk of extinction (**Table 2.2**). The high rating was based primarily on the proportion of out-of-basin hatchery spawners (Appendix B). These spawners consist of strays from the Wells and Wenatchee hatchery programs. Based only on abundance and productivity, the Entiat steelhead population is not viable and has a greater than 25% chance of extinction in 100 years (**Figure 2.17**). Combining all VSP parameters together (using method described in ICBTRT 2005), the Entiat steelhead population is not currently viable and has a moderate to high risk of extinction (**Table 2.5**).

Methow

Abundance

Between 1967 and 2002, escapement of naturally produced steelhead in the Methow subbasin ranged from 1 to 587 (**Table 2.6**; **Figure 2.18**). During this same time period, the 12-year geometric mean ranged from 36 to 242 adults. The geometric mean the year before listing (1996) was 205 (**Table 2.6**; **Figure 2.18**).

Productivity

Assuming that hatchery fish are as effective as naturally produced steelhead, the return per spawner ranged from 0.01 to 1.20 (**Table 2.6**; **Figure 2.19**). The 12-year geometric mean for this scenario ranged from 0.07 to 0.16. The geometric mean the year before listing (1996) was 0.09.

If hatchery fish do not contribute to returning adults, then the return per spawner ranged from 0.08 to 8.65 (**Table 2.6**; **Figure 2.19**). The 12-year geometric mean for this scenario ranged from 0.82 to 2.28. The geometric mean the year before listing (1996) was 0.84. The “true” productivity of Methow steelhead lies somewhere between this scenario and the scenario that hatchery produced steelhead are as effective as naturally produced steelhead.

Spatial structure and diversity

In the Methow subbasin, steelhead currently spawn and rear in the Twisp, mainstem Methow, and Chewuch rivers, and in Beaver and Winthrop National Fish Hatchery creeks (Jateff and Snow 2002). A few steelhead (based on less than 15 redds) also spawn in the Lost River and Buttermilk, Boulder, Methow Hatchery, Eight-Mile, Little Bridge, Libby, Black Canyon, War, Poorman, Eagle, and Lake creeks (**Figure 2.20**). No steelhead have been observed in Wolf creek. The original diversity of the Methow population was reduced because of the GCFMP, past harvest, hydropower development, and habitat degradation. The population is currently distributed across three major watersheds (Twisp, Chewuch, and Upper Methow), which increases population diversity and reduces risk from catastrophic events.

When considering the 9 factors (and 12 metrics identified in ICBTRT 2005 and shown in Appendix B) that determine diversity and spatial structure, the Methow steelhead population is currently considered to be at a high risk of extinction (**Table 2.2**). The proportion of natural spawners that were hatchery fish contributed most to this designation (Appendix B). Based only on abundance and productivity, the Methow steelhead population is not viable and has a greater than 25% chance of extinction in 100 years (**Figure 2.13**). Combining all VSP parameters together (using method described in ICBTRT 2005), the Methow steelhead population is not currently viable and has a moderate to high risk of extinction (**Table 2.5**).

Okanogan

Abundance

Between 1967 and 2002, escapement of naturally produced steelhead in the Okanogan subbasin ranged from 1 to 156 (**Table 2.6**; **Figure 2.21**). During this same time period, the 12-year geometric mean ranged from 11 to 64 adults. The geometric mean the year before listing (1996) was 53 (**Table 2.6**; **Figure 2.21**). In 2005, 300 redds were counted in the U.S. portion of the Okanogan subbasin (Colville Tribes, personal communication).

Productivity

Assuming that hatchery fish are as effective as naturally produced steelhead, the return per spawner ranged from 0.01 to 1.20 (**Table 2.6**; **Figure 2.19**). The 12-year geometric mean for this scenario ranged from 0.07 to 0.16. The geometric mean the year before listing (1996) was 0.09.

If hatchery fish do not contribute to returning adults, then the return per spawner ranged from 0.08 to 8.65 (**Table 2.6**; **Figure 2.19**). The 12-year geometric mean for this scenario ranged from 0.82 to 2.28. The geometric mean the year before listing (1996) was 0.84. The “true” productivity of Okanogan steelhead lies somewhere between this scenario and the scenario that hatchery produced steelhead are as effective as naturally produced steelhead.

Spatial structure and diversity

Steelhead currently spawn in Omak Creek, Similkameen River, mainstem Okanogan River, and occasionally spawn in other tributaries to the Okanogan river. Additionally, there are four steelhead production areas within the Canadian portion of the Okanogan subbasin (**Figure 2.22**). The original diversity of the Okanogan population was reduced because of the GCFMP, past harvest, hydropower development, hatchery practices, and habitat degradation. The population is currently distributed only across two watersheds (Omak and Similkameen), which decreases population diversity and increases risk from catastrophic events.

When considering 9 factors (and 12 metrics identified in ICBTRT 2005 and shown in Appendix B) that determine diversity and spatial structure, the Okanogan steelhead population is currently considered to be at a high risk of extinction (**Table 2.2**). Based on abundance and productivity, the Okanogan steelhead population is not viable and has a greater than 25% chance of extinction in 100 years (**Figure 2.16**). Combining all VSP parameters together (using method described in ICBTRT 2005), the Okanogan steelhead population is not currently viable and has a high risk of extinction (**Table 2.5**).

Upper Columbia Bull Trout

Because of a lack of detailed information on the population dynamics of bull trout in the Upper Columbia Basin, a different approach was used to estimate VSP parameters for bull trout. Bull trout abundance was estimated as the number of redds times 2.0 to 2.8 fish per redd. This approach provided a range of abundance estimates for bull trout within each core area (USFWS 2004, 2005). Productivity was based on trends in redd counts, while diversity was based on general life-history characteristics of bull trout (resident, fluvial, and adfluvial) within each core area. Although these parameters are less rigorous than the parameters used to estimate status of spring Chinook and steelhead, they provide relative indices of abundance, productivity, and diversity.

Wenatchee

Abundance

The USFWS, USFS, and WDFW have conducted bull trout spawning surveys in various streams within the Wenatchee subbasin since the early 1980s. Bull trout redd surveys in the Wenatchee subbasin have changed over time and different streams have different survey periods (e.g., White/Little Wenatchee from 1983 to present, Chiwawa from 1989 to present, Nason from 1996 to present, etc.). Numbers of redds have ranged from 2 to 123 in the White/Little Wenatchee drainages, 1-15 in Nason Creek, and 93-462 in the Chiwawa drainage (**Table 2.7**). Surveys from 2000-2004 were conducted consistently across all populations and redds counts during this period ranged from 309 to 607 in the core area.

Productivity

Directly comparable data from redd surveys for all the local populations only occurs from 2000 to present. For streams with long-term redd counts, numbers of redds have increased over time (e.g., Chiwawa basin). However, there is a fair amount of variability in all the other populations (**Table 2.7**). Number of redds for Little Wenatchee, Nason Creek, Ingalls Creek, and Chiwaukum Creek are very low, and the location of spawning grounds in Icicle Creek is unknown. However, multiple size classes of bull trout have been observed in upper Icicle Creek during USFWS surveys in 1994, 1995, and 2004.

Spatial structure and diversity

Bull trout currently occur in the Chiwawa River, White River, Little Wenatchee River, Nason Creek, Chiwaukum Creek, Icicle Creek, Peshastin Creek, Negro Creek, and Ingalls Creek drainages (USFWS 2002) (**Figure 2.22**). Adfluvial, fluvial, and resident forms of bull trout exist in the Wenatchee subbasin (USFWS 2002).

Entiat

Abundance

The U.S. Forest Service (USFS) has conducted bull trout redd surveys in the Entiat subbasin since 1989, primarily in the Mad River (**Table 2.7**). Numbers have ranged from 10 to 52 redds in the Mad River and 0 to 46 redds in the Entiat River. The large increase in numbers of redds counted in the Entiat River in 2004 resulted from increasing the survey area and changes in survey effort.

Productivity

Numbers of bull trout redds in the Entiat subbasin have increased since they were first counted in 1989, suggesting an increasing trend in production (**Table 2.7**).

Spatial structure and diversity

Bull trout occur in both the Mad and Entiat rivers (USFWS 2002) (**Figure 2.22**). Natural falls currently restrict the distribution of migratory bull trout in the Entiat subbasin. However, there have been minimal bull trout surveys conducted upstream from the falls. It is assumed that most of the bull trout in the Entiat subbasin are fluvial fish, with perhaps a resident form in the upper reaches of the Mad River drainage. Bull trout have been observed in Tillicum and Stormy creeks (USFWS 2002). Recent studies suggest that bull trout from this core area use the mainstem Columbia River for overwintering habitat and foraging (BioAnalysts Inc. 2002, 2003).

Methow

Abundance

Redd surveys in the Methow subbasin began in the early 1990s and were conducted by the USFS, USFWS, WDFW, and others. Total numbers of redds within the subbasin have ranged from 4 to 195 redds (**Table 2.7**). However, these are not valid estimates of abundance, because not all bull trout spawning streams were surveyed annually, lengths of surveys reaches have changed within a given stream, and survey methods have changed over time. Based on more recent surveys (2000-2004), when survey methods were more similar, redd counts ranged from 127 to 195. There is a bull trout fishery in the Lost River. It is uncertain as to what effect this has on the Methow core population. Another factor that may have affected bull trout abundance is the closure of the steelhead fishery between 1997 and 2001.

Productivity

Numbers of redds counted in the Methow subbasin appear to have increased since the mid-1990s. However, this trend is an artifact of changing survey methods. Looking at recent years (2000-2004), when survey methods were similar, there was a fairly stable number of redds ranging from 147 in 2000 to 148 in 2004. Currently, there is insufficient data to establish a trend for the entire core area. In the Twisp and the Upper Methow areas, redd counts are highly variable, but reveal a decreasing trend since 2000 (**Table 2.7**).

Spatial structure and diversity

The distribution of bull trout in the Methow subbasin is somewhat less than it was historically. Currently bull trout occur within the Twisp River, Chewuch River, Lake Creek, Wolf Creek, Early Winters Creek, Upper Methow River, Lost River, Beaver Creek, Foggy Dew Creek, Crater Cree, Eightmile Creek, Buttermilk Creek, Little Bridge Creek, North Creek, and Goat Creek drainages (USFWS 2002) (**Figure 2.22**). Bull trout exist upstream of the anadromous fish barrier on Early Winters Creek. The population structure of the Lost River is unknown, but likely contributes to the genetic diversity of the Methow core population. The presence of bull trout in the Gold Creek drainage is unknown. No redds have been observed there in recent years. The USFWS believes that bull trout in Beaver Creek were reduced because of competition and introgression with brook trout, irrigation diversions, and fish passage problems (J. Craig, USFWS, personal communication). Resident, fluvial, and adfluvial forms still occur in the Methow subbasin (USFWS 2002).

Table 2.1 Adult (age >3) spawner-to-spawner return estimates and 12-year geometric means (GM) of spawners (S) and returns per spawner (R/S) for Upper Columbia spring Chinook. Return levels for brood years 1960-1969 were adjusted to reflect historical average harvest. Spawner numbers include both hatchery and naturally produced fish. Data are from T. Cooney (NOAA Fisheries).

Brood Year	Wenatchee					Entiat					Methow				
	Spawner	Returns	R/S	GM S	GM R/S	Spawner	Returns	R/S	GM S	GM R/S	Spawner	Returns	R/S	GM S	GM R/S
60	2371	3290	1.39			365	998	2.73			2313	3587	1.55		
61	1540	4290	2.79			137	528	3.86			665	2751	4.14		
62	3056	5645	1.85			359	863	2.41			2813	3863	1.37		
63	1874	4524	2.41			452	786	1.74			2093	2624	1.25		
64	2771	4514	1.63			1197	727	0.61			4198	2010	0.48		
65	3523	3588	1.02			324	424	1.31			1556	1655	1.06		
66	6718	2082	0.31			957	260	0.27			4927	1499	0.30		
67	3978	2390	0.60			786	329	0.42			2621	1683	0.64		
68	4663	4106	0.88			786	406	0.52			1958	2082	1.06		
69	3959	3797	0.96			415	525	1.26			1405	1825	1.30		
70	3026	3308	1.09			218	407	1.87			1824	1760	0.97		
71	1589	2722	1.71	2977	1.19	424	342	0.81	451	1.12	1535	1371	0.89	2061	1.02
72	2783	2326	0.84	3017	1.14	190	246	1.30	427	1.05	1644	1099	0.67	2003	0.95
73	5863	3818	0.65	3372	1.01	714	732	1.03	490	0.94	2415	2443	1.01	2231	0.85
74	1989	2652	1.33	3254	0.99	274	788	2.87	480	0.96	1193	1828	1.53	2077	0.86
75	3765	1207	0.32	3449	0.83	486	257	0.53	482	0.87	2108	449	0.21	2078	0.74
76	2401	1491	0.62	3408	0.77	147	299	2.03	405	0.96	713	389	0.55	1793	0.75
77	2862	2342	0.82	3349	0.76	533	321	0.60	422	0.90	1986	445	0.22	1830	0.66

Brood Year	Wenatchee					Entiat					Methow				
	Spawner	Returns	R/S	GM S	GM R/S	Spawner	Returns	R/S	GM S	GM R/S	Spawner	Returns	R/S	GM S	GM R/S
78	3772	2593	0.69	3192	0.81	1016	315	0.31	424	0.91	2601	507	0.20	1735	0.63
79	1063	1406	1.32	2859	0.86	253	277	1.09	386	0.98	524	480	0.92	1517	0.65
80	1519	3025	1.99	2604	0.92	334	208	0.62	360	1.00	438	1064	2.43	1339	0.70
81	1595	4045	2.54	2414	1.00	296	344	1.16	350	0.99	467	735	1.57	1222	0.71
82	1819	2873	1.58	2314	1.03	334	249	0.75	362	0.92	558	1355	2.43	1107	0.76
83	3286	1693	0.52	2459	0.93	334	226	0.68	355	0.91	861	1190	1.38	1055	0.79
84	2341	1105	0.47	2423	0.89	265	55	0.21	365	0.78	929	1167	1.26	1006	0.84
85	4529	1380	0.30	2372	0.84	359	184	0.51	345	0.73	1232	1081	0.88	951	0.83
86	2674	886	0.33	2431	0.74	327	146	0.45	350	0.63	909	733	0.81	930	0.78
87	1878	1065	0.57	2294	0.78	200	86	0.43	325	0.62	1496	726	0.49	903	0.84
88	1692	696	0.41	2228	0.75	209	232	1.11	335	0.59	1641	1963	1.20	968	0.90
89	1349	829	0.61	2093	0.74	115	153	1.33	294	0.63	1144	668	0.58	925	0.97
90	927	183	0.20	1862	0.66	259	41	0.16	263	0.59	1104	59	0.05	861	0.87
91	552	122	0.22	1763	0.57	100	22	0.22	243	0.52	550	78	0.14	865	0.74
92	1080	70	0.06	1713	0.43	131	44	0.34	225	0.49	1630	173	0.11	965	0.57
93	1179	124	0.11	1671	0.33	312	58	0.19	226	0.42	1357	206	0.15	1054	0.47
94	275	205	0.75	1427	0.31	75	38	0.51	199	0.41	293	145	0.49	999	0.41
95	51	229	4.53	1008	0.37	18	34	1.91	156	0.45	33	172	5.21	761	0.46
96	158	506	3.20	805	0.44	44	132	2.99	135	0.56	*	822			
97	385	1768	4.59	656	0.55	81	291	3.59	119	0.66	339	1289	3.80	665	0.48

Brood Year	Wenatchee					Entiat					Methow				
	Spawner	Returns	R/S	GM S	GM R/S	Spawner	Returns	R/S	GM S	GM R/S	Spawner	Returns	R/S	GM S	GM R/S
98	183	686	3.76	524	0.67	53	250	4.72	102	0.80	*	588			
99	119	248	2.09	417	0.74	59	14	0.25	92	0.76	79	112	1.41	480	0.51
00	620			383		152			90		805			447	
01	4446			423		444			101		9904			555	
02	1651			444		246			100		2622			605	
03	539			443		238			108		1047			645	

* Nearly all spring Chinook spawners returning to the Methow in 1996 and 1998 were collected for hatchery broodstock. There were no spawning surveys conducted in those years to determine if some fish escaped and spawned in the Methow subbasin.

Table 2.2 Goals, associated mechanisms, factors, and levels of risk (L-low; M-medium; H-high) for diversity and spatial structure of Upper Columbia spring Chinook and steelhead. Table was developed following guidance from ICBTRT (2005a) (see Appendix B). Wen = Wenatchee, Ent = Entiat, Met = Methow, and Okan = Okanogan.

Goal	Mechanism	Factor	Spring Chinook			Steelhead			
			Wen	Ent	Met	Wen	Ent	Met	Okan
Allowing natural rates and levels of spatially mediated processes	Maintain natural distribution of spawning aggregates	Number and spatial arrangement of spawning areas	L	M	L	L	M	L	H
		Spatial extent or range of population							
		Increase or decrease gaps or continuities between spawning aggregates							
Maintaining natural levels of variation	Maintain natural patterns of phenotypic and genotypic expression	Major life-history strategies	H	H	H	H	H	H	H
		Phenotypic variation							
		Genetic variation							
	Maintain natural patterns of gene flow	Spawner composition							
	Maintain occupancy in a natural variety of available habitat types	Distribution of population across habitat types							
	Maintain integrity of natural systems	Selective in natural processes or impacts							

Table 2.3 Viability ranking of current populations of Upper Columbia River spring Chinook (spatial structure/diversity based on **Table 2.3**; Abundance/Productivity based on **Figure 2.4** and **Figure 2.7**) (table developed based on guidance from ICBTRT 2005a) (see Appendix B)

		Spatial Structure/Diversity Risk			
		Very Low	**Low**	**Moderate**	**High**
Abundance/Productivity Risk	**Very Low (<1%)**				
	Low (1-5%)				
	Moderate (6-25%)				
	High (>25%)				Wenatchee Entiat Methow

Table 2.4 Summary statistics for naturally produced (NP) steelhead escapement and run reconstruction for Wenatchee and Entiat populations. GM = 12-year geometric mean; HE = hatchery effectiveness. See Appendix C for a detailed description of run reconstructions.

Year	NP steelhead escapement		GM NP steelhead escapement		Returns		Returns per spawner		GM Returns per spawner	
	Wenatchee	Entiat	Wenatchee	Entiat	Wenatchee	Entiat	HE = 0	HE = 1	GM HE = 0	GM HE = 1
1967	1316	168			257	33	0.20	0.14		
1968	1878	240			244	31	0.13	0.08		
1969	858	110			173	22	0.20	0.09		
1970	138	18			137	18	0.99	0.31		
1971	377	48			110	14	0.29	0.05		
1972	150	19			191	24	1.27	0.17		
1973	219	28			300	38	1.37	0.18		
1974	82	10			284	36	3.46	0.47		
1975	97	12			229	29	2.37	0.32		
1976	184	24			249	32	1.35	0.28		
1977	450	58			249	32	0.55	0.11		
1978	146	19	290	37	276	35	1.88	0.33	0.75	0.18
1979	305	39	256	33	459	59	1.51	0.28	0.88	0.19
1980	176	22	210	27	774	99	4.40	0.79	1.19	0.22
1981	355	45	196	25	1034	132	2.91	0.58	1.48	0.26
1982	70	9	185	24	1368	175			1.54	0.26
1983	679	87	194	25	1318	168	1.94	0.24	1.83	0.30
1984	683	87	220	28	1883	241	2.76	0.43	1.96	0.32
1985	1382	177	257	33	1406	180	1.02	0.19	1.91	0.32

Year	NP steelhead escapement		GM NP steelhead escapement		Returns		Returns per spawner		GM Returns per spawner	
	Wenatchee	Entiat	Wenatchee	Entiat	Wenatchee	Entiat	HE = 0	HE = 1	GM HE = 0	GM HE = 1
1986	1315	168	323	41	1011	129	0.77	0.20	1.66	0.30
1987	1993	255	416	53	723	92	0.36	0.16	1.40	0.28
1988	1062	136	482	62	1125	144	1.06	0.36	1.37	0.29
1989	1676	214	538	69	536	69	0.32	0.18	1.31	0.30
1990	594	76	604	77	524	67	0.88	0.26	1.22	0.29
1991	1036	133	669	86	432	55	0.42	0.26	1.08	0.29
1992	830	106	761	97	485	62	0.58	0.15	0.90	0.25
1993	507	65	784	100	437	56	0.86	0.28	0.81	0.23
1994	471	60	919	118	301	39	0.64	0.13	0.79	0.22
1995	673	86	919	117	369	47	0.55	0.18	0.71	0.22
1996	393	50	877	112	1111	142	2.82	0.56	0.71	0.22
1997	410	52	793	101	1941	248	4.73	0.74	0.81	0.25
1998	273	35	696	89						
1999	443	57	614	78						
2000	1196	153	620	79						
2001	2864	366	648	83						
2002	1291	165	691	88						
2003	1588	203	716	92						

Table 2.5 Viability ranking of current populations of Upper Columbia River steelhead (spatial structure/diversity based on **Table 2.3**; Abundance/Productivity based on **Figure 2.14** and **Figure 2.17**) (Table developed based on guidance from ICBTRT 2005a; see Appendix B)

Abundance/Productivity Risk	Spatial Structure/Diversity Risk: Very Low	Low	Moderate	High
Very Low (<1%)				
Low (1-5%)				
Moderate (6-25%)				
High (>25%)				Okanogan Wenatchee Entiat Methow

Table 2.6 Summary statistics for naturally produced (NP) steelhead escapement and run reconstruction for Methow and Okanogan populations. GM = 12-year geometric mean; HE = hatchery effectiveness. See Appendix C for a detailed description of run reconstructions

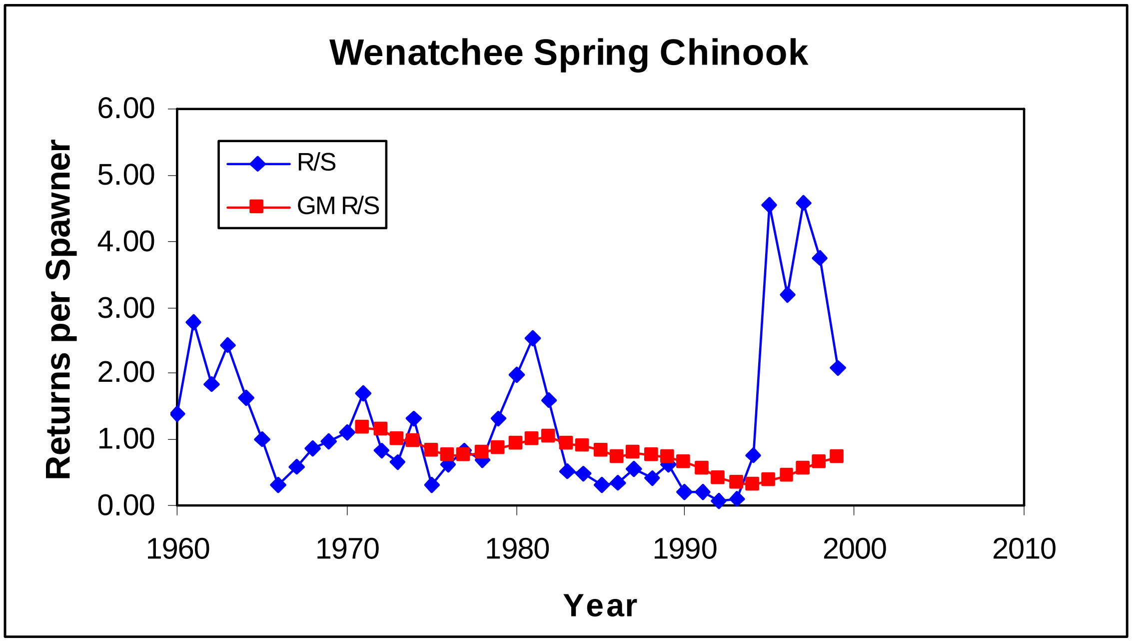
Year	NP steelhead escapement		GM NP steelhead escapement		Returns		Returns per spawner		GM Returns per spawner	
	Methow	Okanogan	Methow	Okanogan	Methow	Okanogan	HE = 0	HE = 1	GM HE = 0	GM HE = 1
1967	135	36			161	43	1.19	0.75		
1968	565	150			124	33	0.22	0.14		
1969	268	71			30	8	0.11	0.05		
1970	69	18			17	5	0.24	0.08		
1971	278	74			21	6	0.08	0.01		
1972	35	9			68	18	1.92	0.17		
1973	27	7			112	30	4.12	0.19		
1974	11	3			84	22	7.49	0.34		
1975	1	1			57	15				
1976	95	25			66	17	0.70	0.06		
1977	161	43			99	26	0.62	0.06		
1978	17	5	57	17	151	40	8.65	0.78	0.82	0.13
1979	101	27	55	16	128	34	1.26	0.11	0.83	0.11
1980	9	2	39	12	124	33		1.20	0.95	0.13
1981	143	38	37	11	185	49	1.29	0.12	1.21	0.14
1982	186	49	41	12	264	70	1.42	0.08	1.44	0.14
1983	77	21	36	11	290	77	3.75	0.04	2.13	0.16
1984	125	33	41	12	474	126	3.78	0.09	2.28	0.15
1985	239	64	49	14	392	104	1.64	0.06	2.08	0.14
1986	262	70	63	19	364	97	1.39	0.08	1.75	0.12

Year	NP steelhead escapement		GM NP steelhead escapement		Returns		Returns per spawner		GM Returns per spawner	
	Methow	Okanogan	Methow	Okanogan	Methow	Okanogan	HE = 0	HE = 1	GM HE = 0	GM HE = 1
1987	453	120	105	28	340	90	0.75	0.13	1.62	0.12
1988	316	84	116	31	455	121	1.44	0.24	1.73	0.13
1989	401	106	126	33	147	39	0.37	0.08	1.65	0.14
1990	315	83	160	42	99	26	0.31	0.06	1.22	0.11
1991	552	146	184	49	68	18	0.12	0.02	0.99	0.10
1992	252	67	242	64	91	24	0.36	0.04	0.91	0.07
1993	130	34	240	64	130	35	1.01	0.10	0.89	0.07
1994	90	24	226	60	116	31	1.29	0.07	0.89	0.07
1995	77	20	226	60	213	56	2.76	0.31	0.86	0.08
1996	140	37	228	60	374	99	2.67	0.14	0.84	0.09
1997	66	17	205	54						
1998	151	40	195	52						
1999	326	86	190	50						
2000	316	84	190	50						
2001	587	156	196	52						
2002	434	115	202	53						

Table 2.7 Bull trout redd counts from streams in the Upper Columbia Basin for years 1983-2003 (data from USFWS and USFS)

Stream /drainage	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Wenatchee Core Area																						
White/Little Wenatchee	45	20	4	2	11	32	33	7	37	26	45	48	26	29	18	35	44	65	22	123	64	54
Chiwaukum watershed																			29	35	42	23
Nason watershed														3	1	9	15	13	3	7	3	15
Chiwawa watershed							176	93	332	255	230	207	405	358	324	347	462	400	254	437	421	376
Peshastin watershed																		0	1	5	9	
Total:	**45**	**20**	**4**	**2**	**11**	**32**	**209**	**100**	**369**	**281**	**275**	**255**	**431**	**390**	**343**	**391**	**521**	**478**	**309**	**607**	**539**	**468**
Entiat Core Area																						
Mad River							18	17	21	16	10	17	16	23	23	43	30	45	34	26	52	37
Entiat River												3	3	2	0	1	6	1	4	7	5	46
Total:							**18**	**17**	**21**	**16**	**10**	**20**	**19**	**25**	**23**	**44**	**36**	**46**	**38**	**33**	**57**	**83**
Methow Core Area																						
Upper Methow watershed										7			33	26	15	13	1	5	27	60		22
Chewuch watershed													22	13	9	8	0	18	31	22	20	10
Twisp watershed										4	5	4	25	0	2	86	101	105	76	93	86	101

Stream /drainage	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04
Middle Methow watershed													0	3	3	27	29	26	20	19	21	36
Lower Methow watershed														2	2	1	0		0	1	0	
Total:										**11**	**5**	**4**	**80**	**44**	**31**	**135**	**131**	**165**	**154**	**195**	**127**	**169**



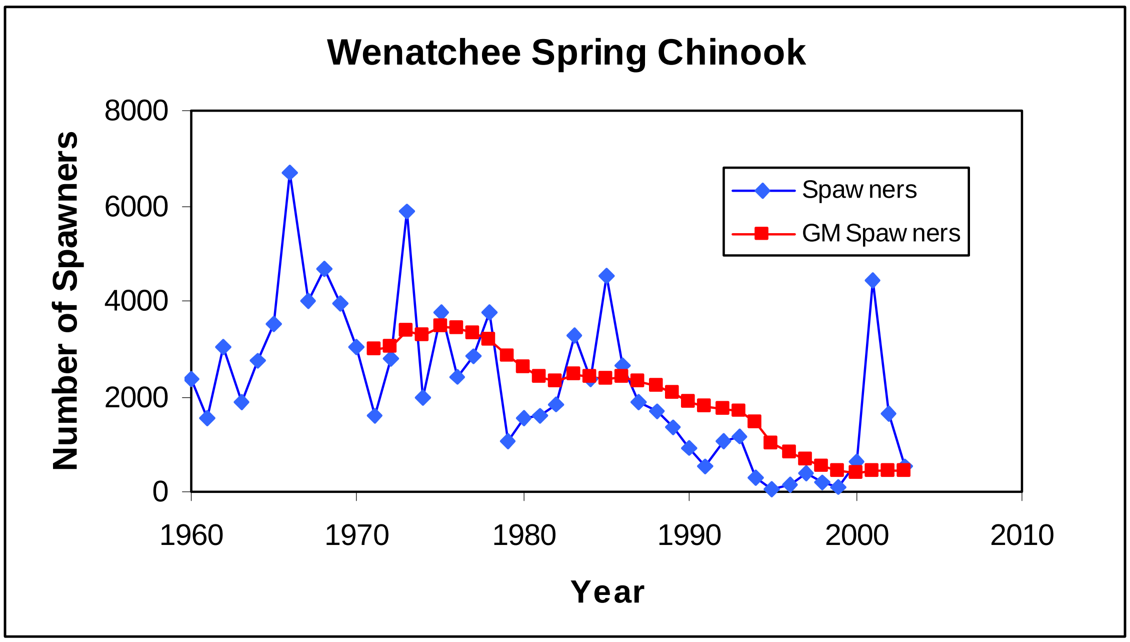


Figure 2.1 Spring Chinook spawners and returns per spawner (R/S) and their 12-year geometric means (GM) in the Wenatchee subbasin during the period 1960 to 1999. Spawner numbers include both hatchery (minus those in Icicle Creek) and naturally produced fish.

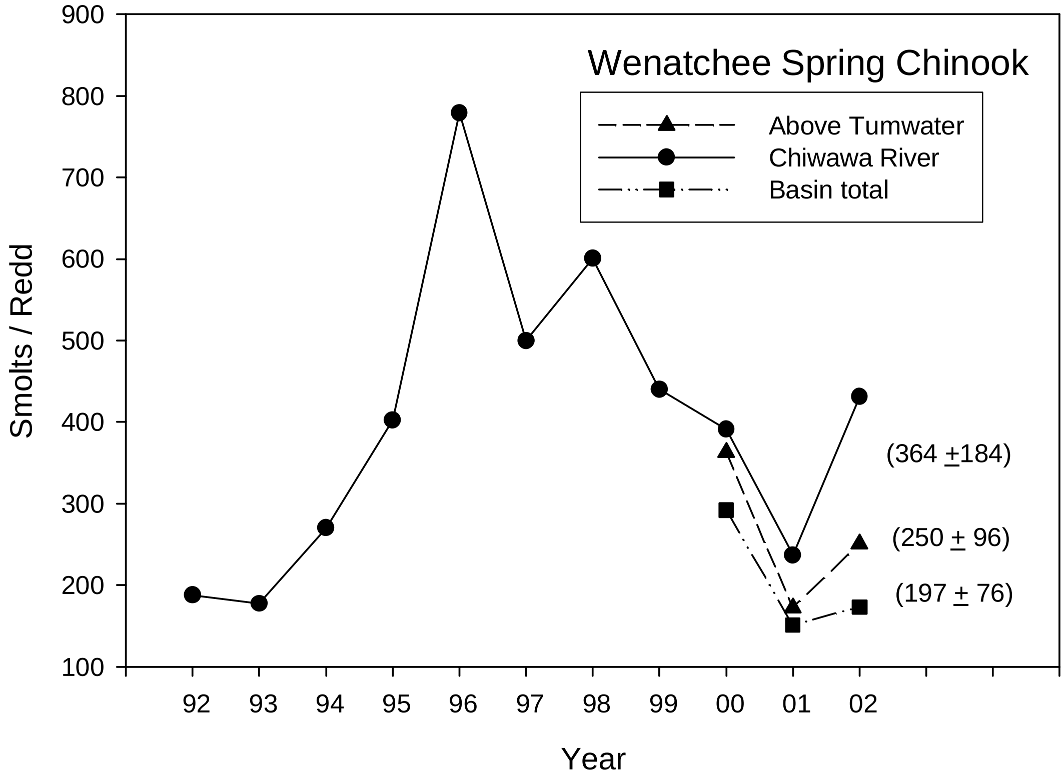


Figure 2.2 Annual smolts per redd for Wenatchee River spring Chinook. The numbers to the right of the lines are the geometric means (± 1 SD).

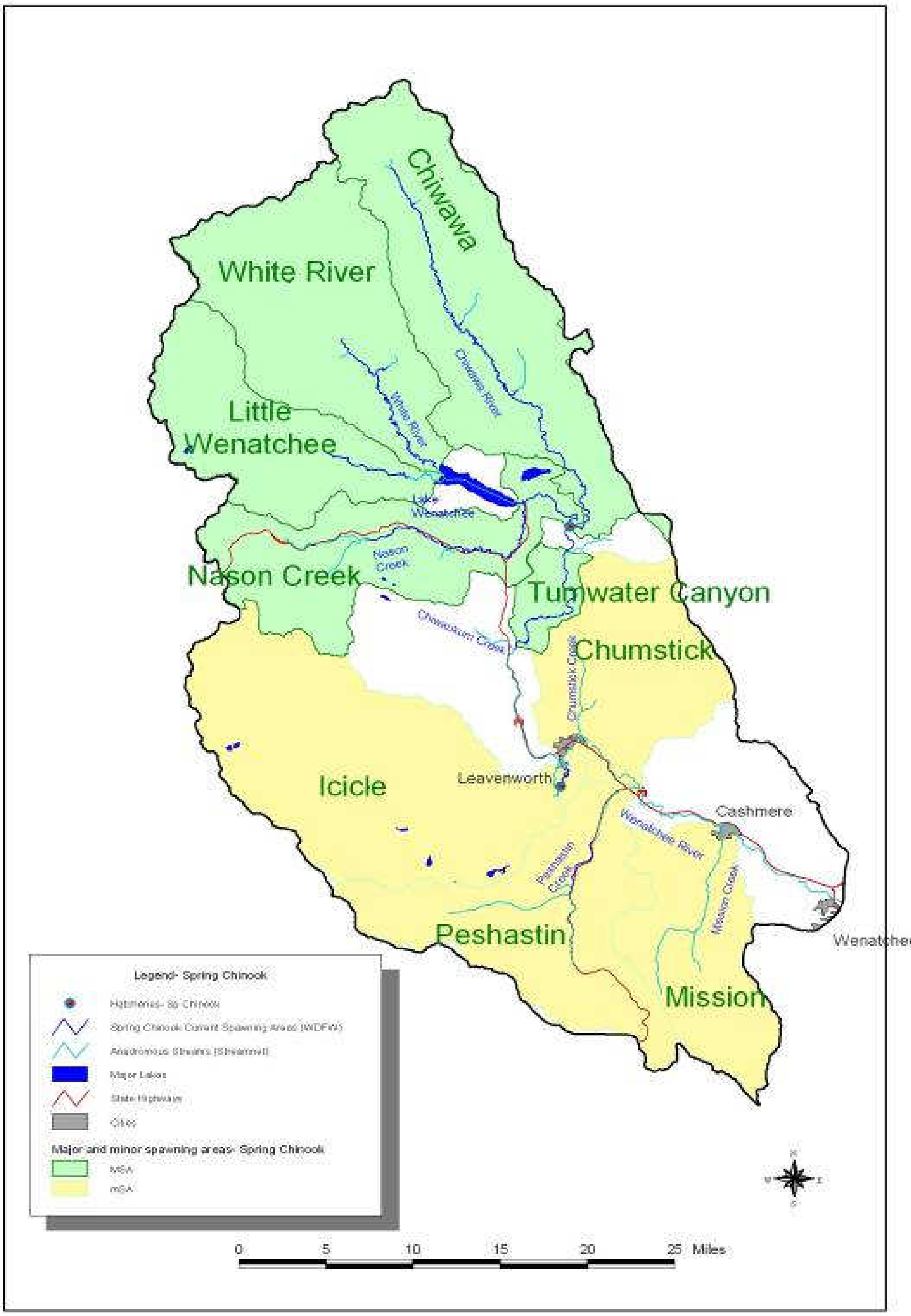


Figure 2.3 Current and potential distribution of spring Chinook in the Wenatchee subbasin

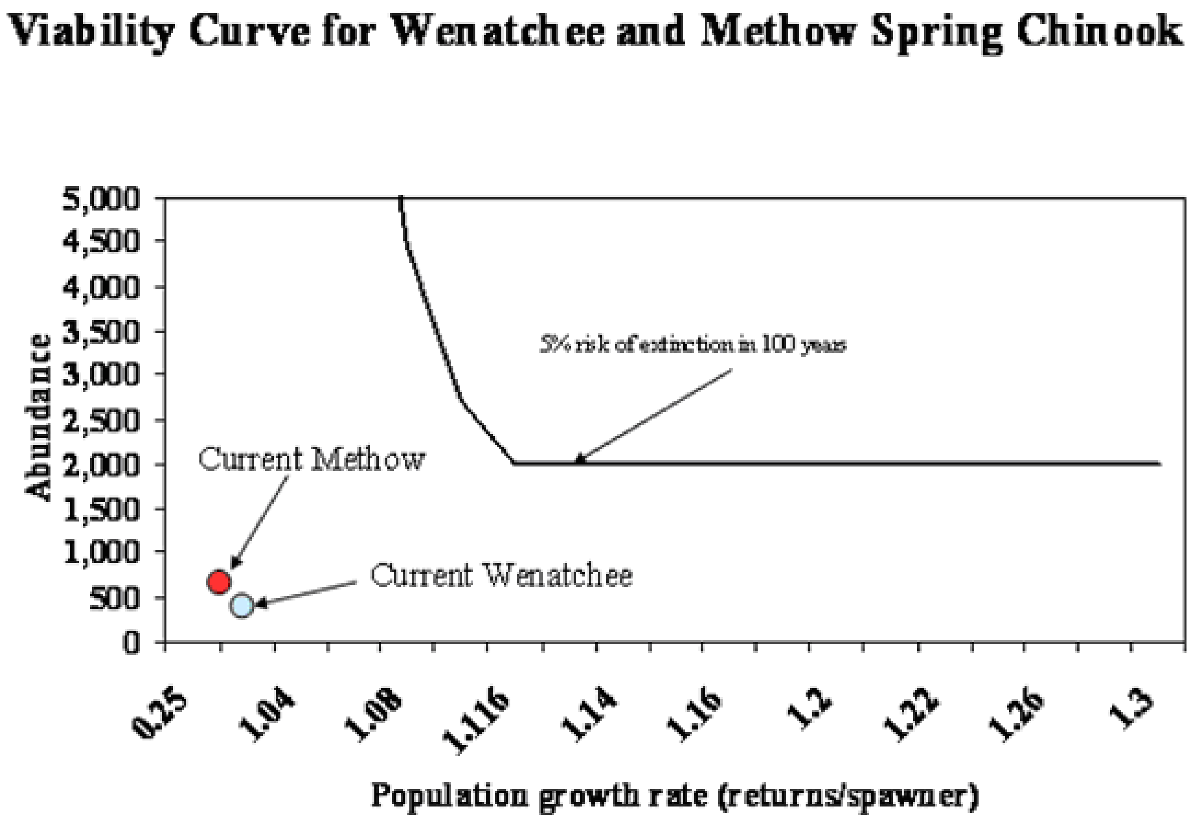
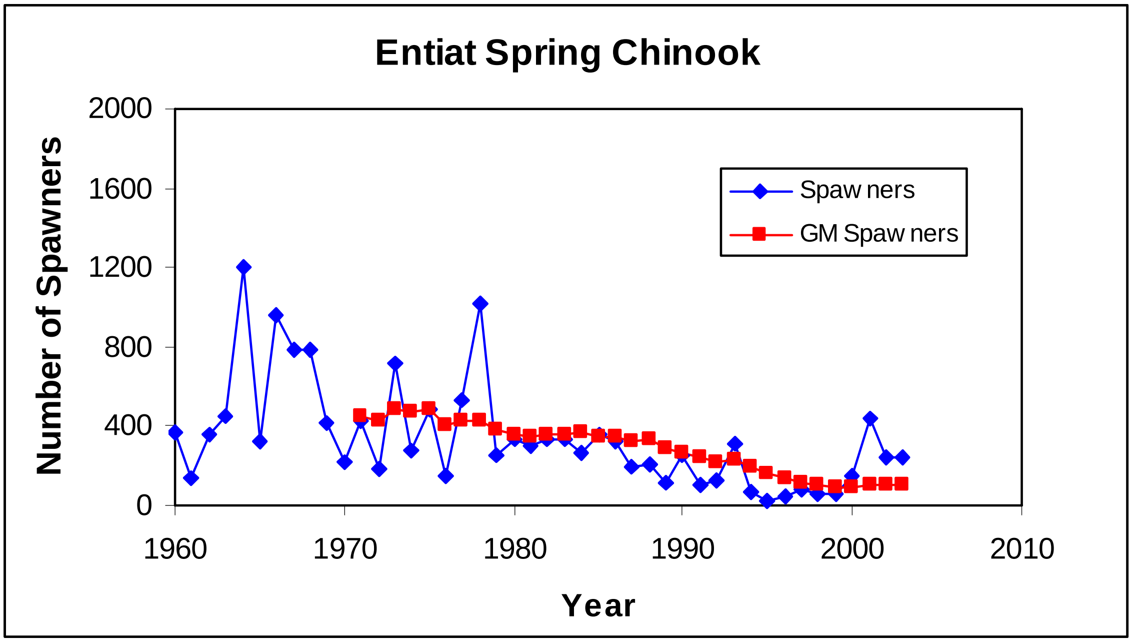


Figure 2.4 Viability curve for Wenatchee and Methow spring Chinook salmon. For the Wenatchee and Methow populations to be viable, their abundance/productivity scores must fall above the viability curve. Variability should be considered as the abundance/productivity estimates approach viability criteria. Viability curve is from the ICBTRT (2005a). This plan recognizes that as abundance and productivity values approach the minimum viability thresholds it will be necessary to incorporate uncertainty and measurement error regarding the status of each population.



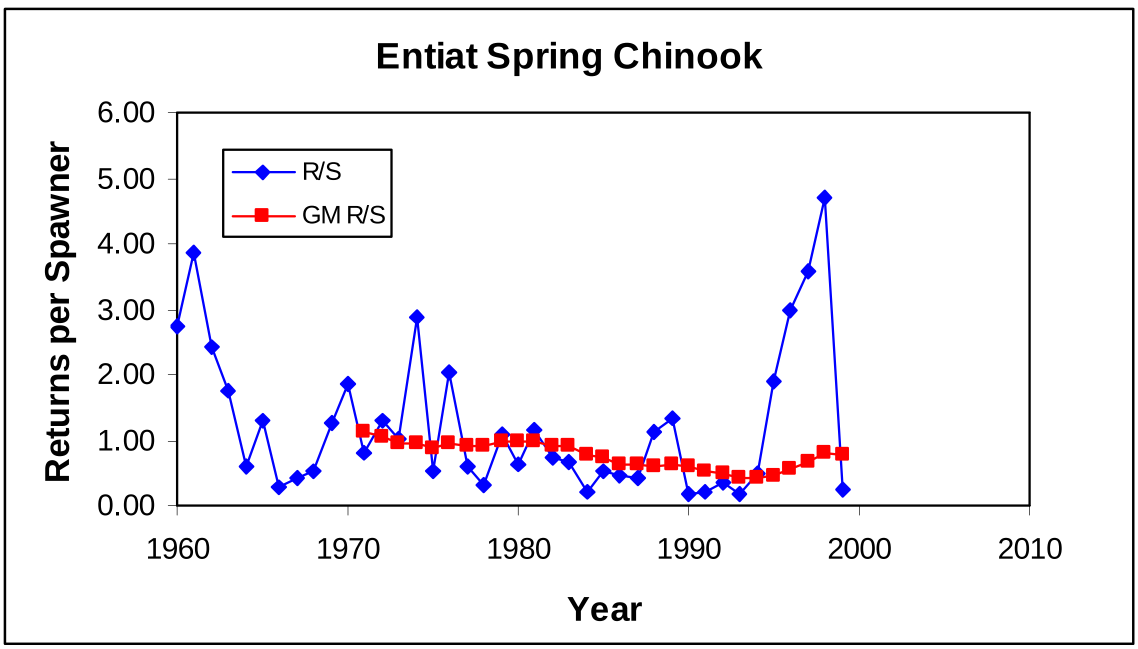


Figure 2.5 Spring Chinook spawners and returns per spawner (R/S) and their 12-year geometric means (GM) in the Entiat subbasin during the period 1960 to 1999. Spawner numbers include both hatchery and naturally produced fish.

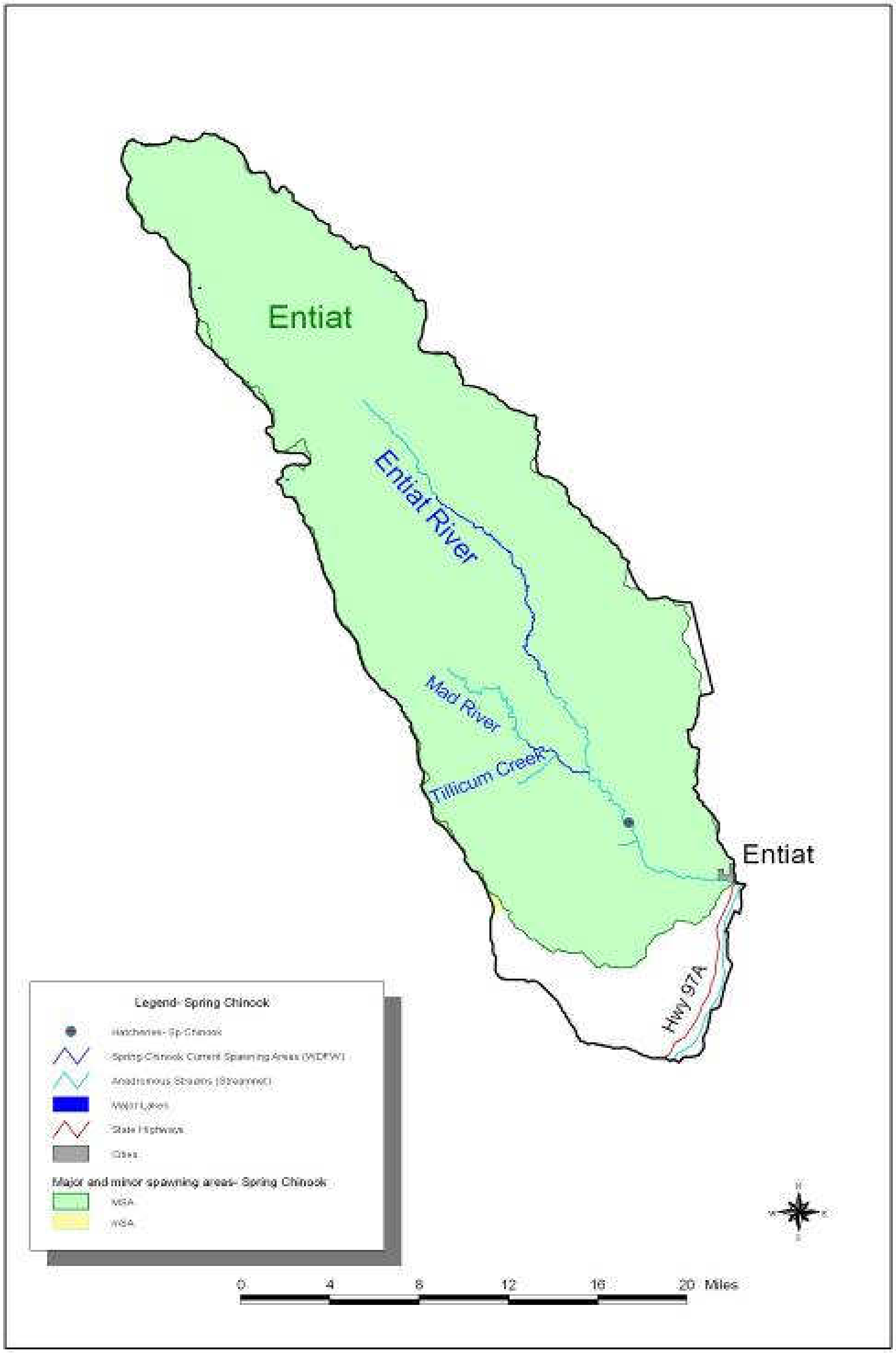


Figure 2.6 Current and potential distribution of spring Chinook in the Entiat subbasin

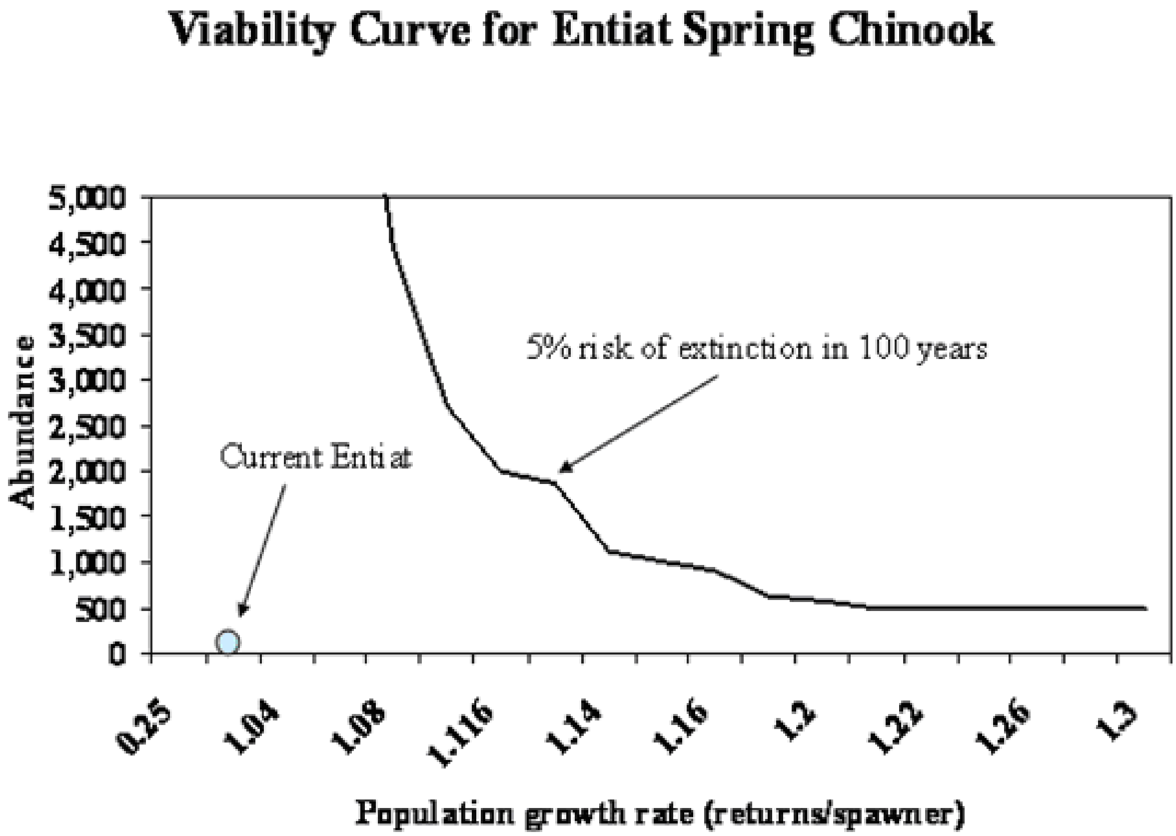


Figure 2.7 Viability curve for Entiat spring Chinook. For the Entiat population to be viable, its abundance/productivity score must fall above the viability curve. Variability should be considered as the abundance/productivity estimates approach viability criteria. Viability curve is from the ICBTRT (2005a). This plan recognizes that as abundance and productivity values approach the minimum viability thresholds it will be necessary to incorporate uncertainty and measurement error regarding the status of each population.

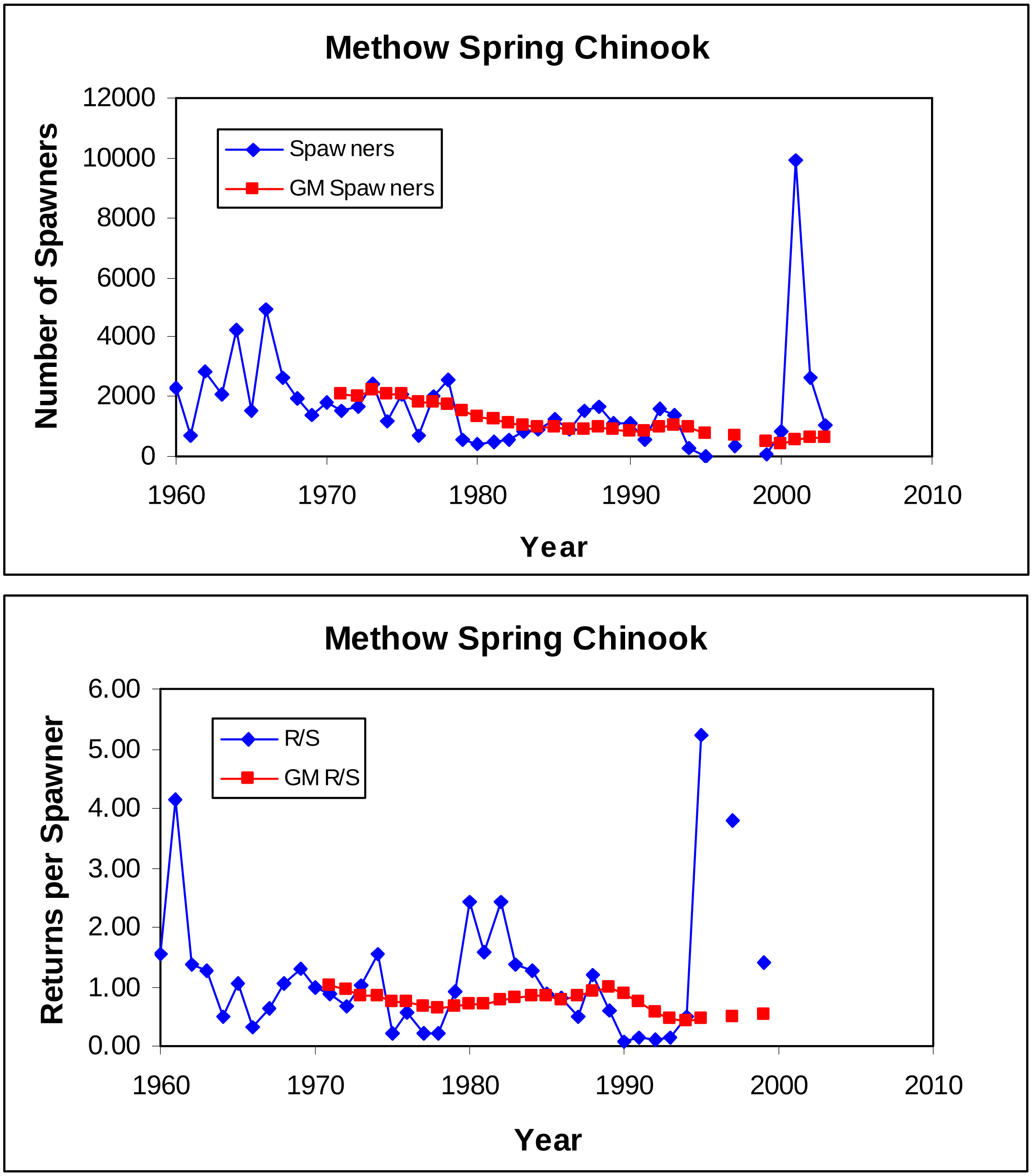


Figure 2.8 Spring Chinook spawners and returns per spawner (R/S) and their 12-year geometric means (GM) in the Methow subbasin during the period 1960 to 1999. It is assumed that all spawners in 1996 and 1998 were collected for hatchery broodstock. Spawner numbers include both hatchery and naturally produced fish.

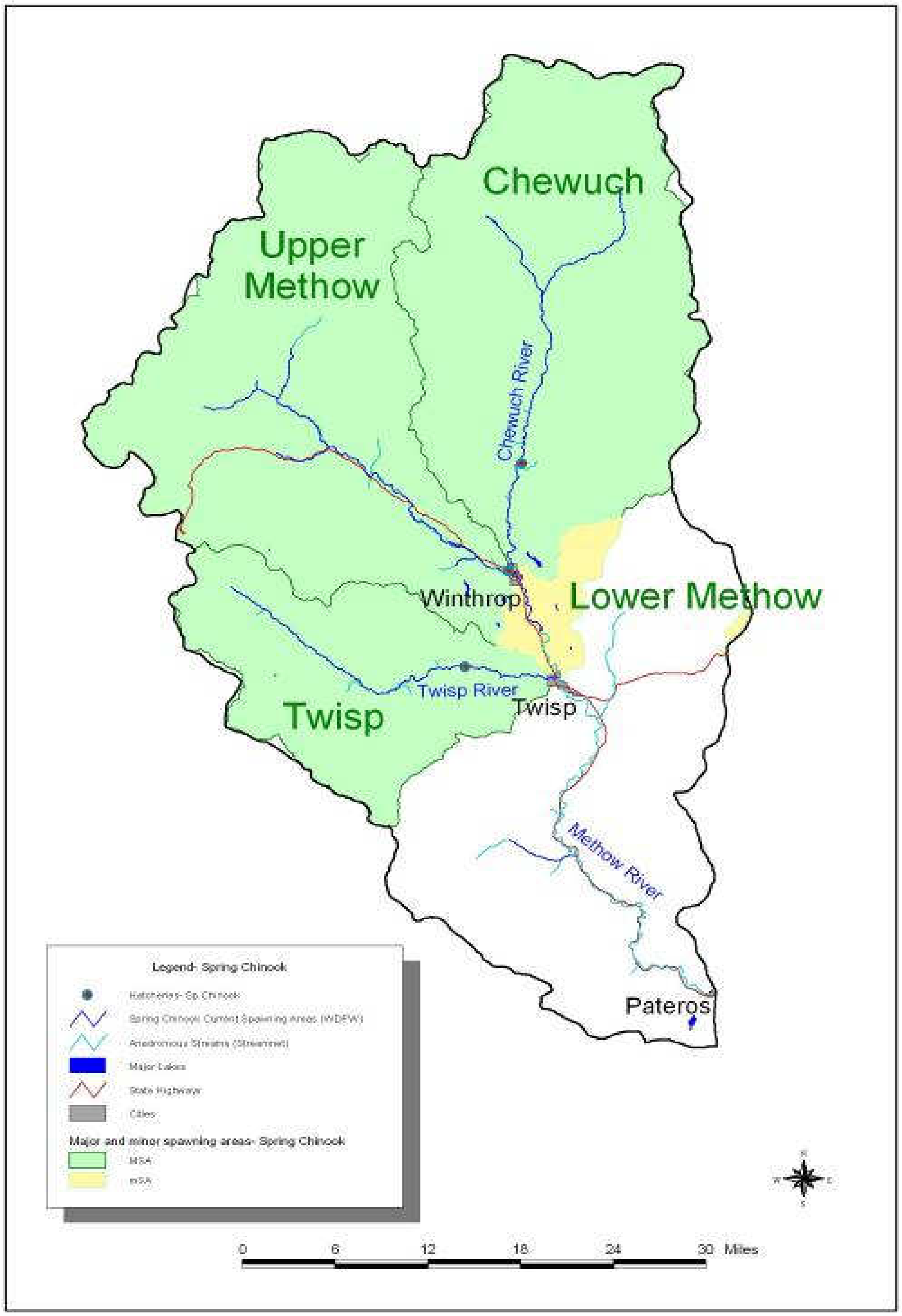


Figure 2.9 Current and potential distribution of spring Chinook in the Methow subbasin

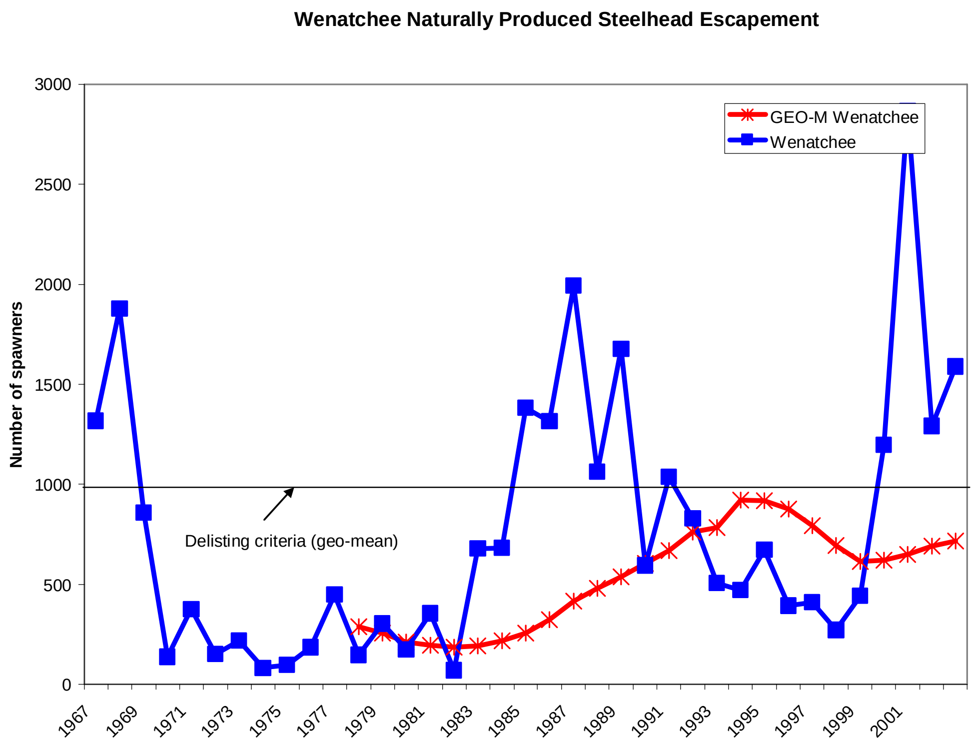


Figure 2.10 Escapement of naturally produced steelhead in the Wenatchee subbasin

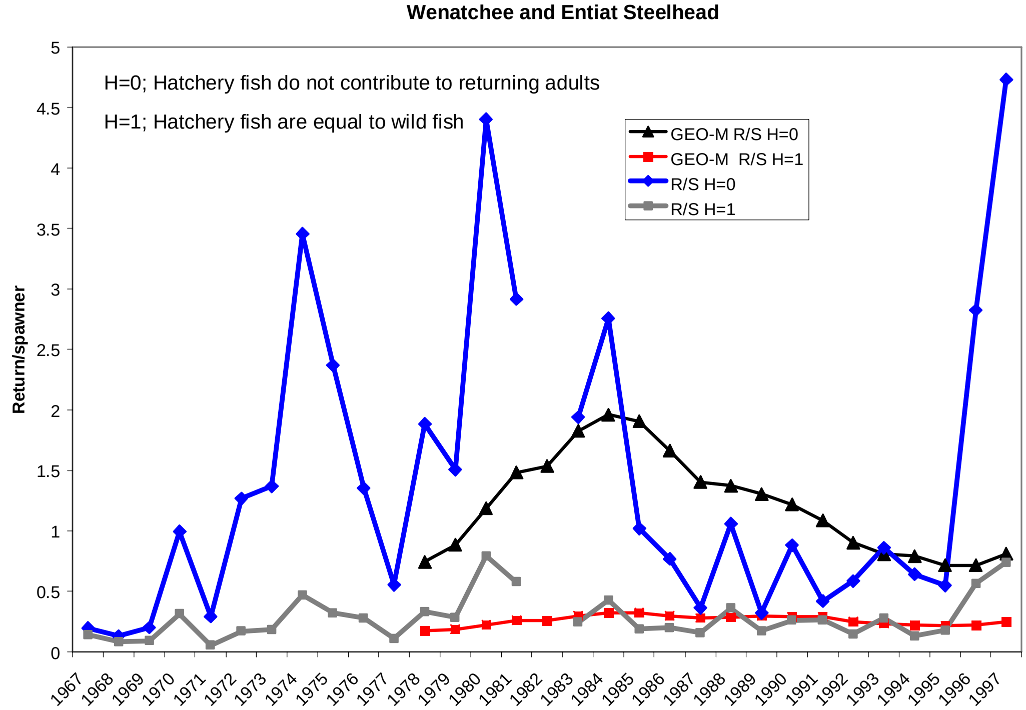


Figure 2.11 Returns per spawner (R/S) of naturally produced steelhead in the Wenatchee and Entiat subbasins. Returns per spawner are shown for hatchery fish that are as reproductively successful as naturally produced fish (H = 1) and hatchery fish that have no reproductive success (H = 0)

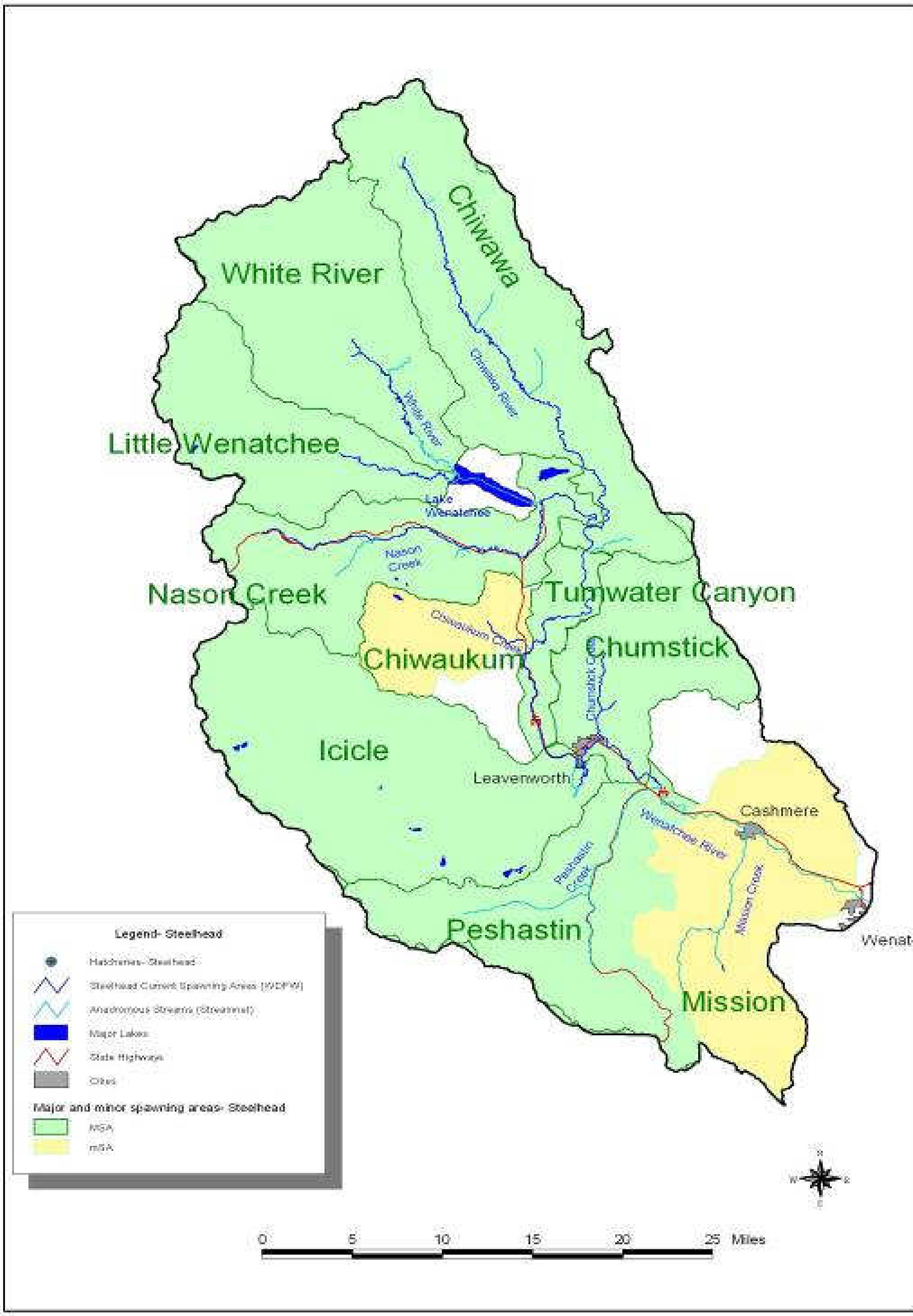


Figure 2.12 Current and potential distribution of steelhead in the Wenatchee subbasin

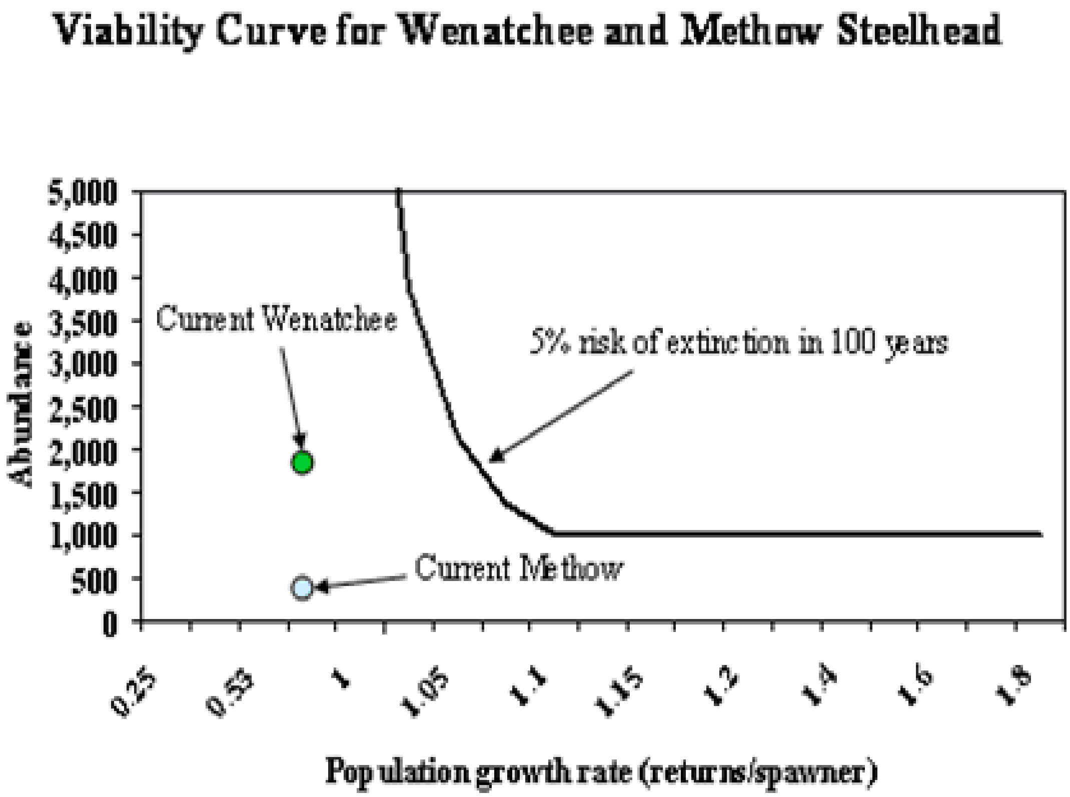


Figure 2.13 Viability curve for Wenatchee and Methow steelhead. This figure is based on the assumption that hatchery fish have no reproductive success. Variability should be considered as the abundance/productivity estimates approach viability criteria. Viability curve is from the ICBTRT (2005a). This plan recognizes that as abundance and productivity values approach the minimum viability thresholds it will be necessary to incorporate uncertainty and measurement error regarding the status of each population.

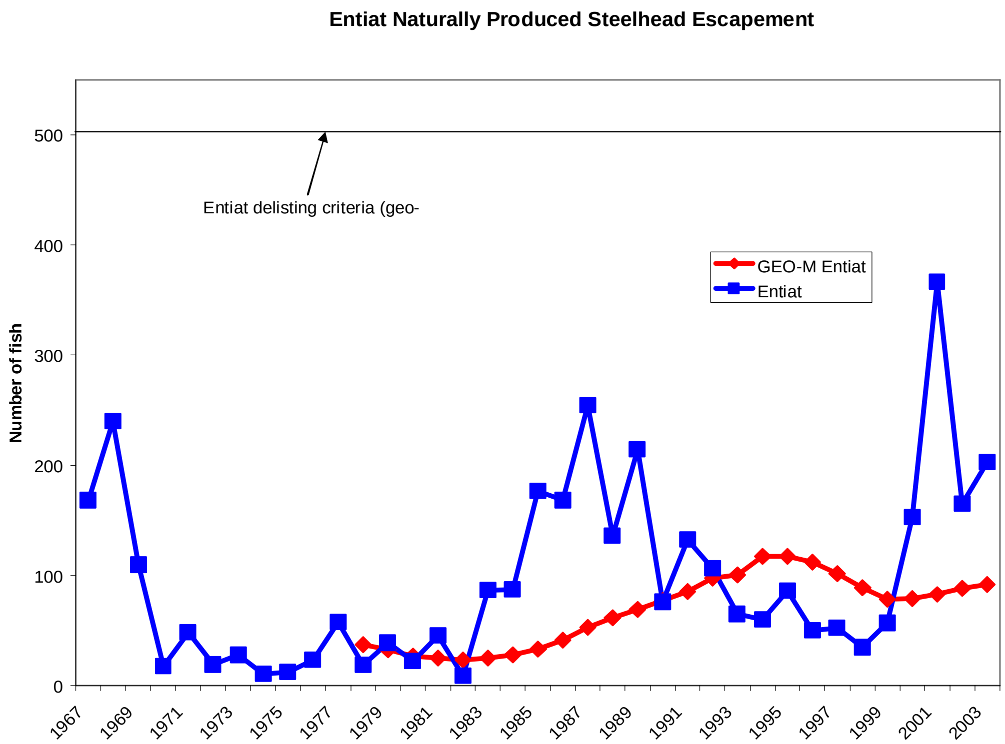


Figure 2.14 Escapement of naturally produced steelhead in the Entiat subbasin

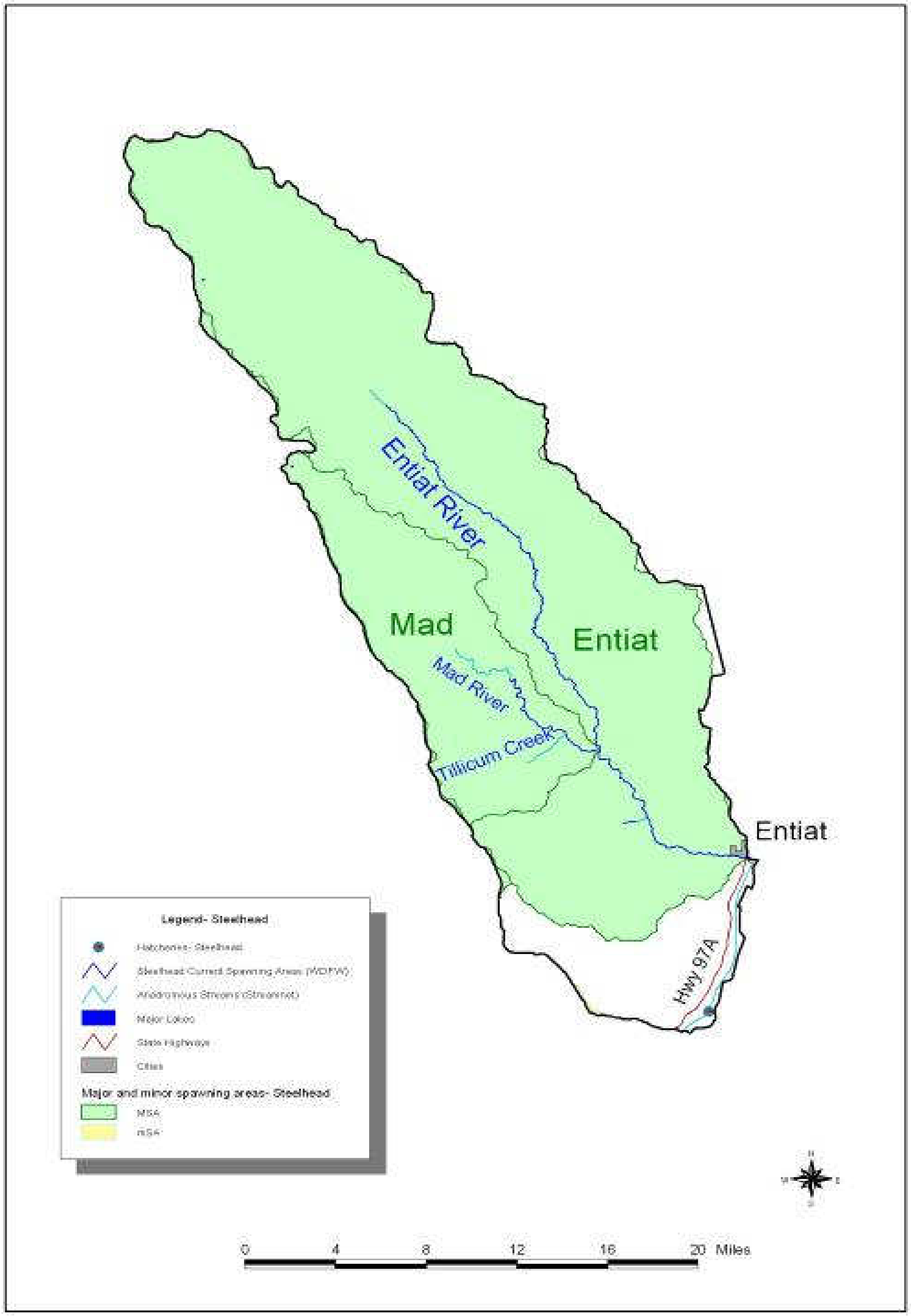


Figure 2.15 Current and potential distribution of steelhead in the Entiat subbasin

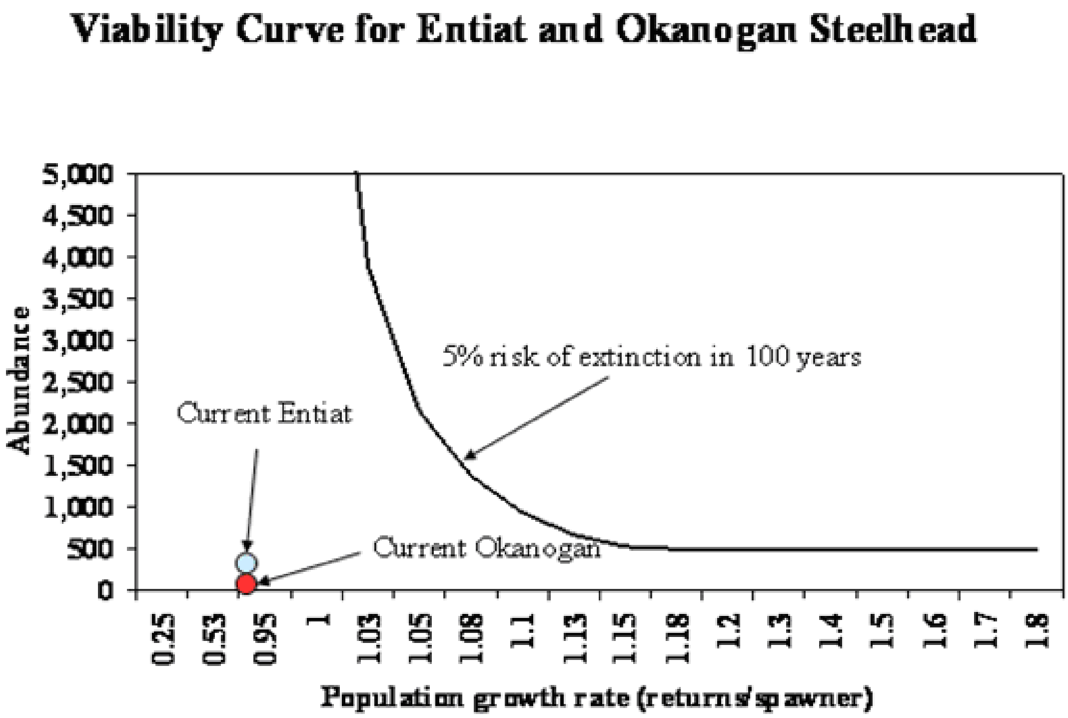


Figure 2.16 Viability curve for Entiat and Okanogan steelhead. Assumes hatchery fish have no reproductive success. Variability should be considered as the abundance/productivity estimates approach viability criteria. Viability curve is from the ICBTRT (2005a). This plan recognizes that as abundance and productivity values approach the minimum viability thresholds it will be necessary to incorporate uncertainty and measurement error regarding the status of each population.

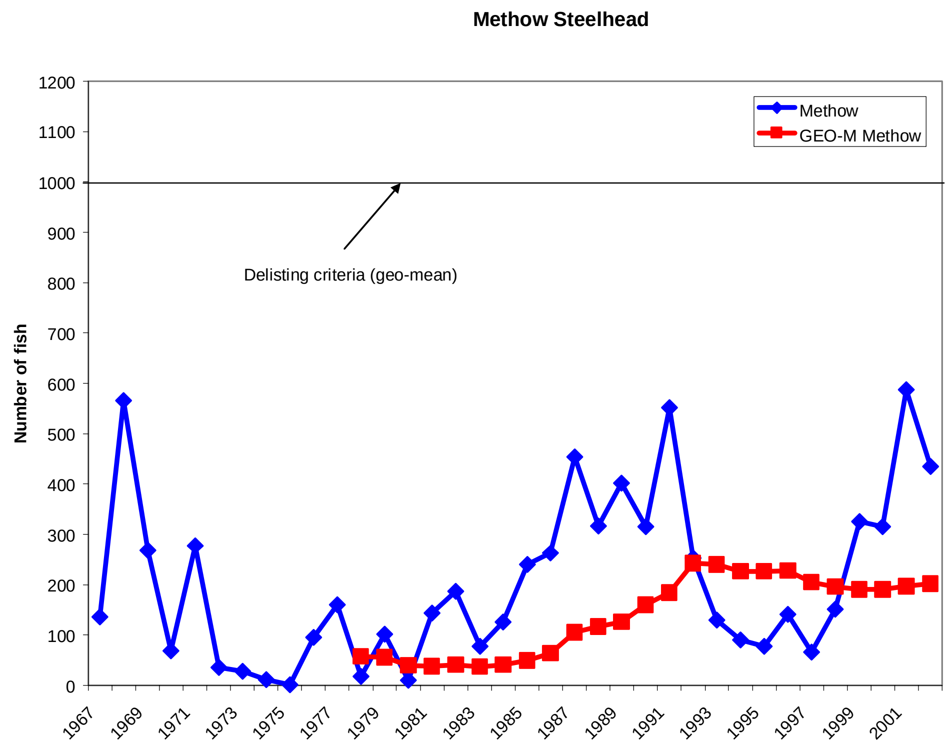
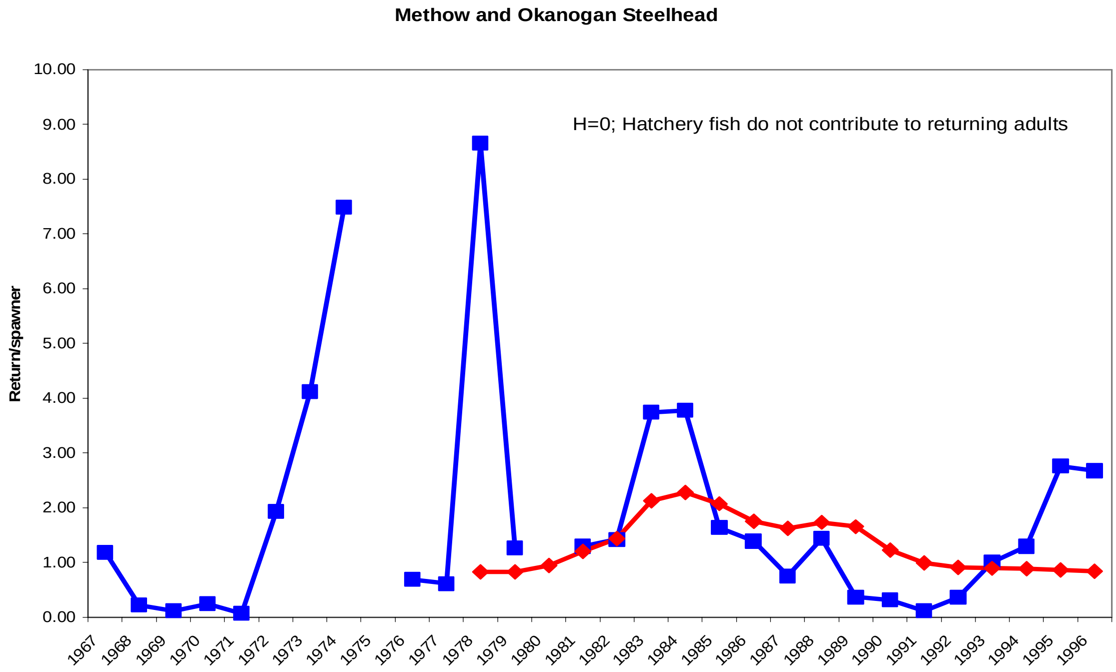


Figure 2.17 Escapement of naturally produced steelhead in the Methow subbasin



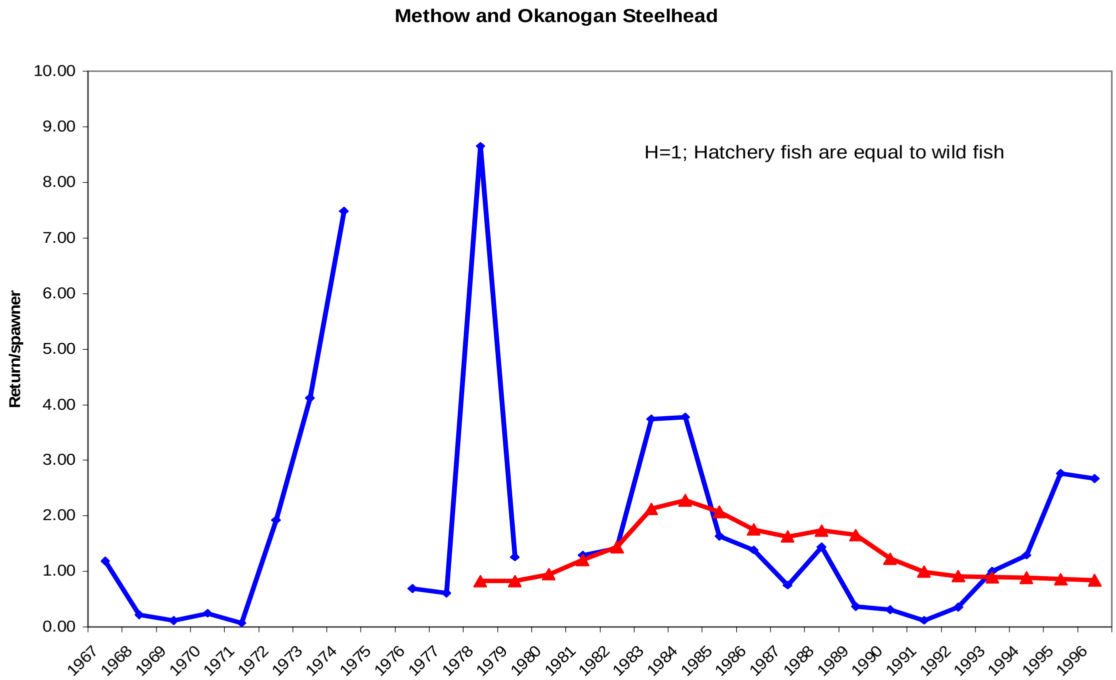


Figure 2.18 Returns per spawner of naturally produced steelhead in the Methow and Okanogan subbasins. Returns per spawner are shown for hatchery fish that have no reproductive success (H = 0) and hatchery fish that are as reproductively successful as naturally produced fish (H = 1).

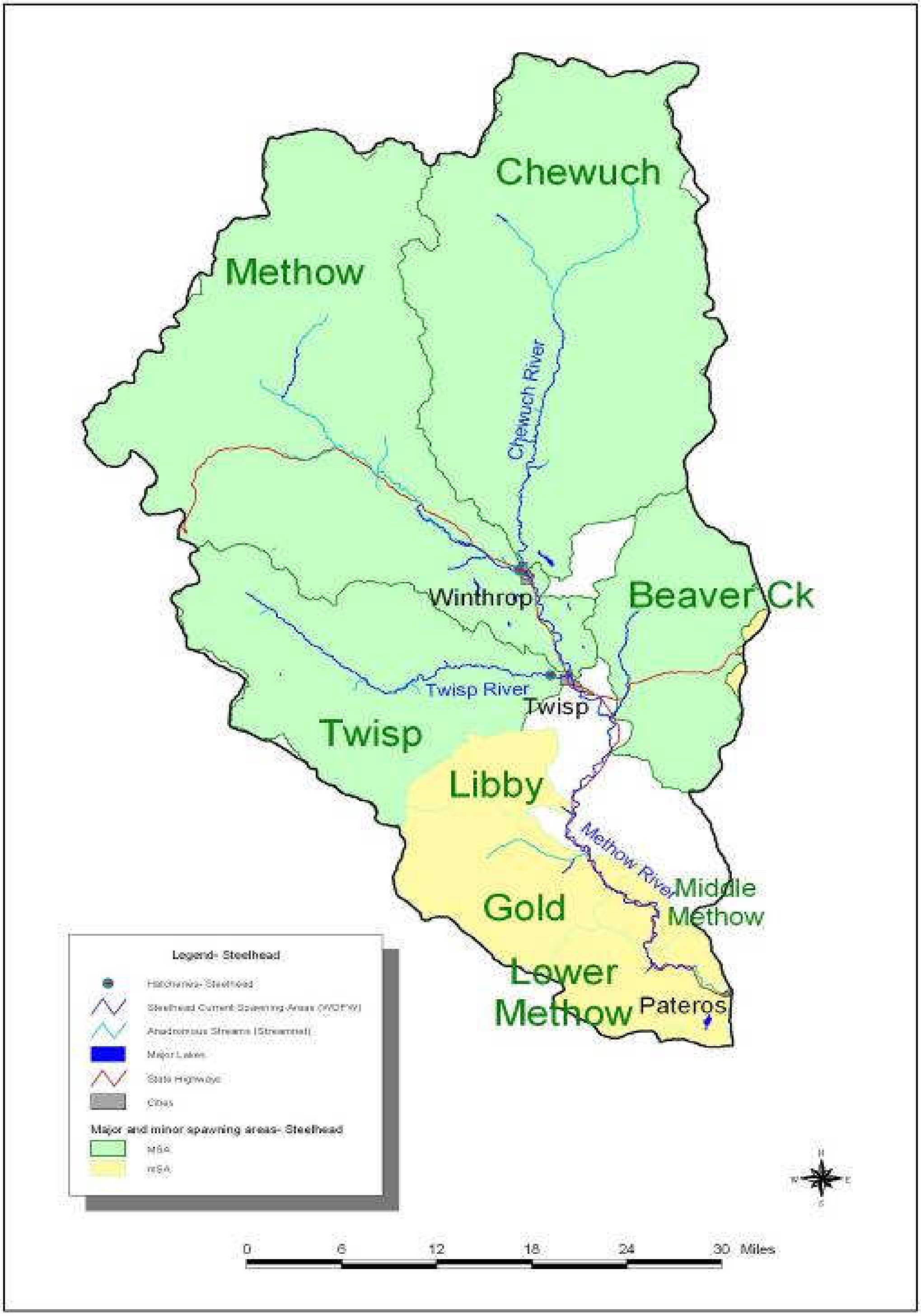


Figure 2.19 Current and potential distribution of steelhead in the Methow subbasin

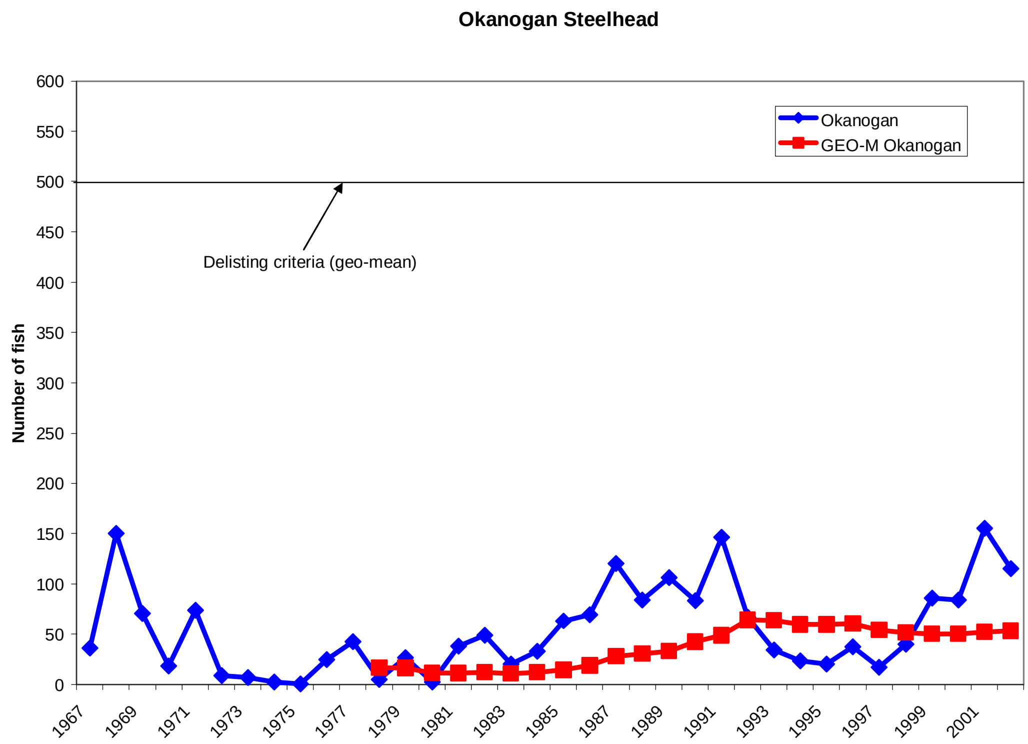


Figure 2.20 Escapement of naturally produced steelhead in the Okanogan subbasin

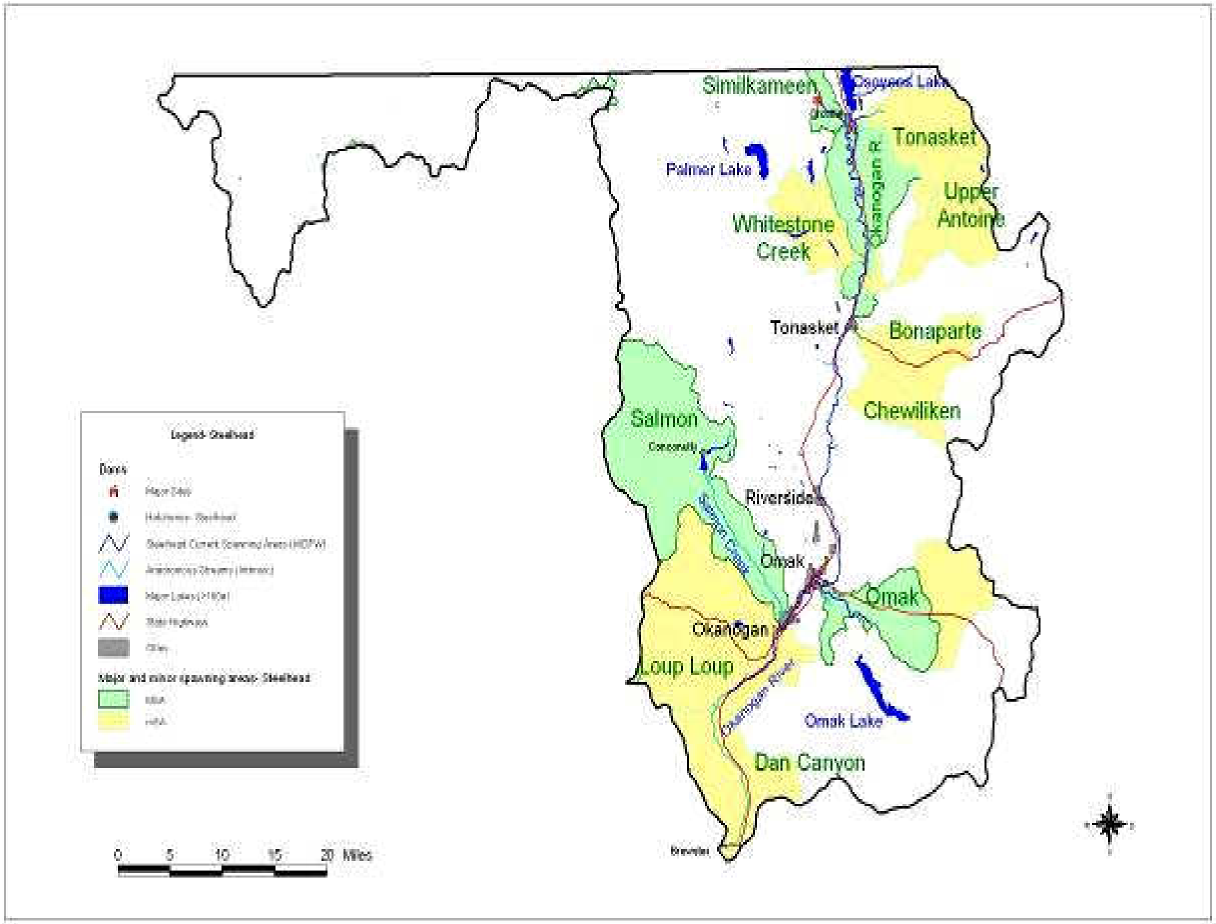


Figure 2.21 Current and potential distribution of steelhead in the U.S. portion of the Okanogan subbasin

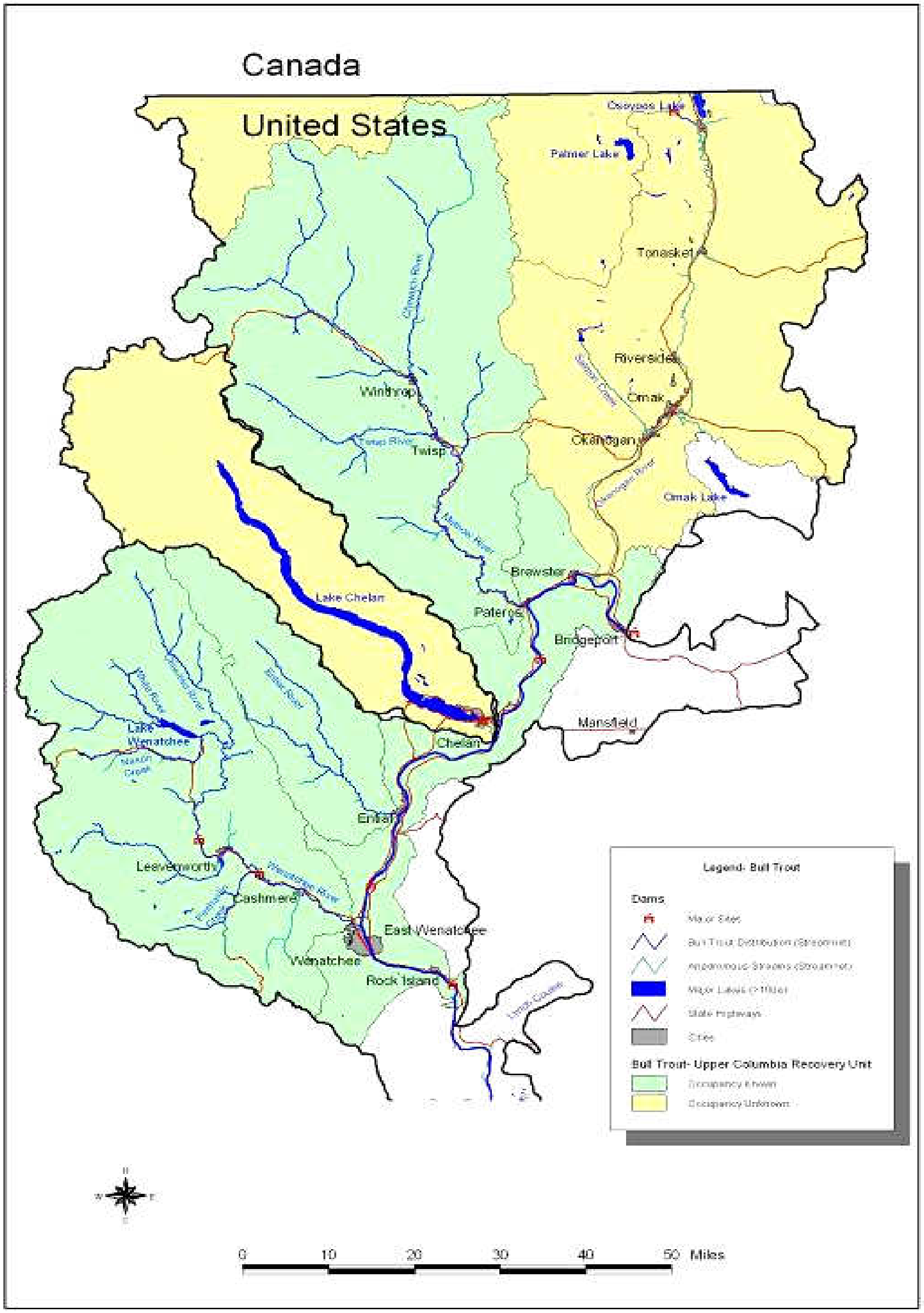


Figure 2.22 Current and potential distribution of bull trout in the Upper Columbia Basin

3 Factors for Decline

3.1 Social, Cultural, and Economic Factors	3.7 Habitat
3.2 Public Policy	3.8 Ecological Factors
3.3 Management Actions	3.9 Factors Outside the ESU and DPS
3.4 Harvest	3.10 Interaction of Factors
3.5 Hatcheries	3.11 Current Threats
3.6 Hydropower	3.12 Uncertainties

Historic and current human activities and governmental policies acting in concert with natural events have affected abundance, productivity, spatial structure, and diversity of Upper Columbia spring Chinook salmon, steelhead, and bull trout populations. A brief discussion follows of factors that limit the abundance, productivity, spatial structure, and diversity of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. A more detailed discussion can be found in the Bull Trout Draft Recovery Plan (USFWS 2002), watershed plans, and subbasin plans.

3.1 Social, Cultural, and Economic Factors

Humans, salmon, and trout colonized and expanded their range in the Columbia River Basin after the most-recent Ice Age (10,000-15,000 years BP). Native Americans developed a culture that relied extensively upon anadromous fish for sustenance in some portions of the area (Craig and Hacker 1940). Their catches increased as their populations rose and techniques of fishing developed. Native Americans captured large numbers of fish for both sustenance and trade, particularly at partial obstacles for fish passage. Their religion, heritage, and economy centered on salmon and other native species.

Native Americans in the Upper Columbia Basin generally had access to an abundant fish resource comprised of spring, summer, and fall runs of Chinook salmon, coho, and sockeye, and steelhead/rainbow as well as bull trout, cutthroat trout, Pacific lamprey, suckers, and white sturgeon. Historically, populations within the Columbia Basin varied widely from year to year and may have ranged from 6-16 million salmon and steelhead (Chapman 1986; NPPC 1986). Estimates of pre-development salmon and steelhead numbers were based on maximum catches in the latter part of the 1800s and assumed catch rates by all fishing gear. Inherent in such calculations is the assumption that fish populations in the 1800s represented a reasonable expression of average effects of cyclic variation in freshwater and ocean habitat conditions. Annual peak catches in the 1800s by all fishers may have included 3-4 million salmon and steelhead (Chapman 1986). Total run size for all salmon and steelhead recently (since 1980) has ranged from 1 to 2 million fish. About three-quarters of recent spring Chinook and summer steelhead runs have consisted of fish cultured to smolt size in hatcheries.

Bull trout have also experienced a reduction in abundance and distribution within their historical range in the coterminous (lower 48 states) United States (USFWS 2002). Throughout their historic range there have been local extirpations (e.g., Coeur d'Alene River Basin). Even in the absence of reliable historical population estimates, it is reasonable to assume that bull trout in the Upper Columbia Basin are less abundant today than they were historically. For example, bull trout are believed to be functionally extirpated in the Lake Chelan and Okanogan subbasins (i.e., few individuals may occur there but do not constitute a viable population). The USFWS (2002) considers bull trout in the Chelan and Okanogan subbasins as "occupancy unknown." Consequently, they are currently less widely distributed in the Upper Columbia Basin than they were historically.

Several social/economic factors depressed numbers of spring Chinook, steelhead, and bull trout sufficiently to lead to ESA listing. With regard to salmon and steelhead, Lackey (2001) wrote:

> The depressed abundance of wild stocks was caused by a well known but poorly understood combination of factors, including unfavorable ocean or climatic conditions; excessive commercial, recreational, and subsistence fishing; various farming and ranching practices; dams built for electricity generation, flood control, and irrigation, as well as many other purposes; water diversions for agricultural, municipal, or commercial requirements; hatchery production to supplement diminished runs or produce salmon for the retail market; degraded spawning and rearing habitat; predation by marine mammals, birds, and other fish species; competition, especially with exotic fish species; diseases and parasites; and many others. Technocrats continue to vigorously debate what proportion of the decline is attributable to which factor.

3.2 Public Policy

Public policy is a course of governmental action or inaction in response to social and environmental problems. It is expressed in goals articulated by political leaders in formal statutes, rules, and regulations; and in the practices of administrative agencies and courts charged with implementing or overseeing programs. Some policies can have negative effects on the survival of salmon, steelhead, and bull trout. For example, early efforts by the Corp of Engineers to minimize the effects of floods included diking, channelization, and removal of woody debris. These efforts reduced habitat diversity and species productivity. Another example that negatively affected the viability of bull trout included the directed bull trout fishery (reduction program) by the Washington Department of Game (WDG) in the region.

The Marine Mammal Protection Act of 1976 afforded pinnipeds (seals and sea lions) protection from killing by humans. These animals increased sharply in abundance thereafter (Fresh 1996). The National Research Council (NRC 1996) discussed the potential for effects on salmon and steelhead. They concluded that such predation was "probably not a major factor in the current decline of salmon in general." However, in some years about 50% of the salmon and steelhead in the Snake River show markings or scars that could be attributed to pinnipeds (from Fish Passage Center weekly reports). Although pinnipeds and salmon coexisted long before man interfered ecologically, human alterations and management practices throughout the species range have resulted in a reduction in salmon and steelhead abundance to the point that increased or targeted predation can have more significant effects on population viability.

As another example, the Corps of Engineers dredges shipping channels in the lower Columbia River and has created artificial islands with the spoils. Caspian terns have exponentially increased in the Columbia River estuary after dredge spoils created near-ideal nesting sites within the boundaries of a USFWS refuge. Many PIT tags have been found on artificial island sites, demonstrating that terns may be very important predators on smolts that must pass through the estuary to reach the sea.

Public policy clearly has more ubiquitous influences, both direct and indirect, than the foregoing examples (NRC 1996). Mainstem dams are a direct outgrowth of public policy, constructed by the federal government (Chief Joseph, Grand Coulee, and four mainstem Columbia River dams downstream from the Snake River) or by public utilities licensed by the Federal Energy Regulatory Commission (Wells, Rocky Reach, Rock Island, Wanapum, and Priest Rapids dams).

The Washington State Office of Financial Management has projected that human population growth will nearly double in the next two decades in many areas in the Upper Columbia region, placing further pressure on natural resources and the environment (http://www.ofm.wa.gov/pop/gma/). Local governments apply these projections as they relate to their planning population allocation to urban growth areas and rural lands.

3.2.1 Local Government Policies, Regulations, and Programs

The local governments (cities, towns, counties, and Colville Tribes) in the Upper Columbia Region have a significant role in the development, adoption, implementation, and enforcement of land-use regulations that address existing and future threats to listed species. In Washington State, land-use planning and a wide array of environmental protection programs are mandated at the state level, but developed, adopted, and implemented at the local level (e.g., counties, cities, and towns). The same is generally true with the Colville Tribes, although their statutory authority is derived from federal regulations and related obligations. This means that threats to recovery of listed species from future development, land uses, and land and facilities management activities can be best addressed by local governments and the Tribes, including criteria regarding development, adoption, implementation, monitoring, and enforcement of land use and environmental protection regulations that affect the habitat of listed species.

Local government programs and regulations that potentially affect listed species can be divided into the following categories:

- Comprehensive Plans (land use, water, wastewater, stormwater, sold waste, etc.)
- Implementing Regulations (zoning, critical areas, shorelines, development standards, etc.)
- Permitting Processes (conditional use, substantial development, building, variance, exemptions, etc.)
- Code Enforcement/Compliance
- Environmental Review (SEPA and NEPA)

The local governments in the Upper Columbia Region and Tribes have numerous policies, regulations, and programs that are designed to avoid or minimize impacts to the environment from activities associated with human land use and management activities. The decline in salmon and trout habitat has resulted from numerous diverse human activities and natural processes over a biologically short period of time. Many of the activities that contributed to decline in salmon habitat conditions occurred before current policies, regulations, and programs were enacted. Therefore, the existence of degraded habitat does not necessarily mean that local government and Tribal policies, regulations, and programs are inadequate, as most were non-existent during the period of decline. However, as part of the recovery planning process, a review of programs that are now in place was undertaken to determine if either compliance or implementation can be improved to aid in recovery.

The review process began by generating a list of specific plans, programs, and activities under the purview of local governments. For each plan, program, and activity, their purpose was described and their relationships to recovery of listed species, VSP parameters, and ESA threats criteria were evaluated (Appendix D). The review process found that most of the local governments in the region are either in compliance or are actively working on obtaining compliance on a wide array of state and federal programs aimed at protecting, restoring, and enhancing the environment (Appendix D).

3.3 Management Actions

Golder Associates (2004) recently compiled a list of management programs related to fish and wildlife from 25 federal, state, and local agencies and governments in the Upper Columbia basin. They gathered the information through a review of existing documents and websites, and through direct contact with agencies. Management programs, sponsors or lead agencies, area affected by the program, the goal of the program, and a determination of the threats of the program to Chinook, steelhead, and bull trout are listed in Appendix E.

In sum, there are at least 132 management programs and projects being implemented in the Upper Columbia Basin. If the programs are implemented correctly and monitored for compliance, most of the programs (103 programs) promote the survival of spring Chinook, steelhead, and bull trout; 16 should have no effect or may promote survival.[47] Thirteen programs may threaten the viability of Chinook, steelhead, and bull trout in the Upper Columbia Basin. All hatchery programs have the potential to threaten viability by reducing the diversity of locally derived stocks. For example, the Entiat and Leavenworth National Fish Hatchery programs use out-of-basin stocks, which if stray into natural spawning areas, may affect the diversity and perhaps spawning success of naturally produced spring Chinook and steelhead (see Section 3.5). On the other hand, hatchery programs may also support recovery by increasing abundance of listed species. The U.S. Bureau of Reclamation (BOR) and the Army Corps of Engineers (ACOE) have programs that may threaten the viability of Chinook, steelhead, and bull trout populations. The Chief Joseph Dam Project (ACOE) and the Okanogan Project (BOR) probably affected or may affect spatial structure and productivity by reducing connectivity and decreasing stream flows needed for rearing and spawning. Programs that are designed to protect property and lives from flood damage can decrease viability of populations by decreasing habitat diversity and complexity. This plan does not advocate programs that could result in loss of property or

[47] Threats to viability were determined by asking two general questions: (1) does the program affect the biology of Chinook, steelhead, and bull trout and (2) does the program affect the environment in which the fish live? Issues considered under the biology of the fish included affects to abundance, spatial structure, genetics, fecundity, survival, habitat use, and community structure. Issues considered under the environment included affects to water quality, flows and hydrology, habitat access, habitat quality, channel condition, riparian condition, and watershed condition. If a given program could negatively affect any of these attributes, the program was considered a possible threat to the viability of the fish.

lives. The point here is that some of these programs are not necessarily consistent with measures for establishing viable fish populations.

A management practice that deserves to be highlighted is the introduction of exotic fish species into the Upper Columbia Basin. Of the approximately 41 fish species in the Upper Columbia Basin, 16 are exotics (see Section 2.2). One species, brook trout, threatens the viability of bull trout in the Upper Columbia Basin. Brook trout are well established in several streams in the Wenatchee, Entiat, Lake Chelan, Methow, and Okanogan subbasins. Hybridization between brook trout and bull trout has been observed in the Chiwawa Basin and in Icicle Creek (T. Hillman, BioAnalysts, personal observation). Hybridization "pollutes" the bull trout gene pool and can result in offspring that are often sterile. Brook trout can also displace bull trout from rearing areas. In some streams (e.g., Big Meadow, Beaver, and Eightmile creeks), brook trout are so well established that they may have greatly reduced the numbers of bull trout in them (USFWS 2002). Current fishing regulations limit the harvest of exotic species. This protects exotic species and could be considered a threat as it reduces potential harvest of fish that compete or prey on ESA-listed species.

3.4 Harvest

It is unlikely that aboriginal fishing (pre-1930s) was responsible for spring Chinook and steelhead declines in the Columbia River (Craig and Hacker 1940; Chapman 1986; Lackey 1999). Their artisanal fishing methods (Craig and Hacker 1940) were incapable of harvesting Upper Columbia River spring Chinook and summer steelhead at rates that approached or exceeded optima for maximum sustained yield, probably 68% and 69% for spring Chinook and steelhead, respectively, as estimated in Chapman (1986).

Even the large aboriginal fishery in the upper reaches of the Columbia River did not significantly reduce the abundance of anadromous fish. The fishery at Kettle Falls, which is presently submerged under the waters of Lake Roosevelt, was second only to Celilo Falls in its overall ceremonial significance and productivity. In the 1800s, before establishment of commercial fisheries in the lower Columbia River, the combined aboriginal harvest of salmon and steelhead in the Upper Columbia River was estimated in excess of two million pounds annually (Koch and Cochran 1977).

Commercial fishing had a significant effect on the abundance of salmon and steelhead in the Columbia River. An intense industrial fishery in the lower Columbia River, employing traps, beach seines, gillnets, and fish wheels, developed in the latter half of the 1800s. In the early 1900s, troll fisheries developed to catch salmon even before they reached the Columbia River. The late-spring and early summer Chinook salmon returns, which constituted the heart of the Columbia River runs, were decimated by the early 1900s (Thompson 1951). As these run components rapidly declined, fishing shifted earlier, later, and to other species. These changes, for a time, numerically masked the precipitous decline in the sought-after late-spring and early summer fish.

By the early 1930s, mean escapement of spring Chinook into the Upper Columbia Basin upstream from Rock Island Dam had declined to fewer than 3,000 fish.[48] That escapement would represent perhaps 12,000 fish arriving in the lower Columbia River, inasmuch as fishing rates exceeded 75% in that period. Mean returns of steelhead to the Upper Columbia Basin were lower than 4,000 fish in the first part of the 1930s. Harvest rates of 70%, and probably higher, were common before the 1940s. If one assumes a 70% harvest rate, returns of Upper Columbia steelhead to the estuary may have amounted to about 13,000 fish.

By the 1930s and 1940s, restrictions on fishing time and gear had increased. For example, purse seines were outlawed in 1917, whip seines in 1923, fish wheels in 1927 (in Oregon), seines and traps east of Cascade Locks in Oregon in 1927, drag seines, traps, and set nets in 1935 (Washington), and seasons were gradually shortened. Catch rates almost certainly were much higher than those appropriate for maximum sustained yield for several decades before then. Presently, fishing rates have been reduced well below historical levels and approach about 12% for spring Chinook and 13% for steelhead.[49]

Intensive harvest not only affected abundance and productivity of fish stocks, but probably also the diversity of populations. Intense size-selective fishing is known to alter genetics of salmon with the result that adult size declines. Historically, intense gillnetting (a method that selectively captures larger fish) in the Columbia River may have increased the proportion of smaller fish in escapements, with potential increases in jack fractions and reduced fecundity of females. Three-ocean spring Chinook adults may have been selected against at earlier high fishing rates. Harvest may have truncated run-timing characteristics or separated runs into early and late components. Harvest also reduced escapements of adults into tributaries, resulting in a reduction of marine-derived nutrients into tributaries.

Fishing was likely an important factor leading to the decline of bull trout in the Upper Columbia Basin. Certain areas within the basin were targeted bull trout fisheries, and large numbers of bull trout were harvested (WDFW 1992). For example, bull trout were harvested commercially in Lake Chelan (Brown 1984). Currently, with the exception of a bull trout fishery on the Lost River, bull trout harvest is prohibited. Although bull trout harvest is prohibited, they are still vulnerable to take due to misidentification, hooking mortality, and poaching. Schmetterling and Long (1999) found that only 44% of anglers correctly identified bull trout, and anglers frequently confused related species (i.e., bull trout and brook trout). Incidental hooking mortality is known to vary from about 5% to 24% for salmonids caught on artificial lures, and between 16% and 58% for salmonids caught with bait (Taylor and White 1992; Schill 1996; Schill and Scarpella 1997). Bull trout are incidentally caught during the sockeye salmon fishery in Lake Wenatchee and also during open seasons for mountain whitefish (USFWS 2002). The effects of hooking mortality, incidental harvest, and poaching could be significant (Taylor and White 1992; Long 1997; Schmetterling and Long 1999).

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[48] According to the Brennen Report (1938), many of the Chinook counted at Rock Island Dam were destined for spawning areas upstream from Grand Coulee Dam.

[49] These rates do not include indirect losses such as catch-and-release mortality, hook-and-loss mortality, and “shaker” loss. Indirect losses can range from 5-58% (Taylor and White 1992; Schill 1996; Schill and Scarpella 1997). Managers generally assume a 10% indirect loss.

3.5 Hatcheries

Presently, WDFW, USFWS, the Yakama Nation, and the Colville Tribes operate 22 artificial production programs in the Upper Columbia Basin, producing spring and summer Chinook, sockeye, coho, and steelhead. Twelve of these programs produce spring Chinook and steelhead. USFWS operates three and WDFW, the others. The three Federal hatcheries (Winthrop, Entiat, and Leavenworth hatcheries) were constructed as mitigation facilities to compensate for the lack of access and loss of spawning and rearing habitat caused by the construction of Grand Coulee Dam. At the time, it was estimated that 85-90% of the fish counted at Rock Island Dam originated upstream from Grand Coulee Dam. About half the spring Chinook ESU and steelhead DPS were taken out of production by these dams. These Federal hatcheries released co-mingled upriver stocks into the Wenatchee, Entiat, and Methow subbasins during the early 1940s. They also released out-of-basin stocks from the lower Columbia River into the Upper Columbia Basin.[50] Currently, the Winthrop National Fish Hatchery is the only federal hatchery in the Upper Columbia Basin that releases locally derived stock.[51] Hatcheries operated by WDFW are for supplementing existing stocks. These programs use locally derived stock for supplementation. Although hatcheries are an integral part of the hydro mitigation programs for the Upper Columbia, they are not intended to be a substitute for healthy, abundant spawning and rearing habitat.

Artificial production programs in the Upper Columbia Basin may have affected abundance, productivity, and diversity of naturally produced stocks in several different ways. The NRC (1996) and Flagg et al. (2001) discussed at length the risks and problems associated with use of hatcheries to compensate for, or supplement, fish produced in the wild. NRC (1996) noted demographic risk, pointing out that large-scale releases of hatchery fish exacerbate mixed-stock harvest problems, thereby reducing the abundance of naturally produced fish. Naturally produced fish cannot sustain harvest rates that would be appropriate for hatchery fish.

Measures used in the GCFMP and steelhead management in the Upper Columbia Basin (until recently) quite likely led to some of the listed risks and contributed to decreased genetic diversity of naturally produced fish. For example, steelhead adults were collected at Priest Rapids, and later at Wells Dam, their progeny reared in hatcheries and released as smolts to the various tributaries without regard to fostering local adaptation in tributaries. As another example, the similarity of DNA (deoxyribonucleic acid) collected from natural Entiat River spring Chinook and Entiat NFH samples indicates that Entiat NFH spring Chinook spawn successfully and have introgressed into or may have replaced the natural Entiat River population (Ford et al. 2004).

However, in the Ford et al. (2004) genetic study, the sample size was small and it only covered a limited number of years when spawning escapement of non-local origin hatchery fish was very high. Therefore, it is possible that the Entiat spring Chinook population could have less risk if genetic samples were evaluated over a longer time period with larger sample sizes.

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[50] The first out-of-basin stocks were released from early Washington Department of Fisheries hatcheries dating back to at least 1914 (Chapman et al. 1995).

[51] Locally derived stock refers to broodstock derived from a target population consisting of naturally produced fish and or hatchery produced fish derived from the naturally produced fish of the target populations.

An effect of hatcheries that is little studied, but one that may have affected the abundance and productivity of populations in the Upper Columbia Basin, is the assumed lower reproductive success of hatchery fish that spawn in the wild. That is, hatchery-reared fish that spawn in the wild often have a lower breeding success than naturally produced spawners. For example, Berejikian and Ford (2004) found that the relative reproductive success of hatchery-produced steelhead in an Oregon stream was as low as 2-13%.

Foraging, social behavior, time of spawning, and predator avoidance can differ for fish reared in the hatchery and in the wild (Flagg et al. 2001). While resulting differences may primarily reduce survival of hatchery-produced salmon and steelhead, negative effects may carry into a naturally produced population where adults of hatchery origin spawn with naturally produced fish. Effects of disease on released hatchery fish and on naturally produced fish are poorly understood, but likely to be negative (Flagg et al. 2001).

Hatchery programs may also have ecological effects that reduce the abundance and productivity of populations in the Upper Columbia Basin. NRC (1996) noted that 5.5 billion salmon smolts of all species are released to the wild each year around the Pacific Rim, with potential trophic effects that may lead to altered body size and survival of naturally produced fish. Emphasis on hatchery fish may also deny marine nutrients to infertile rearing streams used by relatively few naturally produced spring Chinook salmon and steelhead. Recent efforts, however, include the outplanting of hatchery carcasses in streams within the Upper Columbia Basin.

Because the Leavenworth and Entiat National Fish Hatcheries continue to release out-of-basin stocks of spring Chinook into their respective subbasins, these programs may be a threat to the diversity of locally derived spring Chinook in those systems. Tagging studies indicate that fish from the Leavenworth National Fish Hatchery generally have low stray rates (<1%) (Pastor 2004).[52] However, based on expanded carcass recoveries from spawning ground surveys (2001-2004), the Leavenworth National Fish Hatchery and other out-of-basin strays have comprised from 3-27% of the spawner composition upstream from Tumwater Canyon (WDFW, unpublished data). This stray information has contributed to the high-risk categorization of the Wenatchee population. Nonetheless, four years of data is not sufficient to evaluate the true spawner composition or its potential effects on the natural Wenatchee spring Chinook population.

Although state-operated artificial production programs emphasize use of locally derived stock for supplementation, they may also affect diversity and productivity of naturally produced stocks. For example, the supplementation programs may affect the age-at-return of spring Chinook, resulting in more younger-aged hatchery fish spawning in the wild (NMFS 2004). This could affect reproductive potential and ultimately productivity of naturally produced fish. The reproductive success of hatchery fish produced in supplementation programs that spawn naturally in the wild needs study. Additionally, straying of hatchery fish within and among populations can increase a population’s risk for genetic diversity. For example, risk increased because Wenatchee River steelhead strayed upstream of Rocky Reach Dam and Chiwawa River Hatchery spring Chinook comprised greater than 10% of the spawner composition in Nason Creek and the White and Little Wenatchee rivers in 2001 and 2002 (Tonseth 2003, 2004).

[52] It should be noted that prior to 1993, efforts to recover tags on spawning grounds varied.

Hatchery programs for steelhead occur in the Wenatchee, Methow, and Okanogan basins and are operated by WDFW, USFWS, and the Colville Tribes. These programs mitigate for habitat inundated by and juveniles killed at hydroelectric projects. Prior to 1997, most of the hatchery steelhead were of a co-mingled stock collected either at Priest Rapids or Wells dams. In 1997 WDFW began a program of Wenatchee steelhead with broodstock collected from the Wenatchee basin. The Methow and Okanogan basins continue to use broodstock collected at Wells Dam. The combined broodstock for the Methow and Okanogan basins and the high proportion of hatchery fish on the spawning grounds contributes to the high risk of the DPS.

Although there are currently no bull trout artificial propagation programs in the Upper Columbia Basin, the USFWS has determined that reaching a recovery condition in the Upper Columbia Basin within 25 years may require the use of artificial propagation. This may involve the transfer of bull trout into unoccupied habitat within the historic range. Artificial propagation may also involve the use of federal or state hatcheries to assist in recovery. Research is needed to evaluate the effectiveness and feasibility of using artificial propagation in bull trout recovery.

3.6 Hydropower

Spring Chinook and steelhead production areas in the pre-development period included the Wenatchee, Entiat, Methow, Okanogan, and limited portions of the Similkameen, Spokane, San Poil, Colville, Kettle, Pend Oreille, and Kootenay rivers.[53] Grand Coulee and Chief Joseph dams eliminated access to the Columbia River upstream of those projects. The GCFMP, designed to transfer populations formerly produced upstream into remaining habitat downstream from Grand Coulee, trapped fish at Rock Island in 1939-1943. Managers placed some adults in tributaries (e.g., Nason Creek) to spawn naturally, and artificially propagated others. Spring Chinook from outside the Upper Columbia Basin were introduced.[54] The construction of these dams and the GCFMP transfigured the abundance, spatial structure, and diversity of spring Chinook and steelhead populations in the Upper Columbia Basin (Chapman et al. 1995).

The era of mainstem multi-purpose dams downstream from the Grand Coulee project began with Rock Island Dam in 1933 and culminated with completion of Wells Dam and John Day Dam in 1967 and 1968, respectively. Seven mainstem dams lie between the Wenatchee River and the sea, eight downstream from the Entiat River, and nine between the Methow/Okanogan systems and the estuary. Adult salmon and steelhead losses at each project could be as high as 4% or more in some years (Chapman et al. 1994 and 1995), and juvenile losses at each project can amount to approximately 5-10%.[55] Some of the losses result from physical effects of adult and juvenile/smolt passage. Others derive from altered limnological conditions that increase predation by fish and birds. Whatever the direct causes, losses for Wenatchee adults and

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[53] Natural falls blocked salmon and steelhead access to some areas of the Spokane, Colville, Kettle, Pend Oreille, Similkameen, and Kootenay rivers.

[54] Spring Chinook from outside the Upper Columbia Basin were introduced because disease eliminated the original stock from being propagated. The fish introduced were a mixture of Upper Columbia and Snake River spring Chinook (Pastor 2004).

[55] Estimates of smolt mortality (per project and cumulative) rely more on PIT tag and acoustic tag survival studies for yearling Chinook and steelhead in the Upper Columbia Basin. Chapman et al. (1995) discussed uncertainties associated with inter-dam conversion rates for adults and mortality associated with dam passage cannot be separated from natural mortality.

juveniles could accumulate to an estimated 25% and 52%, respectively. For Methow River fish, which must pass two additional dams, losses may accumulate to an estimated 31% and 61% for adults and juveniles, respectively.[56] The cumulative loss rates also explain why so much mitigative effort has been allocated to hydroproject-related mortality rates.

Dams for storage, like Grand Coulee, and mainstem multipurpose dams have had other effects on the ecology of salmon and steelhead. Estuarine limnology has shifted from a basis of large organics and bottom invertebrates to small organics and planktonic organisms that favor non-salmonids (Chapman and Witty 1993). Spring freshet flows and turbidity have declined in the river and estuary, and the Columbia River plume has been reduced seasonally (Ebbesmeyer and Tangborn 1993; Chapman et al. 1994 and 1995; NRC 1996) with potential but largely unknown effects on survival of salmon and steelhead in the estuary and nearshore ocean.

The effects of dams on bull trout in the Upper Columbia Basin are less well understood. Dams on the mainstem Columbia River and tributaries have modified stream flows and temperature regimes, altered productivity, changed habitat quantity and quality, and blocked migration corridors. These changes probably affected the abundance and spatial structure of bull trout in the Upper Columbia Basin (Bull Trout Draft Recovery Plan 2002). However, recent research suggests that the increased trophic productivity of Columbia River reservoirs may benefit bull trout, because bull trout rearing in the reservoirs grow faster and larger there than do bull trout that remain in tributaries (BioAnalysts 2003). Recent and ongoing telemetry studies in the Upper Columbia Basin also indicate that adult bull trout move through the dams and arrive on spawning grounds within their spawning windows (BioAnalysts 2003). On the other hand, the effects of dams on juvenile bull trout movement and survival are unknown.

3.7 Habitat

Various land-use activities and management practices in concert with natural events may have affected the habitat used by Chinook salmon, steelhead, and bull trout in the Upper Columbia Basin. Activities within the Upper Columbia Basin that may have affected habitat conditions include diversions and dams, agricultural activities, stream channelization and diking, roads and railways, timber harvest, and urban and rural development (Mullan et al. 1992; Chapman et al. 1994, 1995; UCRTT 2003; Subbasin Plans 2004, 2005).

Limiting factors may not be fully understood within each subbasin. This plan relies on monitoring and adaptive management to assist in the identification of limiting factors and to assess effects of habitat actions. As such, the limiting factors identified in this plan can be considered working hypotheses, which can be tested to better understand the factors and associated threats that currently limit ESA-listed species in the Upper Columbia Basin (see Section 8.2).

Some of the factors that affected the habitat of the three species historically have been partially addressed through changes in land-use practices (e.g., diversions, fish screens, riparian buffer

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[56] Whether the loss rates per project are slightly higher or lower than shown, the cumulative loss rates provide an impression of the importance, relative to other factors, of mainstem dams as a factor for decline. The pre-dam loss rates for adults and smolts that pass through each project reach are unknown, but unlikely to have reached post-dam levels in most years.

strips, improved livestock management, etc.). However, as noted in the subbasin plans and watershed plans, there are activities that continue to affect the habitat of Chinook salmon, steelhead, and bull trout in the Upper Columbia Basin. Identified in Section 5.5.2 are limiting factors and their assumed causal mechanisms (threats) that affect habitat conditions for spring Chinook, steelhead, and bull trout in each subbasin. Within each subbasin (population or core area), the limiting habitat factors and causal agents are identified by assessment unit. Limiting factors and threats were derived from watershed plans, subbasin plans, EDT analysis, and the biological strategy prepared by the Upper Columbia Regional Technical Team (UCRTT 2003).

3.8 Ecological Factors

The biotic communities of aquatic systems in the Upper Columbia Basin are highly complex. Within aquatic communities, assemblages and species have varying levels of interaction with one another. Direct interactions may occur in the form of predator-prey, competitor, and disease- or parasite-host relationships. In addition, many indirect interactions may occur between species. For example, predation of one species upon another may enhance the ability of a third species to persist in the community by releasing it from predatory or competitive constraints (e.g., Mittelbach 1986; Hillman et al. 1989a). These interactions continually change in response to shifting environmental and biotic conditions. Human activities and management decisions that change the environment, the frequency and intensity of disturbance, or species composition can shift the competitive balance among species, alter predatory interactions, and change disease susceptibility. All of these changes may result in community reorganization and a reduction in Chinook, steelhead, and bull trout abundance and spatial structure. The overall effect of ecological factors on population viability is mostly unknown.

3.8.1 Competition

Competition among organisms occurs when two or more individuals use the same resources and when availability of those resources is limited (Pianka 2000). That is, for competition to occur, demand for food or space must be greater than supply (implies high recruitment or that the habitat is fully seeded) and environmental stresses few and predictable. Two types of competition are generally recognized: (1) interference competition, where one organism directly prevents another from using a resource through aggressive behavior, and (2) exploitation competition, where one species affects another by using a resource more efficiently. Salmonids likely compete for food and space both within species (intraspecific) and between species (interspecific). Interspecific interactions are more likely to occur between native and exotic species, rather than between species that coevolved together (Reeves et al. 1987; Hillman 1991).

Exotic species are more likely to interact with spring Chinook, steelhead, and bull trout because exotics have not had time to segregate spatially or temporally in their resource use. For example, there is a possibility that brook trout interact with spring Chinook, steelhead, and bull trout in the upper basin. Welsh (1994) found no evidence that brook trout displaced Chinook salmon. On the other hand, Cunjak and Green (1986) found that brook trout were superior competitors to rainbow/steelhead at colder temperatures (9°C), while rainbow/steelhead were superior at warmer temperatures (16°C). Brook trout are important competitors with bull trout (Dambacker et al. 1992; Nakano et al. 1998). Goetz (1989) reported that where brook trout and bull trout occur together, bull trout populations have declined.

Although coho salmon were native to the upper basin, they have been absent for many decades. Recently, there have been efforts to re-establish them in the Upper Columbia Basin (Murdoch et al. 2002). Because there is uncertainty about the positive or negative effects of the reintroduction program, studies are underway to evaluate the potential effects of the program on listed species.

A potentially important source of exploitative competition occurring outside the geographic boundary of the ESU and the DPS may be between the exotic American shad (***Alosa sapidissima***) and juvenile Chinook and steelhead. Palmisano et al. (1993a, 1993b) concluded that increased numbers of shad likely compete with juvenile salmon and steelhead, resulting in reduced abundance and production of salmon and steelhead.

3.8.2 Predation

Fish, mammals, and birds are the primary natural predators of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. Although the behavior of spring Chinook, steelhead, and bull trout precludes any single predator from focusing exclusively on them, predation by certain species can nonetheless be seasonally and locally important. Changes in predator and prey populations along with major changes in the environment, both related and unrelated to development and management decisions in the Upper Columbia Basin, have reshaped the role of predation (Mullan et al. 1986; Li et al. 1987).

Although several fish species consume spring Chinook, steelhead, and bull trout in the Upper Columbia Basin, northern pikeminnow, walleyes, and smallmouth bass have the potential to negatively affect the abundance of juvenile salmonids (Gray and Rondorf 1986; Bennett 1991; Poe et al. 1994; Burley and Poe 1994). These are large, opportunistic predators that feed on a variety of prey and switch their feeding patterns when spatially or temporally segregated from a commonly consumed prey. Channel catfish have the potential to significantly affect the abundance of juvenile salmonids (see e.g., Gray and Rondorf 1986; Poe et al. 1994), but because they are rare in the Upper Columbia (Dell et al. 1975; Burley and Poe 1994), they probably have a small effect on survival of juvenile spring Chinook, steelhead, and bull trout there. Native species such as sculpins and white sturgeon also prey on juvenile salmonids (Hunter 1959; Patten 1962, 1971a, 1971b; Mullan 1980; Hillman 1989). Sculpins eat large numbers of juvenile Chinook and steelhead in tributaries (Hillman 1989).

Most adult salmonids within the Upper Columbia Basin are opportunistic feeders and are therefore capable of preying on juvenile spring Chinook, steelhead, and bull trout. Those likely to have some affect on the survival of juvenile salmonids include adult bull trout, rainbow/steelhead trout, cutthroat trout, brook trout, and brown trout. Of these, bull trout and rainbow trout are probably the most important; however, cutthroat trout are also known to prey on other salmonids.[57] These species occur together with juvenile spring Chinook, steelhead, and

[57] The recovery of ESA-listed species that prey on other ESA-listed species (e.g., bull trout that prey on juvenile spring Chinook and steelhead) may appear to be counterproductive. However, the recovery levels established in this plan for bull trout will not prevent the recovery of the other listed species. The three ESA-listed species evolved together in the Columbia Basin and their niches are sufficiently segregated to prevent one species from driving the others to extinction. Large bull trout are generalists and will not prey exclusively on spring Chinook and steelhead.

bull trout in most tributaries; hence the probability for interaction is high. The presence of migrant stocks of bull trout in the region further increases the likelihood for interaction there.

Predation by piscivorous birds on juvenile salmonids may represent a large source of mortality. Fish-eating birds that occur in the Upper Columbia Basin include great blue herons (***Ardea herodias***), gulls (***Larus*** spp.), osprey (***Pandion haliaetus***), common mergansers (***Mergus merganser***), American dippers (***Cinclus mexicanus***), cormorants (P***halacrocorax*** spp.), Caspian terns (***Sterna caspia***), belted kingfishers (***Ceryle alcyon***), common loons (***Gavia immer***), western grebes (***Aechmophorus occidentalis***), black-crowned night herons (***Nycticorax nycticorax***), and bald eagles (***Haliaeetus leucocephalus***) (T. West, Chelan PUD, personal communication). These birds have high metabolic rates and require large quantities of food relative to their body size. In the Columbia River estuary, avian predators consumed an estimated 16.7 million smolts (range, 10-28.3 million smolts), or 18% (range, 11-30%) of the smolts reaching the estuary in 1998 (Collis et al. 2000). Caspian terns consumed primarily salmonids (74% of diet mass), followed by double-crested cormorants (***P. auritus***) (21% of diet mass) and gulls (8% of diet mass). The NMFS (2000) identified these species as the most important avian predators in the Columbia River basin.

Mammals may be an important agent of mortality to spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. Predators such as river otters (***Lutra Canadensis***), raccoons (***Procyon lotor***), mink (***Mustela vison***), and black bears (***Ursus americanus***) are present in the Upper Columbia Basin. These animals, especially river otters, are capable of removing large numbers of salmon and trout (Dolloff 1993). Black bears consume large numbers of salmon (and bull trout),[58] but generally scavenge post-spawned salmon. Pinnipeds, including harbor seals (***Phoca vitulina***), California sea lions (***Zalophus californianus***), and Stellar sea lions (***Eumetopia jubatus***) are the primary marine mammals preying on Chinook and steelhead originating from the Upper Columbia basin (Spence et al. 1996). Pacific striped dolphin (***Lagenorhynchus obliquidens***) and killer whale (***Orcinus orca***) may also prey on adult Chinook and steelhead. Seal and sea lion predation is primarily in saltwater and estuarine environments though they are known to travel well into freshwater after migrating fish. All of these predators are opportunists, searching out locations where juveniles and adults are most vulnerable. These species have always interacted to some degree.

The UCSRB supports immediate adoption of more effective predator control programs, including lethal removal when necessary, of the marine and avian predators that have the most significant negative impacts on returns of Upper Columbia Basin ESA-listed salmonid fish stocks.

3.8.3 Disease and Parasitism

Spring Chinook, steelhead, and bull trout can be infected by a variety of bacterial, viral, fungal, and microparasitic pathogens. Numerous diseases may result from pathogens that occur naturally in the wild or that may be transmitted to naturally produced fish via infected hatchery fish. In most cases, environmental stress (such as unsuitable temperatures) reduces the resistance of fish

[58] Evidence of bears preying on bull trout has been noted several times in Nason and Rock creeks in the Wenatchee subbasin.

to disease. Among the infections are bacterial diseases, including bacterial kidney disease (BKD), columnaris, furunculosis, redmouth disease, and coldwater disease; virally induced diseases, including infectious hepatopoietic necrosis (IHN), infectious pancreatic necrosis (IPNV), and erythrocytic inclusion body syndrome (EIBS); protozoan-caused diseases, including ceratomyxosis and dermocystidium; and fungal infections, such as saprolegnia (Bevan et al. 1994). One theory is that disease may have contributed to the loss of bull trout in the Lake Chelan subbasin (Brown 1984). Numerous bull trout covered with fungus (a secondary infection)[59] were found dead along the shoreline shortly before the last bull trout were observed in the subbasin.

Chinook in the Columbia River have a high incidence of BKD (Chapman et al. 1995). Incidence appears higher in spring Chinook (Fryer 1984) and can be a major problem in hatchery-reared Chinook throughout the Columbia Basin (Chapman et al. 1995). Viral infections such as IPNV have been detected in hatchery steelhead in the Upper Columbia region (Chapman et al. 1994).

Sublethal chronic infections can impair the performance of Chinook, steelhead, and bull trout in the wild, thereby contributing secondarily to mortality or reduced reproductive success. Fish weakened by disease are more sensitive to other environmental stresses. Additionally, they may become more vulnerable to predation (Hoffman and Bauer 1971), or less able to compete with other species. For example, both Hillman (1991) and Reeves et al. (1987) found that water temperature affected interactions between redside shiners and the focal species. Both researchers noted that outcomes of interactions were, in part, related to infection with ***F. columnaris***. In their studies, most Chinook and steelhead were infected at warmer temperatures, whereas shiners showed a higher incidence of infection at cooler temperatures.

3.9 Factors outside the ESU and DPS

The most comprehensive and instructive index of spring Chinook and steelhead survival beyond the boundary of the ESU and the DPS (downstream from the mouth of the Yakima River) is smolt-to-adult return rate (SAR). It is a common survival index used to characterize the performance of salmonid populations throughout the Pacific Northwest. This survival index reflects all agents of mortality affecting the life cycle of salmon and steelhead from migrating smolts through returning adults. Various sources of mortality acting on populations during this portion of their life cycle include:[60]

- Hydrosystem operations
- Migration conditions in the mainstem, including both natural and man-made causes (e.g., actions associated with urbanization and industrialization) and their effects on water quality (e.g., total dissolved gases and temperature)
- Fish condition, which can vary annually by hatchery or rearing stream
- Marine/estuarine conditions and processes influenced by natural and man-made factors

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[59] Fungus is a secondary infection. The primary cause could have been an infectious agent, a toxic substance, or some other factor (USFWS 1990).
[60] An estimate of the relative effect of each factor on SAR cannot be calculated at this time.

- Harvest in marine and riverine waters
- Predation

Changes in ocean conditions can have large effects on SARs. For example, adult returns during the period 1980-1999, during periods of poor ocean conditions, were much lower than those during better ocean conditions (2000-2004). In the QAR assessment, results for Upper Columbia spring Chinook showed the survival improvement required to avoid the risk of extinction criteria was either 95, 47, or 2% depending on whether a historical time period back to 1980, 1970, or 1960 (a period of better ocean conditions) was used, respectively. If one were to add recent years (2000-2004, representing better ocean conditions) to the analysis, estimated required survival increases would decrease by about one third or more. Recovery will require sufficient abundance and productivity to withstand the periods of poor ocean conditions.

SARs can be calculated in different ways. Juvenile salmonids implanted with either passive integrated transponder (PIT) tags or coded wire tags (CWT) can be used to estimate SAR, if returning adults can be sampled at strategic locations. Alternatively, the survival index can be calculated by estimating smolt abundance passing some site (e.g., a dam or the mouth of a tributary), then subsequently estimating adult returns to that location for a specific brood year. Often, SARs are expressed in terms of return rates to the mouth of the Columbia River. This calculation requires additional information such as estimates of in-river harvest and adult passage mortality. SARs expressed in terms of return rates to the mouth of the Columbia River are less useful when evaluating viability, because viability is based on how many fish reach the spawning grounds, not the Columbia River mouth.

3.9.1 Spring Chinook

Historical estimates of SARs for naturally produced spring Chinook in the Upper Columbia Basin have been reported by Mullan et al. (1992) and Raymond (1988). Mullan et al. (1992) estimated smolt-to-adult return rates for the collective populations produced in the Wenatchee, Entiat, and Methow rivers for the years 1967 -1987. Over that period, SARs ranged from 2.0 to 10.1%. These estimates reflected corrections for adult passage mortality as well as marine and in-river harvest. Therefore, these rates overestimate the survival of adults back to the spawning grounds.

Raymond (1988) estimated percent returning hatchery and naturally produced adults to Priest Rapids Dam for the years 1962 through 1984. Values for naturally produced and hatchery spring Chinook ranged from 0.3 to 4.9% and 0.1 to 4.5%, respectively, over those years. One reason Raymond's values were generally lower than those reported by Mullan et al. (1992) may be that his estimates were not adjusted for adult passage mortality and marine harvest, whereas Mullan's were. Also, the reference locations for calculating SARs differed, with Raymond focusing on dam counts and the other investigators referencing the spawning grounds. Therefore, Raymond's estimates of SAR would also overestimate the survival of adults back to the spawning grounds.

WDFW (unpublished data) recently calculated an eight-year (1993-2000) geometric mean SAR for naturally produced spring Chinook from the Chiwawa River, a watershed in the Wenatchee Subbasin. They estimated numbers of smolts from a trap located near the mouth of the Chiwawa River. They calculated adults using broodstock, tributary spawning escapement, and harvest estimates. They derived spawning escapement estimates from total ground redd counts, expanded by the male to female ratio of broodstock collected from the Chiwawa Weir. They estimated harvest rates by using a surrogate stock (spring Chinook from the Leavenworth National Fish Hatchery), which have a probability of harvest similar to naturally produced Chiwawa stock. WDFW estimated an eight-year geometric mean SAR of 0.63 (standard deviation of ±0.63). Unlike other SARs, this estimate reflects survival of adults back to the spawning grounds, which provides the most relevant assessment of viability.

3.9.2 Steelhead

Raymond (1988) estimated smolt-to-adult return percentages for the combined naturally produced and hatchery steelhead population, 1962-1984. Adult return rates to Priest Rapids Dam ranged from a low of 0.2% for the smolt migration of 1977 to a high of 6.4% for the 1982 smolt migration. Mullan et al. (1992) reported SARs for only one stock, Well Hatchery steelhead, during the period 1982-1987. The percent return to the mouth of the Columbia River averaged 6.38%, ranging from 1.32 to 14.28%. Survival back to Wells Dam averaged 3.01% and ranged from 0.72 to 7.31%. These estimates aligned closely with Raymond's estimates for the overlapping years 1982-1984. Chapman et al. (1994) compiled data from three hatcheries in the Upper Columbia (Chelan, Entiat, and Leavenworth) for the years 1961-1991. Smolt-to-adult survival averaged 1.7%, with a range from 0.16-7.54%.

3.10 Interaction of Factors

As noted above, a wide range of factors have affected the abundance, productivity, spatial structure, and diversity of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. What is less clear is how different factors have interacted to depress populations within the Upper Columbia Basin.

Presently, harvest has been greatly reduced from historic levels, dams are addressing ways to increase passage and reservoir survival, hatcheries are addressing spatial structure and diversity issues, and habitat degradation is being reduced by implementation of recovery projects, voluntary projects, voluntary efforts of private landowners, improved land management practices on public and private lands, and changing regulations. Nevertheless, additional actions must be taken within all the Hs in order for listed stocks in the Upper Columbia Basin to recover. Actions taken within one or two Hs will not recover listed populations. For example, hatcheries can only be effective to sustain a fishery if habitat also remains in good condition. In the same way, changes only within the hydropower system will not in itself lead to recovery. Because all the Hs, and their interactions, affect the viability of listed populations in the Upper Columbia Basin, actions implemented within all Hs are needed to recover the populations.

Populations within the Upper Columbia River Basin were first affected by the intensive commercial fisheries in the lower Columbia River. These fisheries began in the latter half of the 1800s and continued into the 1900s and nearly extirpated many salmon and steelhead stocks. These fisheries largely affected the abundance, productivity, and diversity of stocks in the Upper Columbia Basin. With time, the construction of dams and diversions, some without passage, blocked salmon and steelhead migrations, fragmented bull trout populations, and killed upstream and downstream migrating fish. Dams and diversions reduced the abundance and productivity of stocks, but also affected their spatial structure by blocking historic spawning and rearing areas. Early hatcheries constructed to mitigate for fish loss at dams and loss of spawning and rearing habitat were operated without a clear understanding of population genetics, where fish were transferred without consideration of their actual origin. Although hatcheries were increasing the number of natural spawners, they also decreased the diversity and productivity of populations they intended to supplement.

Concurrent with these activities, human population growth within the basin was increasing and numerous land uses (agriculture, mining, timber harvest, transportation systems, and urban and rural development), in many cases encouraged and supported by governmental policy, were degrading and polluting salmon and trout spawning and rearing habitat. In addition, exotic (non-native) species were introduced by both public and private interests throughout the region that directly or indirectly affected salmon and trout. All these activities (harvest, hydropower, hatcheries, and habitat) acting in concert with natural disturbances (e.g., drought, floods, landslides, fires, debris flows, and ocean cycles) have decreased the abundance, productivity, spatial structure, and diversity of Chinook salmon, steelhead, and bull trout in the Upper Columbia Basin.

One way to assess the effects of different Hs and their interactions is to integrate smolts/redd estimates (measure of tributary productivity) and SARs (measure of factors outside the subbasin) and examine the interaction of the two factors on population viability. WDFW (unpublished data) calculated smolts/redd and SARs for naturally produced spring Chinook in the Wenatchee subbasin. These data suggest that at current smolts/redd estimates for the Wenatchee subbasin, SARs need to be higher than 1% to reach a population growth rate of 1.0 (returns/spawner) (**Figure 3.1**). Lower SARs (1.0%) result in population growth rates of 1.0 if tributary habitat is capable of producing more than 300 smolts/redd. However, at the high spawner abundances needed for recovery, juvenile productivity (smolts/redd) is expected to decrease because of density-dependent effects (**Figure 3.2**). The available data suggest that the pristine habitat of the Chiwawa River can only produce 200-300 smolts/redds at the abundances that will be required to meet adult spawner targets for recovery (**Figure 3.2**).[61] During periods of poor ocean conditions, tributary productivity will need to be sufficiently high to maintain a population growth rate of 1.0. Currently, these estimates are only available for spring Chinook in the Wenatchee subbasin. Similar data are needed from other populations within the Upper Columbia Basin. Further development of this analysis and application to other populations is needed to assess the contribution of tributary actions to recovery.

3.11 Current Threats

The previous sections identified factors that led to the decline of Upper Columbia spring Chinook, steelhead, and bull trout. In this section the plan summarizes current threats to the continued existence of the three species. These threats are organized according to the five categories as set forth in Section 4(a)(1) of the ESA and all apply to this recovery plan:

- The present or threatened destruction, modification, or curtailment of its habitat or range.
- Overutilization for commercial, recreational, scientific, or educational purposes.
- Disease or predation.

[61] These data must be used cautiously. They currently lack a sufficient number of productivity estimates at high spawner abundances.

- Inadequacy of existing regulatory mechanisms.
- Other natural or human-made factors affecting its continued existence.
- The information outlined in this section comes from the Federal Register Rules and Regulations, watershed plans, and subbasin plans.

3.11.1 Spring Chinook

The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range

- Although land and water management activities have improved, factors such as dams, diversions, roads and railways, agriculture (including livestock grazing), residential development, and historic forest management continue to threaten spring Chinook and their habitat in some locations in the Upper Columbia Basin.
- Water diversions without proper passage routes disrupt migrations of adult spring Chinook.
- Unscreened diversions trap or divert juvenile spring Chinook resulting in reduced survival.
- Hydroelectric passage mortality reduces abundance of migrant spring Chinook.
- Sedimentation from land and water management activities is a cause of habitat degradation in some salmon streams.
- Loss of habitat complexity, off-channel habitat, and large, deep pools due to sedimentation and loss of pool-forming structures such as boulders and large woody debris threatens spring Chinook and their habitat in some locations in the Upper Columbia Basin.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

- The effects of recreational fishing on naturally produced spring Chinook may be heightened during fisheries for hatchery produced Chinook.
- Incidental harvest mortality in mixed-stock fisheries and commercial fisheries contributes to the loss of naturally produced spring Chinook.
- Illegal harvest (poaching) continues to threaten spring Chinook.

Disease or Predation

- The presence of non-native (exotic) species (e.g., walleye and smallmouth bass) has resulted in increased predator populations that prey on spring Chinook.
- Increased predation by northern pikeminnow affects the survival of downstream migrating spring Chinook.
- Avian predation is a threat to spring Chinook populations.
- Predation by pinnipeds is also a concern.

Inadequacy of Existing Regulatory Mechanisms[62]

- The implementation and enforcement of existing Federal and State laws designed to conserve fishery resources, maintain water quality, and protect aquatic habitat have not been entirely successful in preventing past and ongoing habitat degradation.
- Although the Washington State Growth Management Act (GMA) and Shoreline Management Act (SMA) have been significantly changed to improve management, conditions and protection efforts for listed species, local regulatory improvements, and compliance monitoring (enforcement) have lagged behind because of political support and a lack of funding.
- The extent and distribution of Federal lands limits the ability of the Northwest Forest Plan and PACFISH/INFISH to achieve its aquatic habitat restoration objectives at watershed and river basin scales.
- The "base" State of Washington Forest Practice Rules do not adequately address large woody debris recruitment, tree retention to maintain stream bank integrity and channel networks within floodplains, and chronic and episodic inputs of coarse and fine sediment that maintain habitat that are properly functioning for all life stages of spring Chinook.
- Implementation of the Federal Clean Water Act has not been completely successful in protecting spring Chinook, particularly with respect to non-point sources of pollution.

Other Natural or Human-Made Factors Affecting its Continued Existence

- Natural climatic conditions (e.g., fires, floods, droughts, landslides, etc.)[63] can exacerbate the problems associated with degraded and altered riverine and estuarine habitats.
- Drought conditions reduce already limited spawning, rearing, and migration habitat.
- Poor ocean conditions (e.g., less upwelling, warm surface waters, etc.) negatively affect spring Chinook production.
- The use of non-locally derived broodstock for hatchery programs may negatively affect genetic integrity.
- The collection of naturally produced spring Chinook for hatchery broodstock may harm small or dwindling natural populations if not done with caution.
- Competition, genetic introgression, and disease transmission resulting from hatchery introductions may reduce the productivity and survival of naturally produced spring Chinook.

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[62] The UCSRB believes innovative and outcome based land-use planning and management techniques will be more effective in improving habitat conditions than increasing restrictive and prescriptive regulations.

[63] Natural disturbance is not necessarily a bad thing. Indeed, species richness and diversity are higher in areas with some disturbance ("Intermediate Disturbance Hypothesis"; Connell 1978). However, when disturbances occur too often (resulting from the cumulative effects of both natural and un-natural disturbances), species richness and diversity decrease because some species go extinct.

3.11.2 Steelhead

The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range

- Although land and water management activities have improved, factors such as dams, diversions, roads and railways, agriculture (including livestock grazing), residential development, and historic forest management continue to threaten steelhead and their habitat in some locations in the Upper Columbia Basin.
- Water diversions without proper passage routes disrupt migrations of adult steelhead.
- Unscreened diversions trap or divert juvenile steelhead resulting in reduced survival.
- Hydroelectric passage mortality reduces abundance of migrant steelhead.
- Sedimentation from land and water management activities is a cause of habitat degradation in some streams.
- Loss of habitat complexity, off-channel habitat, and large, deep pools due to sedimentation and loss of pool-forming structures such as boulders and large woody debris threatens steelhead and their habitat in some locations in the Upper Columbia Basin.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

- The effects of recreational fishing on naturally produced steelhead may be heightened during fisheries for hatchery-produced steelhead.
- Incidental harvest mortality in mixed-stock fisheries and commercial fisheries contributes to the loss of naturally produced steelhead.
- Illegal harvest (poaching) continues to threaten steelhead.

Disease or Predation

- The presence of non-native species (e.g., walleye and smallmouth bass) has resulted in increased predator populations that prey on steelhead.
- Increased predation by northern pikeminnow affects the survival of downstream migrating steelhead.
- Avian predation is a threat to steelhead populations.
- Predation by pinnipeds is also a concern.

Inadequacy of Existing Regulatory Mechanisms

- The implementation and enforcement of existing Federal and State laws designed to conserve fishery resources, maintain water quality, and protect aquatic habitat have not been entirely successful in preventing past and ongoing habitat degradation.
- Although the Washington State Growth Management Act (GMS) and Shoreline Management Act (SMA) have been significantly changed to improve management, conditions and

protection efforts for listed species, local regulatory improvements, and compliance monitoring (enforcement) have lagged behind because of political support and a lack of funding.

- The extent and distribution of Federal lands limits the ability of the Northwest Forest Plan and PACFISH/INFISH to achieve its aquatic habitat restoration objectives at watershed and river basin scales.
- The “base” State of Washington Forest Practice Rules do not adequately address large woody debris recruitment, tree retention to maintain stream bank integrity and channel networks within floodplains, and chronic and episodic inputs of coarse and fine sediment that maintain habitat that are properly functioning for all life stages of steelhead.
- Implementation of the Federal Clean Water Act has not been completely successful in protecting steelhead, particularly with respect to non-point sources of pollution.

Other Natural or Human-Made Factors Affecting its Continued Existence

- Natural climatic conditions (e.g., fires, floods, droughts, landslides, etc.) can exacerbate the problems associated with degraded and altered riverine and estuarine habitats.
- Drought conditions reduce already limited spawning, rearing, and migration habitat.
- Poor ocean conditions (e.g., less upwelling, warm surface waters, etc.) negatively affect steelhead production.
- The use of non-locally derived broodstock for hatchery programs may negatively affect genetic integrity.
- The collection of naturally produced steelhead for hatchery broodstock may harm small or dwindling natural populations if not done with caution.
- Competition, genetic introgression, and disease transmission resulting from hatchery introductions may reduce the productivity and survival of naturally produced steelhead.

3.11.3 Bull Trout

The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range

- Although land and water management activities have improved, factors such as dams, diversions, roads and railways, agriculture (including livestock grazing), residential development, and historic forest management continue to threaten bull trout and their habitat in some locations in the Upper Columbia Basin.
- Water diversions without proper passage routes disrupt movements of migrant bull trout.
- Unscreened diversions trap or divert juvenile bull trout resulting in reduced survival.
- Passage through hydroelectric projects may reduces abundance of migrant bull trout.
- Sedimentation from land and water management activities is a cause of habitat degradation in some bull trout streams.

- Loss of habitat complexity, connectivity, channel stability, decreased in-stream flow, and increased water temperatures due to land and water management activities threatens bull trout in some locations in the Upper Columbia Basin.

Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

- Illegal and incidental harvest (e.g., during the Lake Wenatchee sockeye fishery) reduces the abundance of bull trout in the Upper Columbia Basin.
- Harvest as a result of misidentification continues under existing fishing regulations.
- Poaching continues and can be especially detrimental to small, isolated, local populations of migratory bull trout.

Disease or Predation

- The presence of non-native species (e.g., brook trout, bass, lake trout, etc.) has resulted in increased predator populations that prey on juvenile bull trout.

Inadequacy of Existing Regulatory Mechanisms

- The implementation and enforcement of existing Federal and State laws designed to conserve fishery resources, maintain water quality, and protect aquatic habitat have not been entirely successful in preventing past and ongoing habitat degradation.
- Although the Washington State Growth Management Act (GMS) and Shoreline Management Act (SMA) have been significantly changed to improve management, conditions and protection efforts for listed species, local regulatory improvements, and compliance monitoring (enforcement) have lagged behind because of political support and a lack of funding.
- The extent and distribution of Federal lands limits the ability of the Northwest Forest Plan and PACFISH/INFISH to achieve its aquatic habitat restoration objectives at watershed and river basin scales.
- The “base” State of Washington Forest Practice Rules do not adequately address large woody debris recruitment, tree retention to maintain stream bank integrity and channel networks within floodplains, and chronic and episodic inputs of coarse and fine sediment that maintain habitat that are properly functioning for all life stages of bull trout.
- Implementation of the Federal Clean Water Act has not been completely successful in protecting bull trout, particularly with respect to non-point sources of pollution and water temperature.

Other Natural or Human-Made Factors Affecting its Continued Existence

- Natural climatic conditions (e.g., fires, floods, droughts, landslides, etc.) can exacerbate the problems associated with degraded and altered riverine habitat.
- Drought conditions can reduce already limited spawning, rearing, and migration habitat.

- Introduction of brook trout threatens bull trout through hybridization, competition, and predation.
- Introduction of non-native species for recreational fisheries may increase incidental catch and illegal harvest of bull trout.

As noted earlier, recent activities to address threats and reverse the long-term decline of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin are being initiated at Federal, State, and local levels (e.g., restrictive harvest regulations, adoption of various land management rules, and development of conservation strategies and plans). While these efforts are important to the conservation and recovery of ESA-listed species, additional work is needed to minimize threats to recovery (the subject of Section 5).

3.12 Uncertainties

The preceding sections described many of the important factors that have, and continue to, reduce the abundance, productivity, spatial structure, and diversity of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. It is clear that actions must be taken in all Hs (not just habitat) in order to recover listed populations. However, there are "key" areas of uncertainty[64] identified in Biological Opinions (BiOp), PATH (Plan for Analyzing and Testing Hypotheses), QAR analyses, USFWS Bull Trout Draft Recovery Plan, and Northwest Power and Conservation Council documents that can affect the success of actions implemented within each of the Hs. Resolution of uncertainties will greatly improve chances of attaining recovery goals outlined in this plan. These "key" uncertainties are highlighted below.

3.12.1 Ocean Productivity and Natural Variation

Global-scale processes in the ocean and atmosphere can regulate the productivity of marine, estuarine, and freshwater habitats of Chinook salmon and steelhead. Although managers cannot control these processes, natural variability must be understood to correctly interpret the response of salmon to management actions. For example, assessing needed survival improvements based on spawner returns from 1980-1999, during periods of below average climatic and other background conditions (Coronado and Hilborn 1998), has the effect of projecting these generally poor ocean conditions into the future. In the QAR assessment, results for Upper Columbia spring Chinook showed the survival improvement required to avoid the risk of extinction criteria was either 95, 47, or 2% depending on whether a historical time period back to 1980, 1970, or 1960 was used, respectively. If one were to add recent years (2000-2004, representing better ocean conditions) to the analysis, estimated required survival increases would decrease by about one third or more. Additional research is needed to help understand the mechanisms of ocean and climatic survival conditions, help improve forecasting and relating fisheries management capabilities, and help increase the likelihood that Upper Columbia populations persist over the full range of environmental conditions they are likely to encounter.

[64] Key uncertainties identify important gaps in our knowledge about the resources and functional relationships that determine fish viability.

3.12.2 Global Climate Change

The potential impacts of global climate change are recognized at national and international levels (Scott and Counts 1990; Beamish 1995; McGinn 2002). Many climate models project changes in regional snowpack and stream flows with global climate change. The effects of these changes could have significant effects on the success of recovery actions and the status of listed fish populations in the Upper Columbia Basin. The risks of global climate change are potentially great for Upper Columbia stocks because of the sensitivity of salmon stocks to climate-related shifts in the position of the sub-arctic boundary, the strength of the California Current, the intensity of coastal upwelling, and the frequency and intensity of El Nino events (NPCC 2004). Bull trout are particularly sensitive to water temperatures and it is uncertain how global climate change will affect their habitat. More research is needed to address the effects of climate change on ocean circulation patterns, freshwater habitat, and salmon and trout productivity.

3.12.3 Hatchery Effectiveness

Uncertainties exist regarding the potential for both benefits and harm of hatchery-produced fish on naturally spawning populations (see Section 5.3). A major uncertainty is whether it is possible to integrate natural and artificial production systems in the same subbasin to achieve sustainable long-term productivity. There is also uncertainty about the reproductive success of hatchery fish spawning in the wild. NOAA Fisheries evaluated survival requirements using a broad range of 20 to 80% historical effectiveness of hatchery-origin spawners to cover this uncertainty.[65] It is difficult to address the uncertainties and potential risks associated with hatcheries, because experimental methods for obtaining this information will take several years to get initial results and much longer before conclusions can be inferred from the empirical information. NOAA Fisheries and WDFW have initiated some of these studies in the Upper Columbia Basin and it is important that these experiments continue. Although supplementation is considered a potential benefit to recovery, it carries risks as noted here.

3.12.4 Density Independence

NOAA Fisheries analysis (2000 FCRPS BiOp) of needed survival improvements for spring Chinook and steelhead assumes that fish survival is independent of population density at all life stages. While density dependence is not apparent in single-stock models of population dynamics using only 1980-present data, PATH and others have found strong evidence of compensatory mortality (higher survival rates at lower population levels) and carrying capacity limits in Upper Columbia populations using data from the late 1950s to present. If the survival rates of Upper Columbia populations are density dependent at certain life stages (i.e., egg-to-smolt survival), then the analysis would tend to be pessimistic about extinction risks and optimistic with regard to survival increases necessary to achieve recovery levels. Incorporating density dependence would therefore tend to support lower risk for management actions that may not have immediate survival benefits, but require higher overall survival improvements to meet longer-term recovery goals. WDFW and the ICBTRT are currently drafting an approach for measuring tributary habitat performance that includes an evaluation of tributary density-dependence. They have

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[65] This plan used 0-100% effectiveness of hatchery-produced spawners in steelhead run reconstructions (see Appendix C).

identified density-dependence in smolt production for Wenatchee spring Chinook (**Figure 3.2**). Additional research on density dependence (independence) is needed to provide a better understanding of the potential benefit of actions over time.

3.12.5 Differential Delayed Mortality of Transported Chinook and Steelhead (D Value)

The differential delayed mortality of transported spring Chinook and steelhead (D value) is the estimated ratio of the post-Bonneville survival of transported fish relative to in-river migrating fish. This differential mortality can occur during any time from release downstream from Bonneville Dam, through the estuary and ocean life stage, and during adult upriver migration to the specific dam from which they were transported. The factors determining D are complex and poorly understood. Little information is available on potential D values for Upper Columbia spring Chinook and steelhead. Historical data when fish were transported from McNary indicate a D ranging from 0.8 to 1.0. This uncertainty has little effect under current conditions because few Upper Columbia stocks are currently transported. However, an improved understanding of D will be necessary to determine the appropriate role of McNary transportation in the future. Furthermore, the future role of transportation and the potential benefit of major hydro-system configurations are highly sensitive to this uncertainty.

3.12.6 Invasive Species

Another critical uncertainty is the effect of invasive species on the viability of listed populations in the Upper Columbia Basin. One such species, American shad, may affect the abundance and survival of spring Chinook and steelhead in the lower Columbia River. It is possible that the growing population of shad is competing directly with juvenile Chinook and steelhead by cropping food sources important to salmonids in the lower Columbia River. It is also possible that the large numbers of shad in the lower river contribute to the growth of northern pikeminnow, smallmouth bass, and walleye, which are important predators of salmon and steelhead. Shad may be sustaining large populations of predators during periods when salmon and steelhead are not available to the predators, and, as a result, more and larger predators are present during periods when salmon and steelhead are moving through the lower Columbia River.

Brook trout is an invasive species within the Upper Columbia Basin that competes with bull trout for food and space. Brook trout can hybridize with bull trout and adult brook trout are known to feed on juvenile bull trout. Research is needed to assess the direct and indirect effects of invasive species (including invasive plants)[66] on the abundance and survival of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin.

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[66] A short list of invasive plants include denseflower cordgrass, giant hogweed, Hydrilla, salt meadow cordgrass, Brazilian elodea, common cordgrass, Eurasian watermilfoil, fanwort, garden loosestrife, indigobush, parrotfeather, Japanese knotweed, perennial pepperweed, purple loosestrife, saltcedar, smooth cordgrass, wand loosestrife, water primrose, yellow floating heart, common reed, leafy spurge, curly-leaf pondweed, hairy whitetop, hoary cress, reed canarygrass, and yellow flag iris.

3.12.7 Independent Populations

ICBTRT and QAR identified independent spring Chinook and steelhead populations within the Upper Columbia Basin. QAR and PATH assessments assumed that spawning aggregations of an ESU or a DPS behaved as independent populations in isolation. Likewise, the Bull Trout Draft Recovery Plan (USFWS 2002) identified independent "core" bull trout populations, which are made up of several "local" populations. Given the geographic proximity and genetic similarity of many of these sub-groups, the assumption of independence is questionable and may lead to pessimistic assessments of needed survival improvements. Research regarding population structures, natural straying and movement among aggregations, and improvements to the assessment methods to include meta-population dynamics may be warranted. The monitoring program outlined in this plan and detailed in the Upper Columbia Monitoring Strategy (Hillman 2004), completed watershed plans, and subbasin plans will contribute substantially to resolving this uncertainty.

3.12.8 Effects of Dams on Bull Trout

The Bull Trout Draft Recovery Plan (USFWS 2002) has identified dams as an important factor for the decline of bull trout in the Upper Columbia Basin. Although it is true that dams can affect salmonids by delaying or impeding migration of adults and by injuring or killing juveniles that pass downstream, there is currently little information on the effects of dams on bull trout in the Upper Columbia River. Recent research by BioAnalysts (2002, 2003) indicates that adult bull trout passed through mainstem PUD dams with no loss and arrived on spawning grounds within their spawning window. In contrast, there is virtually no information on the effects of mainstem dams on juvenile (or subadult) bull trout. Additional work is needed to assess the effects of dams on the viability of bull trout in the Upper Columbia Basin.

Dams and other passage barriers in the Upper Columbia may affect bull trout. For example, in the Wenatchee River basin, Tumwater Dam, Dryden Dam, Dam 5 on Icicle Creek, and the weir on the Chiwawa River may affect bull trout spatial structure and diversity. Seasonal closure of adult passage facilities at the dams may adversely affect adult bull trout movement during certain times of year.

3.12.9 Interaction between Resident and Migrant Bull Trout Life-History Types

The Bull Trout Draft Recovery Plan (USFWS 2002) proposes recovery criteria for bull trout based on connectivity, abundance, productivity, and spatial structure of migrant (fluvial and adfluvial) life-history types. A critical uncertainty is the role of resident life-history types in maintaining viable populations of bull trout. Little is known about the abundance and spatial structure of resident forms in the Upper Columbia Basin, and even less is known about their contribution to migrant life-history types. Research is needed to assess the spatial structure and importance of resident types in maintaining viable populations of bull trout in the Upper Columbia Basin.

3.12.10 Effects of Harvest, Hatchery, Hydropower, and Habitat Actions

A critical uncertainty associated with the implementation of this recovery plan will be the effect of management actions or strategies on the environment and on life-stage specific survival rate and population level responses. It is unclear how strategies implemented within each of the Hs (Harvest, Hatcheries, Hydropower, and Habitat) will interact and contribute to recovery. In particular, a high level of uncertainty exists for the magnitude and response time of habitat actions. Even if all habitat actions could be implemented immediately (which they cannot), there will be delays in the response to actions. Populations will likely respond more quickly to some actions (e.g., diversion screens and barrier removals) than they will to others (e.g., riparian plantings). Although the effects of interacting strategies on population VSP parameters remain unknown, monitoring will contribute substantially to resolving this uncertainty.

3.12.11 Effects of Human Population Growth

Human population growth in the Upper Columbia Basin and its effects on recovery of listed species is a critical uncertainty. The size of the human population within the Upper Columbia region is expected to nearly double in the next two decades (may not apply equally across all subbasins).[67] Projected development will probably expand along streams and rivers at a greater rate than in upland areas. At the time this plan was written, critical area ordinances and comprehensive plans are being updated. A high degree of coordination among agencies, tribes, and counties will be needed to maximize recovery efforts.

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[67] See http://www.ofm.wa.gov/pop/gma/

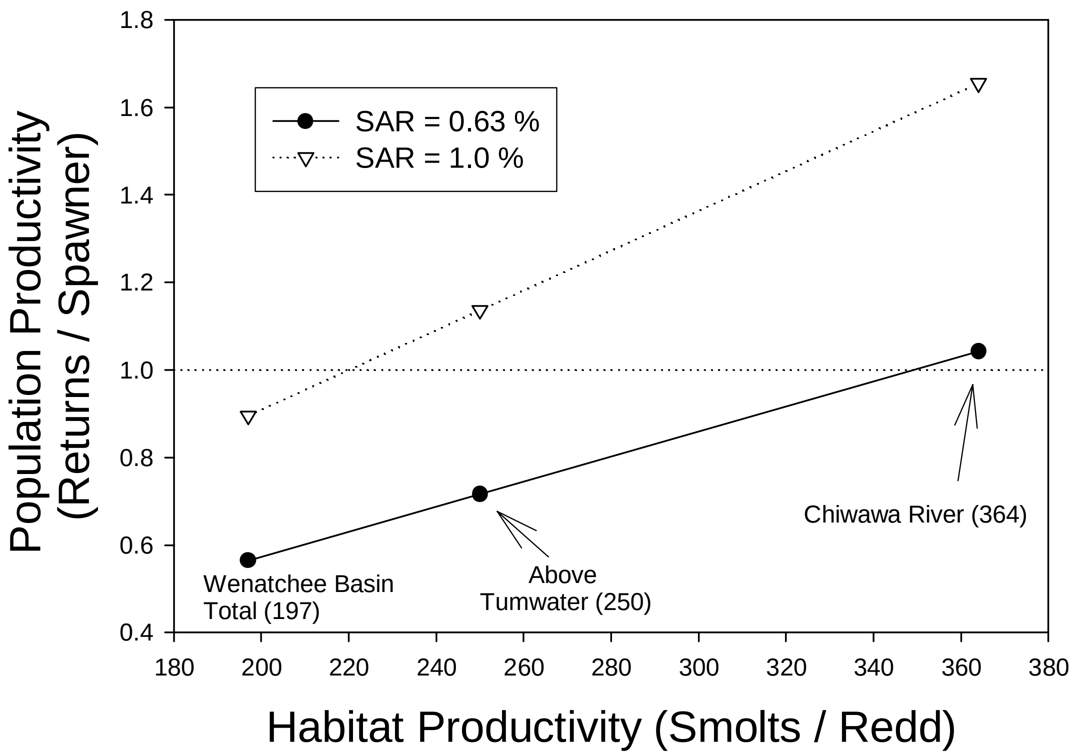

Figure 3.1 Returns per spawner for three levels of productivity (average smolts/redd) and smolt-to-adult return rates (SAR) for spring Chinook in the Wenatchee River, Washington. The SAR of 0.63% was the 8-yr geometric mean from 1993-2000 for naturally produced Chiwawa River spring Chinook (WDFW, unpublished data). The 1% SAR was modeled at the same productivity values for a theoretical comparison. This simple arithmetic model does not account for variance, autocorrelation, or density dependence and should not be used to determine targets for either metric.

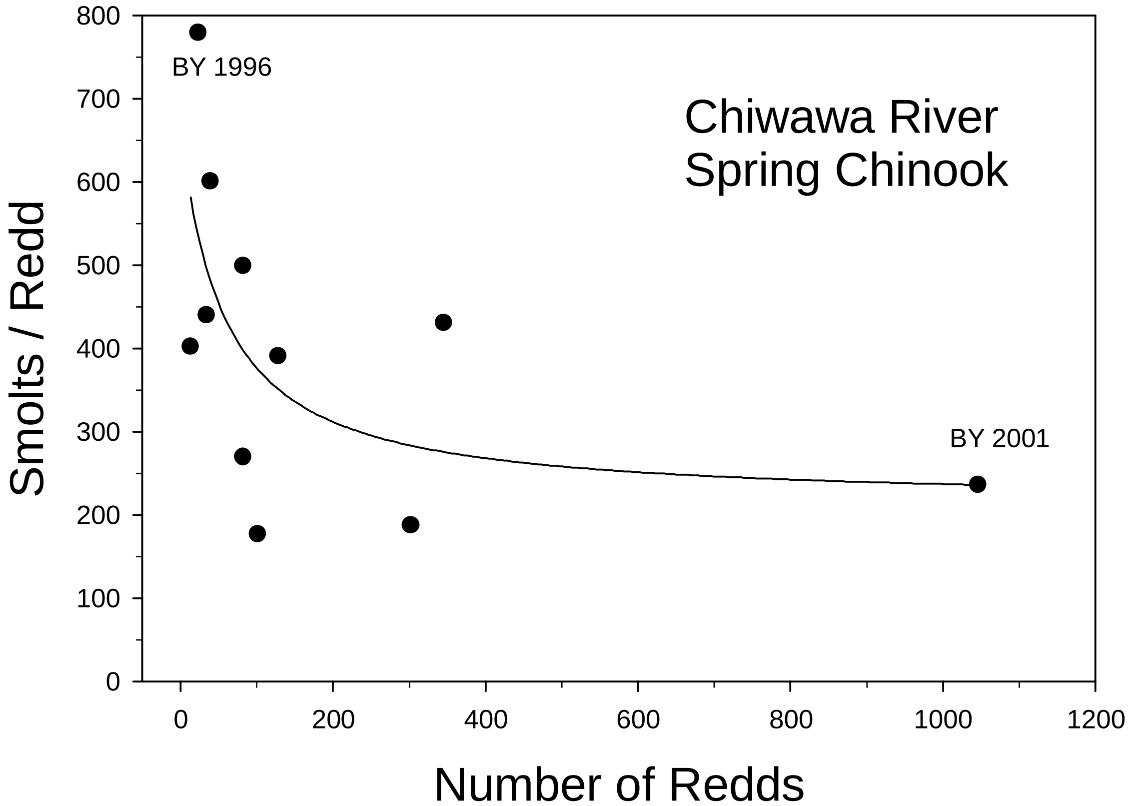

Figure 3.2 A density-dependent relationship between Chinook salmon smolts per redd and the number of redds in the Chiwawa River, a relatively pristine tributary of the Wenatchee River, Washington. Brood years (BY) are only specified for extreme values

4 Delisting Criteria

4.1 Guiding Principles
4.2 Recovery Strategy
4.3 Recovery Goals and Objectives
4.4 Recovery Criteria
4.5 Recovery Timeframe

In the previous sections, this plan described the status of ESA-listed populations in the Upper Columbia Basin and reasons for their decline. In this section, the plan identifies goals, objectives, reclassification criteria and recovery criteria for naturally produced spring Chinook salmon, steelhead, and bull trout in the Upper Columbia Basin. This plan differentiates between "reclassification" and "recovery" criteria (NOAA 2004). "Reclassification" criteria represent the levels of abundance, productivity, spatial structure, and diversity necessary for "endangered" species (spring Chinook) to be classified as "threatened" under the ESA. "Recovery" criteria are the same as "delisting" criteria, which represent the levels of abundance, productivity, spatial structure, and diversity necessary for each species to be removed from ESA listing. Recovery levels are higher than reclassification levels.

It should be noted, however, that these biological criteria (VSP parameters) are only one component of the decision-making process of whether or not listed fish are reclassified and de-listed. Before the species can be reclassified or de-listed, NOAA Fisheries and USFWS must evaluate if the existing and ongoing institutional measures are sufficient to address the threats (see Section 3.11) to protect the viability of the populations and the ESU and DPS.

4.1 Guiding Principles

Although there are no specific regulations regarding recovery, the statutory language of the ESA offers some guidance in recovery planning. Section 4(f) of the ESA addresses the development and implementation of recovery plans. The following are the key provisions of the Act for development of recovery plans:

- 4(f)(1) – Recovery plans shall be developed and implemented for listed species unless the Secretary "…finds that such a plan will not promote the conservation of the species."
- 4(f)(1)(A) – Priority is to be given, to the maximum extent practicable, to "…species, without regard to taxonomic classification, that are most likely to benefit from such plans, particularly those species that are, or may be, in conflict with construction or other forms of economic activity."
- 4(f)(1)(B) – Each plan must include, to the maximum extent practicable, "(i) a description of site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species; (ii) objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list; and, (iii) estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal."

In summary, statutory (e.g., Freedom of Information Act, Federal Advisory Committee Act, Administration Procedure Act, National Environmental Policy Act, Paperwork Reduction Act, and the Information Quality Act) guidance requires certain elements to be included in the plan.

Within these "sideboards," plan developers are given considerable discretion to determine the details of how they develop the plan. This plan is science-based and relied on the guidance provided by the ICBTRT and the Bull Trout Draft Recovery Plan. Delisting criteria were developed by the ICBTRT in concert with the three Eastern Washington Regions (including Tribes), WDFW, and USFWS. The following criteria provide guidance to decision makers within each region.

4.2 Recovery Strategy

At the time of listing, spring Chinook and steelhead in the Upper Columbia Basin exhibited low abundance and productivity (see Section 2). Trends in abundance were mostly downward and replacement ratios were low. Likewise, bull trout abundance in the Upper Columbia Basin was relatively low (see Section 2). Most bull trout populations (or subpopulations) exhibited depressed or unknown trends. Since 2000, naturally produced spring Chinook and steelhead abundance and productivity have increased. However, they still remain at levels that are considered below recovered population levels.

The strategy of this plan is to recommend goals, objectives, and actions that address the primary factors within each "H" (Hydro, Hatchery, Harvest, and Habitat) that limit the abundance, productivity, spatial structure, and diversity of naturally produced spring Chinook, steelhead, and bull trout in the Upper Columbia Basin.[68] Each action is linked directly to a specific limiting factor (see Section 5). For example, recommended actions within the hydropower system are intended to increase survival of juveniles and adults passing through dams and reservoirs; recommended actions within hatcheries are intended to address abundance, productivity, and diversity issues associated with propagation of stocks; recommended actions within harvest are intended to reduce incidental take of listed species; and recommended actions within habitat are directed at protecting important habitats and minimizing stresses (various land-use and management activities) that degrade spawning and rearing habitat conditions.[69] Ultimately, the implementation of specific recovery actions should lead to the restoration of naturally produced spring Chinook salmon, steelhead, and bull trout populations such that they become viable components of the ecosystem managed within the context of multiple land uses and natural resource management. These actions will also benefit other fish species and some wildlife, and lessen the chance for additional listings in the Upper Columbia Basin.

For all listed species, recovery requires reducing or eliminating threats to the long-term persistence of populations, maintaining widely distributed populations across diverse habitats of their native ranges, and preserving genetic diversity and life history characteristics. Successful recovery of the species means that populations, DPS, and ESU have met certain measurable criteria associated with viable salmonid populations (ICBTRT 2005). This plan focuses on four viable salmonid population (VSP) parameters: abundance, productivity, spatial structure, and

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[68] Note that goals and criteria must be met entirely from naturally produced fish. Hatchery fish are not included in the abundance and productivity criteria.

[69] It is important to note that habitat improvements will reach a point of diminishing returns. In other words, at some point in the future, all improvements, through protection and restoration, will have a very limited affect on fish habitat. This plan promotes an end point of habitat improvements, that when met, will conclude the responsibility of landowner action to improve or preserve habitat (see Section 5).

diversity of naturally produced fish (see ICBTRT 2005a, b for a detailed discussion on VSP parameters) and bull trout goals and objectives. Importantly, this plan does not expect listed species where they did not occur historically, nor does it expect abundances that occurred historically.

4.2.1 Abundance

Population abundance must be large enough to have a high probability of surviving environmental variation observed in the past and expected in the future, to be resilient to environmental and anthropogenic disturbances, to maintain genetic diversity, and to support or provide ecosystem functions. In this plan, the contribution of abundance to recovery will be measured using the twelve-year geometric mean abundance of adult fish on spawning grounds. McElhany (2000) recommended an 8-20 year time period. Ford et al. (2001) recommended a twelve-year time period because it overcomes survey variability, fluctuating environmental conditions, natural fluctuations in population cycles, multiple generations, and is more socially accepted than a 16 or 20-year timeframe. For spring Chinook and bull trout,[70] abundance will be based on redd counts. Because of a lack of long-term steelhead redd counts, abundance of adult steelhead on spawning grounds will be estimated from inter-dam counts and radio-telemetry studies.

4.2.2 Productivity

The productivity of a population is a measure of its ability to sustain itself or its ability to rebound from low numbers. Productivity can be measured as spawner:spawner ratios (a.k.a., returns per spawner or recruits per spawner), annual population growth rate, or trends in abundance of naturally produced fish. This plan uses spawner:spawner ratios as an index of productivity for spring Chinook and steelhead, and trends in redd counts for bull trout. There is currently no information available to estimate spawner:spawner ratios for bull trout. Spawner:spawner ratios for spring Chinook and steelhead will be expressed as the 12-year geometric mean recruits per spawner (following Ford et al. 2001). Stock-recruitment curves will be used to estimate “intrinsic productivity” [71] when high levels of Chinook salmon and steelhead abundance are eventually achieved.

This plan also recognizes the primary importance of smolts/redd as a metric for habitat productivity. That is, in addition to evaluating productivity for the entire life cycle (mean spawner:spawner ratios), this plan uses smolts/redd to isolate the function of tributary habitat, without the confounding effects of mortality outside the subbasin. Although this plan currently lacks the information needed to identify recovery criteria based on smolts/redd, monitoring programs are in place or planned that will allow the use of this index as a consistent approach to evaluating restoration actions in the future.

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[70] The USFWS developed a range of 2 to 2.8 fish/redd to estimate adult abundance (USFWS 2004).
[71] Intrinsic productivity is the expected productivity at low to moderate spawner abundance relative to spawning capacity.

4.2.3 Spatial Structure

Spatial structure concerns the geographic distribution of a population and the processes that affect the distribution. Populations with restricted distributions and few spawning areas are at a higher risk of extinction due to catastrophic environmental events (e.g., a single landslide) than populations with more widespread and complex spatial structures. A population with complex spatial structure will include multiple spawning areas and will allow the expression of natural patterns of gene flow and life history characteristics. Some populations, such as Entiat spring Chinook, have a naturally simple spatial structure and therefore have an inherently higher risk of extinction. As noted earlier, this plan does not expect spatial structure where it did not exist historically. Also, the role of artificial production in spatial structure is not fully understood.

4.2.4 Diversity

Population diversity concerns the phenotypic (morphology, behavior, and life-history traits) and genotypic (DNA) characteristics of populations. Because environments continually change due to natural process (e.g., fires, floods, drought, landslides, volcanism, etc.) and anthropogenic influences, populations exhibiting greater diversity are more resilient to both short- and long-term changes. Phenotypic diversity allows more diverse populations to use a wider array of environments and protects populations against short-term temporal and spatial environmental changes. Genotypic diversity (DNA), on the other hand, provides populations with the ability to survive long-term changes in the environment. It is the combination of phenotypic and genotypic diversity expressed in a natural setting that provides populations with the ability to adapt to long-term changes.

In some cases, the mixing of hatchery fish (or excessive numbers of out-of-basin stocks) with naturally produced fish on spawning grounds can actually decrease genetic diversity within the population (Hallerman 2003). According to the ICBTRT (2005a, b), diversity of naturally produced populations, ESUs, and DPSs can decrease because of hatchery adaptations of domestication, losses of genetic variability through supportive breeding, and erosion of natural population structure through homogenization. Recovery actions should be designed to reduce domestication and homogenization, and prevent gene flow rates greater than natural levels. Hatchery programs that increase genetic diversity should be emphasized.

4.2.5 Combining VSP Parameters

Abundance and productivity are closely linked. That is, rates of productivity at relatively low abundance should be, on average, sufficiently greater than 1.0 to allow the population to rapidly return to abundance target levels.[72] In contrast, productivity rates can be closer to 1.0 when population abundance is at target levels. The relationship between productivity and abundance is called a viability curve and it describes those combinations of abundance and productivity that yield a particular risk threshold.

[72] A productivity rate of 1.0 indicates that the population is replacing itself and is stable. A rate less than 1.0 indicates that the population is not replacing itself and is declining. A rate greater than 1.0 indicates that the population is more than replacing itself and is growing.

The ICBTRT has developed viability curves for spring Chinook and steelhead of different population size groups. The ICBTRT identified different size groups based on estimates of historically accessible spawning and rearing habitat. Spring Chinook populations within the Upper Columbia ESU fall within the “basic” (Entiat population) and “large” (Wenatchee and Methow populations) size categories (**Figure 4.1**). Steelhead populations within the Upper Columbia DPS fall within the “basic” (Entiat and Okanogan populations) and “intermediate” (Wenatchee and Methow populations) size categories (**Figure 4.2**). The Okanogan steelhead population is categorized as “basic” in the U.S. and “intermediate” if streams in Canada are included. Further analyses may redefine the minimum numbers for Upper Columbia Basin populations. This could change the designation of populations within the ESU and the DPS in the Upper Columbia Basin.

Viability curves truncate at minimum spawner numbers that differ depending on population size categories. Regardless of population productivity, basic populations must maintain a minimum spawner abundance of 500 spawners, intermediate a minimum of 1,000 spawners, and large populations must maintain a minimum of 2,000 spawners to be considered viable. These minimum levels were developed by the ICBTRT (2005a, b). Note that the area above the viability curves indicates that the populations are at a low risk of extinction, while areas below the curves represent high risk. Under historical conditions, it is likely that most populations demonstrated combinations of intrinsic production potential and abundance above the 5% viability curve. There are no viability curves for bull trout and therefore separate criteria are identified for bull trout abundance and productivity (see Section 4.4.3).

Spatial structure and diversity are also closely related. Because spatial structure is the process that drives diversity, the two (spatial structure and diversity) are very difficult to separate (ICBTRT 2005a, b). Therefore, following the recommendations of the ICBTRT (2005a, b), this plan will evaluate spatial structure and diversity together. The mechanisms, factors, and metrics used to assess spatial structure and diversity are presented in **Table 4.1**. Further analyses may redefine the factors and metrics used to assess spatial structure and diversity. This could change the designation of populations within the ESU and DPS in the Upper Columbia Basin.

4.3 Recovery Goals and Objectives

The overall goal of this plan is recovery of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin.

The specific goal for spring Chinook and steelhead is:

- **To secure long-term persistence of viable populations of naturally produced spring Chinook and steelhead distributed across their native range.**

The specific goal for bull trout is:

- **To secure long-term persistence of self-sustaining, complex, interacting groups of bull trout distributed across the native range of the species.**

4.3.1 Spring Chinook

Because spring Chinook are currently listed as endangered under the ESA (64 FR 14307), this plan identifies two levels of objectives for them. The first identifies objectives related to reclassifying the species as threatened and the second relate to recovery. Recovery of the spring Chinook ESU will require the recovery of the Wenatchee, Entiat, and Methow populations (ICBTRT 2005a, b). This deviates from the recent recommendation of the ICBTRT that at least two populations must meet abundance/productivity criteria that represent a 1% extinction risk over a 100-year period. This plan requires that all spring Chinook populations within the ESU must meet abundance/productivity criteria that represent a 5% extinction risk over a 100- year period.

Reclassification Objectives

Abundance/Productivity

Increase the abundance and productivity of naturally produced spring Chinook within each population in the Upper Columbia ESU to levels that would lead to reclassification of the ESU as threatened under the ESA.

Spatial Structure/Diversity

Increase the current distribution of naturally produced spring Chinook in the Upper Columbia ESU and conserve genetic and phenotypic diversity.

Recovery Objectives

Abundance

Increase the abundance of naturally produced spring Chinook spawners within each population in the Upper Columbia ESU to levels considered viable.

Productivity

Increase the productivity (spawner:spawner ratios and smolts/redds) of naturally produced spring Chinook within each population to levels that result in low risk of extinction.[73]

Spatial Structure/Diversity

Restore the distribution of naturally produced spring Chinook to previously occupied areas (where practical) and allow natural patterns of genetic and phenotypic diversity to be expressed.

4.3.2 Steelhead

As of June 2007, steelhead are again listed as endangered under the ESA. (See 1.4.2 for information about changes in the steelhead listing status).Therefore, this plan identifies two levels of objectives for them. The first identifies objectives related to reclassifying the species as threatened and the second relate to recovery. Recovery of the Upper Columbia Steelhead DPS will require the recovery of the Wenatchee, Entiat, Methow, and Okanogan populations, but not the Crab Creek population (ICBTRT 2005a, b). This deviates from the recent recommendation of the ICBTRT that at least two populations within the DPS must meet abundance/productivity criteria that represent a 1% extinction risk over a 100-year period. This plan requires that all

[73] Low risk is defined as no more than a 5% probability of going below 5 spawners per year for a generation (typically 4-5 years) in a 100-year period (ICBTRT 2005a).

steelhead populations, except the Crab Creek population, must meet abundance/productivity criteria that represent a 5% extinction risk over a 100-year period.

Reclassification Objectives

Abundance/Productivity

Increase the abundance and productivity of naturally produced steelhead within each population in the Upper Columbia DPS to levels that would lead to reclassification of the DPS as threatened under the ESA.

Spatial Structure/Diversity

Increase the current distribution of naturally produced steelhead in the Upper Columbia DPS and conserve genetic and phenotypic diversity.

Recovery Objectives

Abundance

Increase the abundance of naturally produced steelhead spawners within each population in the Upper Columbia DPS to levels considered viable.

Productivity

Increase the productivity (spawner:spawner ratios) of naturally produced steelhead within each population to levels that result in low risk of extinction.

Spatial Structure/Diversity

Restore the distribution of naturally produced steelhead to previously occupied areas (where practical) and allow natural patterns of genetic and phenotypic diversity to be expressed.

4.3.3 Bull Trout

Bull trout in the Upper Columbia Basin are currently listed as threatened under the ESA (63 FR 31647). Therefore this plan only identifies delisting or recovery objectives. It is important to note that core populations within the Upper Columbia Basin make up only a portion of the total Columbia Basin population.

Recovery Objectives

Abundance

Increase the abundance of adult bull trout within each core population in the Upper Columbia Basin to levels that are considered self-sustaining.

Productivity

Maintain stable or increasing trends in abundance of adult bull trout within each core population in the Upper Columbia River Basin.

Spatial Structure/Diversity

Maintain the current distribution of bull trout in all local populations, restore distribution to previously occupied areas (where practical), maintain and restore the migratory form and connectivity within and among each core area, conserve genetic diversity, and provide for genetic exchange.

4.4 Recovery Criteria

This section identifies the reclassification and recovery criteria for each objective. Although criteria must be measurable and objective, they need not all be quantitative (NMFS 2004). The purpose of criteria is to assess whether actions are resulting in recovery of listed species in the Upper Columbia Basin. The criteria developed for recovery of spring Chinook, steelhead, and bull trout address quantitative and qualitative measurements of abundance, productivity, and spatial structure/diversity on a population or core population basis.

4.4.1 Spring Chinook

The following criteria must be met before the Upper Columbia Spring Chinook ESU can be reclassified as threatened and ultimately recovered. The UCSRB recommended these criteria based on information contained in ICBTRT (2005a) and Ford et al. (2001). This information included intrinsic potential, population viability analysis, habitat capacity estimates, and historical run sizes.

Reclassification Criteria

Abundance/Productivity

Criterion 1: The 8-year[74] geometric mean for abundance and productivity of naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations must fall above the 10% extinction-risk (viability) curves shown in Figure 4.1.

Spatial Structure/Diversity

Criterion 2: The ***mean*** score for the three metrics of natural rates and levels of spatially mediated processes (Goal A) will result in a ***moderate*** or lower risk assessment for naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations and all threats for "high" risk have been addressed (see **Table 4.1** and Appendix B; ICBTRT 2005a).

Criterion 3: The ***mean*** score[75] for the eight metrics of natural levels of variation (Goal B) will result in a ***moderate*** or lower risk assessment for naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations and all threats for "high" risk have been addressed (see **Table 4.1** and Appendix B; ICBTRT 2005a).

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[74] An 8-year timeframe represents at least two generations.

[75] Averaging the metrics to calculate Goal B scores lowers the bar for reclassification. The spatial structure and diversity matrix developed by the ICBTRT (2005a) assesses risk for Goal B by weighting the lowest score. Thus, risk under Goal B is weighted heavily toward those metrics that have low scores (see Appendix B). By averaging the metrics, each metric receives equal weight and the resulting score will be higher than using the method proposed by the ICBTRT.

Recovery Criteria

Abundance/Productivity

Criterion 1: The 12-year geometric mean for abundance and productivity of naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations must fall above the 5% extinction-risk (viability) curves shown in **Figure 4.1**.

Criterion 2: At a minimum, the Upper Columbia Spring Chinook ESU will maintain at least 4,500 naturally produced spawners and a spawner:spawner ratio greater than 1.0 distributed among the three populations as follows:[76]

Population	Minimum 12-yr GM Spawners	Minimum 12-yr GM Spawner:spawner[77]
Wenatchee	2,000	1.2
Entiat	500	1.4
Methow	2,000	1.2
Total for ESU	**4,500**	**>1.0**

Spatial Structure/Diversity

Criterion 3: Over a 12-year period, naturally produced spring Chinook will use currently occupied major spawning areas (minor spawning areas are addressed primarily under Criteria 4 and 5)[78] throughout the ESU according to the following population-specific criteria (**Figures 4.3-4.5**):

Wenatchee

Naturally produced spring Chinook spawning will occur within the four of the five major spawning areas in the Wenatchee subbasin (Chiwawa River, White River, Nason Creek, Little Wenatchee River, or Wenatchee River) and within one minor spawning area downstream from Tumwater Canyon (Chumstick, Peshastin, Icicle, or Mission). The minimum number of naturally produced spring Chinook redds within each major spawning area will be either 5% of the total number of redds within the Wenatchee subbasin or at least 20 redds within each major area, whichever is greater (adapted from Ford et al. 2001).

Entiat

Naturally produced spring Chinook will spawn within the one major spawning area within the Entiat subbasin.

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[76] This is a minimum criterion for abundance and productivity. Because of variability in the estimates, the criteria may not represent a 5% risk of extinction within 100 years, but likely a higher extinction risk.
[77] These values represent the minimum growth rates associated with the minimum number of spawners of a viable population.
[78] Based on local knowledge of the subbasins, this plan modified the major and minor spawning areas identified by the ICBTRT.

Methow

Naturally produced spring Chinook spawning will occur within the Twisp, Chewuch, and Upper Methow major spawning areas. The minimum number of naturally produced spring Chinook redds within each major spawning area will be either 5% of the total number of redds within the Methow subbasin or at least 20 redds within each major area, whichever is greater (adapted from Ford et al. 2001).

Okanogan

Recovery of spring Chinook in the Okanogan Subbasin is not a requirement for delisting because the ICBTRT determined that this population was extinct (ICBTRT 2005a). However, this plan recognizes that if a major spawning area could be established in the Okanogan using an Upper Columbia spring Chinook stock, then the ESU would be at a lower risk of extinction.

Areas Upstream from Chief Joseph

Recovery of spring Chinook in areas upstream from Chief Joseph Dam is not a requirement for delisting because the ICBTRT determined that these populations and major population groups were extinct (ICBTRT 2005a). However, this plan recognizes that if a major spawning area could be established in the area upstream from Chief Joseph Dam using an Upper Columbia spring Chinook stock, then the ESU would be at a lower risk of extinction.

Criterion 4: The ***mean*** score for the three metrics of natural rates and levels of spatially mediated processes (Goal A) will result in a ***moderate*** or lower risk assessment for naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations and all threats for "high" risk have been addressed (see **Table 4.1** and Appendix B; ICBTRT 2005a).

Criterion 5: The score[79] for the eight metrics of natural levels of variation (Goal B) will result in a ***moderate*** or lower risk assessment for naturally produced spring Chinook within the Wenatchee, Entiat, and Methow populations and all threats for "high" risk have been addressed (see **Table 4.1** and Appendix B; ICBTRT 2005a).

4.4.2 Steelhead

The following criteria must be met before the Upper Columbia Steelhead DPS can be classified as recovered. The UCSRB recommended these criteria based on information contained in ICBTRT (2005a) and Ford et al. (2001). This information included intrinsic potential analysis, population viability analysis, habitat capacity estimates, and historical run sizes.

[79] Scoring for Goal B under recovery follows the criteria provided by the ICBTRT (2005a). This means that metrics under Goal B with the lowest score receive greater weight than metrics with higher scores (see Appendix B).

Steelhead Reclassification Criteria

- Abundance and productivity (based on 8-year geometric mean) of naturally produced steelhead with in the Wenatchee, Entiat, Methow, and Okanogan populations must reach levels that would have less than a 10% risk of extinction over a 100-year period.
- Processes affecting spatial structure must result in at least a **moderate** or lower risk assessment for naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations and all factors considered "high" risk will have been addressed.
- Processes affecting diversity will result in at least a **moderate** or lower risk assessment for naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations and all factors considered "high" risk will have been addressed.

Recovery Criteria

Abundance/Productivity

Criterion 1: The 12-year geometric mean for abundance and productivity of naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations must fall above the 5% extinction-risk (viability) curves shown in **Figure 4.2**.

Criterion 2: At a minimum, the Upper Columbia steelhead DPS will maintain at least 3,000 spawners and a spawner:spawner ratio greater than 1.0 distributed among the four populations as follows:[80]

Population	Minimum 12-yr GM Spawners	Minimum 12-yr GM Spawner:Spawner[81]
Wenatchee	1,000	1.1
Entiat	500	1.2
Methow	1,000	1.1
Okanogan	500[82]	1.2
Total for DPS	**3,000**	**>1.0**

[80] This is a minimum criterion for abundance and productivity. Because of variability in the estimates, the criteria may not represent a 5% risk of extinction within 100 years, but likely a higher extinction risk.
[81] These values represent the minimum growth rates associated with the minimum number of spawners of a viable population.
[82] The ICBTRT has determined that 500 naturally produced steelhead adults will meet the minimum abundance recovery criteria within the U.S. portion of the Okanogan subbasin. If the Canadian portion of the Okanogan subbasin was included, the minimum abundance recovery criteria would be 1,000 naturally produced steelhead adults. Voluntary and bilateral efforts are underway to coordinate actions to meet this goal.

Spatial Structure/Diversity

Criterion 3: Over a 12-year period, naturally produced steelhead will use currently occupied major spawning areas (minor spawning areas are addressed primarily under Criteria 4 and 5) throughout the ESU according to the following population-specific criteria (**Figures 4.6-4.9**):

Wenatchee

Naturally produced steelhead spawning will occur within four of the five major spawning areas in the Wenatchee Subbasin (Chiwawa River, Nason Creek, Icicle Creek, Peshastin Creek, or Chumstick Creek). The minimum number of naturally produced steelhead redds within four of the five major spawning areas will be either 5% of the total number of redds within the Wenatchee population or at least 20 redds within each of four of the five major areas, whichever is greater (adapted from Ford et al. 2001).

Entiat

Naturally produced steelhead will spawn within the two major spawning area within the Entiat subbasin (Upper Entiat and Mad rivers). The minimum number of naturally produced steelhead redds within the two major spawning areas will be either 5% of the total number of redds within the Entiat population or at least 20 redds within each major area, whichever is greater (adapted from Ford et al. 2001).

Methow

Naturally produced steelhead spawning will occur within the three of the four major spawning areas (Twisp, Chewuch, Beaver, or Upper Methow). The minimum number of naturally produced steelhead redds within each major spawning area will be either 5% of the total number of redds within the Methow subbasin or at least 20 redds within each major area, whichever is greater (adapted from Ford et al. 2001).

Okanogan

Steelhead spawning will occur within the two major spawning areas (Salmon and Omak creeks) and within at least two of the five minor spawning areas (Ninemile, Whitestone, Bonaparte, Antoine, or Loup Loup). The minimum number of naturally produced steelhead redds within three of the four spawning areas will be either 5% of the total number of redds within the Okanogan subbasin or at least 20 redds within each area, whichever is greater (adapted from Ford et al. 2001).

Areas Upstream from Chief Joseph

Recovery of steelhead in areas upstream from Chief Joseph Dam is not a requirement for delisting, because the ICBTRT determined that these populations and major population groups were extinct (ICBTRT 2005a). However, this plan recognizes that if a major spawning area could be established in the area upstream from Chief Joseph Dam using an Upper Columbia steelhead stock, then the DPS would be at a lower risk of extinction.

Crab Creek

This plan does not address recovery criteria for the Crab Creek steelhead population. As described in Section 1.3.6, recovery of the Crab Creek population is not needed for the recovery of the Upper Columbia steelhead DPS. However, this plan recognizes that if a major spawning area could be established in the Crab Creek subbasin, then the DPS would be at a lower risk of extinction.

Criterion 4: The ***mean*** score for the three metrics of natural rates and levels of spatially mediated processes (Goal A) will result in a ***moderate*** or lower risk assessment for naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations and all threats for "high" risk have been addressed (see **Table 4.1Error! Reference source not found.** and Appendix B; ICBTRT 2005a, b).

Criterion 5: The score for the eight metrics of natural levels of variation (Goal B) will result in a ***moderate*** or lower risk assessment for naturally produced steelhead within the Wenatchee, Entiat, Methow, and Okanogan populations and all threats for "high" risk have been addressed (see **Table 4.1** and Appendix B; ICBTRT 2005a, b).

4.4.3 Bull Trout

The following criteria for Upper Columbia bull trout must be met before the Columbia River bull trout population can be recovered. The USFWS recommended these criteria, which were based on habitat capacity estimates, effective population size estimates, and conservation principles and guidelines (USFWS 2002, 2004, 2005).

Recovery Criteria

Abundance

Criterion 1: The abundance of Upper Columbia bull trout will increase and maintain a 12-year geometric mean of 4,144-5,402 spawners (range is based on 2-2.8 fish/redd), distributed among the three core areas as follows:

Population	Minimum 12-yr GM Spawners
Wenatchee	1,612-2,257
Entiat	298-417
Methow	1,234-1,728[83]
Total	**4,144-5,402**

Productivity

Criterion 2: The trend in numbers of bull trout redds (an index of numbers of spawners) within each population in the core areas (Wenatchee, Entiat, and Methow) are stable or increasing over a 12-year period.

[83] This criterion does not include bull trout in the Lost River drainage.

Spatial Structure/Diversity

Criterion 3: Bull trout will use currently occupied spawning areas and "potential" areas currently not occupied throughout the Upper Columbia Basin according to the following population-specific criteria:

Wenatchee

Bull trout spawning will occur within the seven interconnected areas (Chiwawa, White, Little Wenatchee, Nason, Icicle, Chiwaukum, and Peshastin), with 100 or more adults spawning annually within three to five areas.

Entiat

Bull trout spawning will occur within the two interconnected areas (Entiat and Mad), with 100 or more adults spawning annually in each area.

Methow

Bull trout spawning will occur within the ten interconnected areas (Gold, Twisp, Beaver, Chewuch, Lake Creek, Wolf, Early Winters, Upper Methow, Goat, and Lost), with 100 or more adults spawning annually within three to four areas.

Criterion 4: The migratory form of bull trout and connectivity within and among core areas must be present.

4.5 Recovery Timeframe

The time required to achieve reclassification (for spring Chinook and steelhead) and recovery of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin depends on the species status, factors currently affecting their viability, implementation and effectiveness of recovery actions, and responses to actions. A large amount of work within all sectors (i.e., Hs) will be needed to recover the ESU, the DPS, and their populations. In addition, long periods of time may be needed before some habitat actions result in measurable effects on species viability parameters. What follows are best estimates of the time required to meet recovery if the actions identified within this plan are implemented.

4.5.1 Spring Chinook

Reclassification

Based on the current status of spring Chinook (i.e., increasing abundance and productivity), reclassification could occur within 5-15 years.[84]

Recovery

If the actions identified in this plan are implemented and out-of-ESU conditions continue to improve, recovery of Upper Columbia spring Chinook could occur within 10-30 years.

[84] Because recovery status is retroactive, the "good" returns since 2000 will be included in the geometric means. Thus, reclassification could occur within a few years after this plan is adopted.

4.5.2 Steelhead

Reclassification

Based on the current status of steelhead (i.e., increasing abundance and productivity), reclassification could occur within 5-15 years.

Recovery

If the actions identified in this plan are implemented and out-of-DPS conditions continue to improve, recovery of Upper Columbia steelhead could occur within 10-30 years.

4.5.3 Bull Trout

Recovery

If the actions identified in this plan are implemented, then at least the Upper Columbia component of the Columbia River population could meet recovery criteria within 15-25 years.[85]

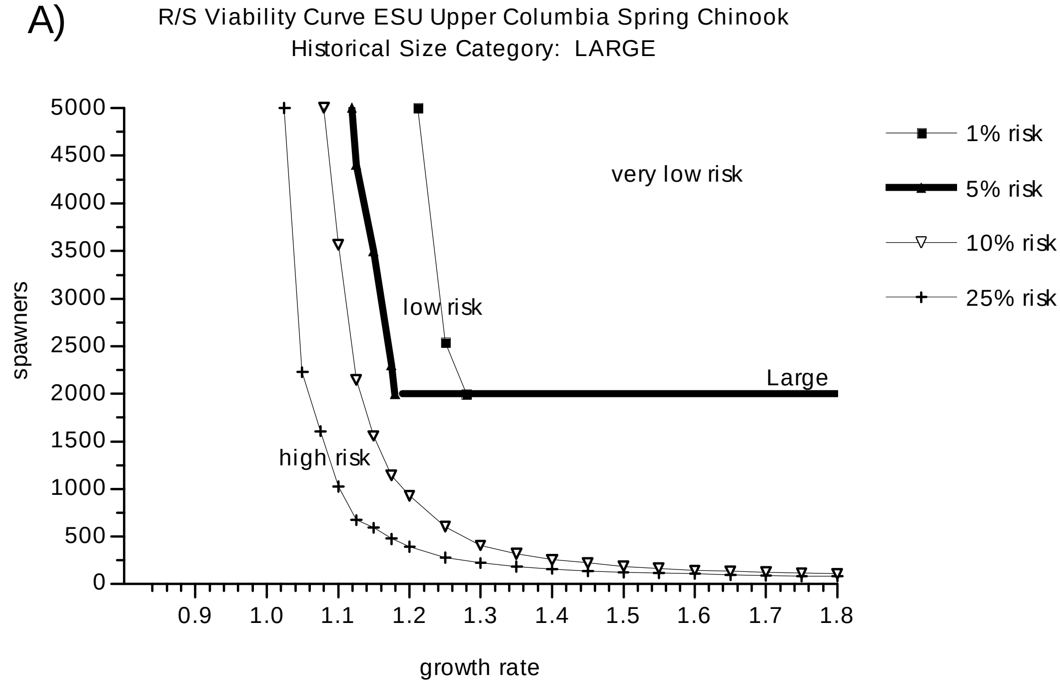
[85] The Upper Columbia is a portion of the Columbia DPS; therefore, to reach recovery it is necessary that the entire DPS meet recovery criteria.

Table 4.1 Mechanisms, factors, and metrics used to assess spatial structure and diversity of spring Chinook and steelhead populations in the Upper Columbia Basin. Table is from ICBTRT (2005a,b)

Goal	Mechanism	Factor	Metrics
A. Allow natural rates and levels of spatially mediated processes.	1. Maintain natural distribution of spawning aggregates.	a. Number and spatial arrangement of spawning areas.	Number of MSAs, distribution of MSAs, and quantity of habitat outside MSAs.
		b. Spatial extent or range of population	Proportion of historical range occupied and presence/absence of spawners in MSAs.
		c. Increase or decrease gaps or continuities between spawning aggregates.	Change in occupancy of MSAs that affects connectivity within the population.
B. Maintain natural levels of variation.	1. Maintain natural patterns of phenotypic and genotypic expression.	a. Major life history strategies.	Distribution of major life history expression within a population.
		b. Phenotypic variation.	Reduction in variability of traits, shift in mean value of trait, loss of traits.
		c. Genetic variation.	Analysis addressing within and between population genetic variations.
	2. Maintain natural patterns of gene flow.	a. Spawner composition	(1) Proportion of hatchery origin natural spawners derived from a local (within population) brood stock program using best practices.
			(2) Proportion of hatchery origin natural spawners derived from a within MPG brood stock program, or within population (not best practices) program.
			(3) Proportion of natural spawners that are unnatural out-of-MPG strays.
			(4) Proportion of natural spawners that are unnatural out-of-ESU and -DPS strays.
	3. Maintain occupancy in a natural variety of available habitat types.	a. Distribution of population across habitat types.	Change in occupancy across ecoregion types.
	4. Maintain integrity of natural systems.	a. Selective change in natural processes or impacts.	Ongoing anthropogenic activities inducing selective mortality or habitat change within or out of population boundary

Wenatchee and Methow

A)



Entiat

A)

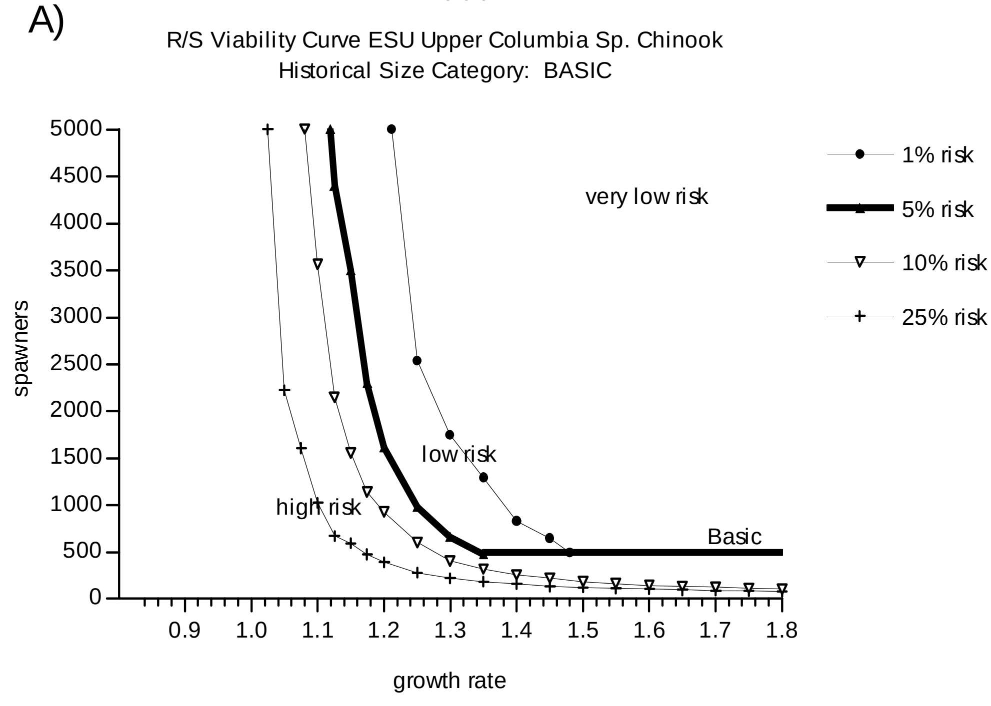
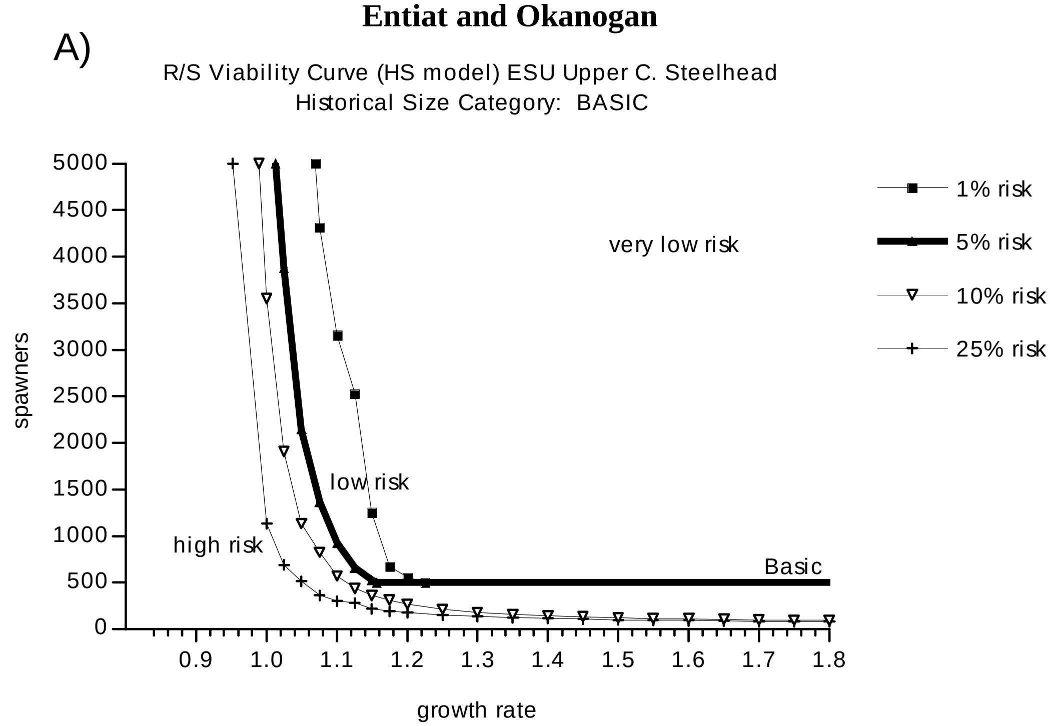


Figure 4.1 Viability curves for Upper Columbia spring Chinook. The ***top figure*** represents the Wenatchee and Methow Entiat populations and the ***bottom figure*** represents the Entiat population.

Entiat and Okanogan



Wenatchee and Methow

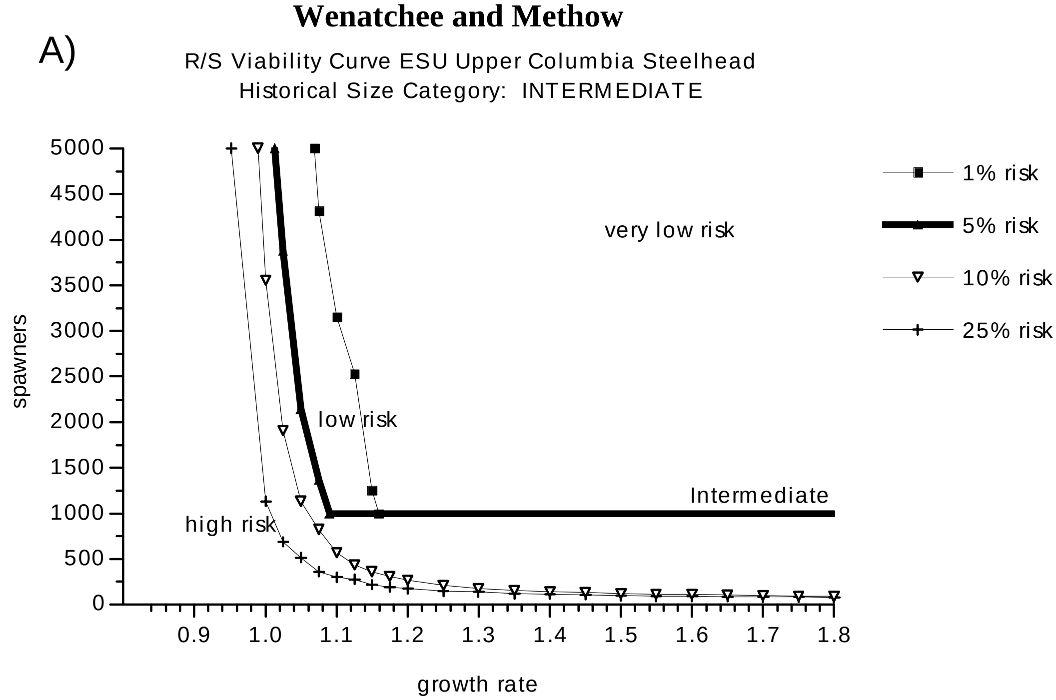


Figure 4.2 Viability curves for Upper Columbia steelhead. The ***top figure*** represents the Entiat and Okanogan populations and the ***bottom figure*** represents the Wenatchee and Methow populations.

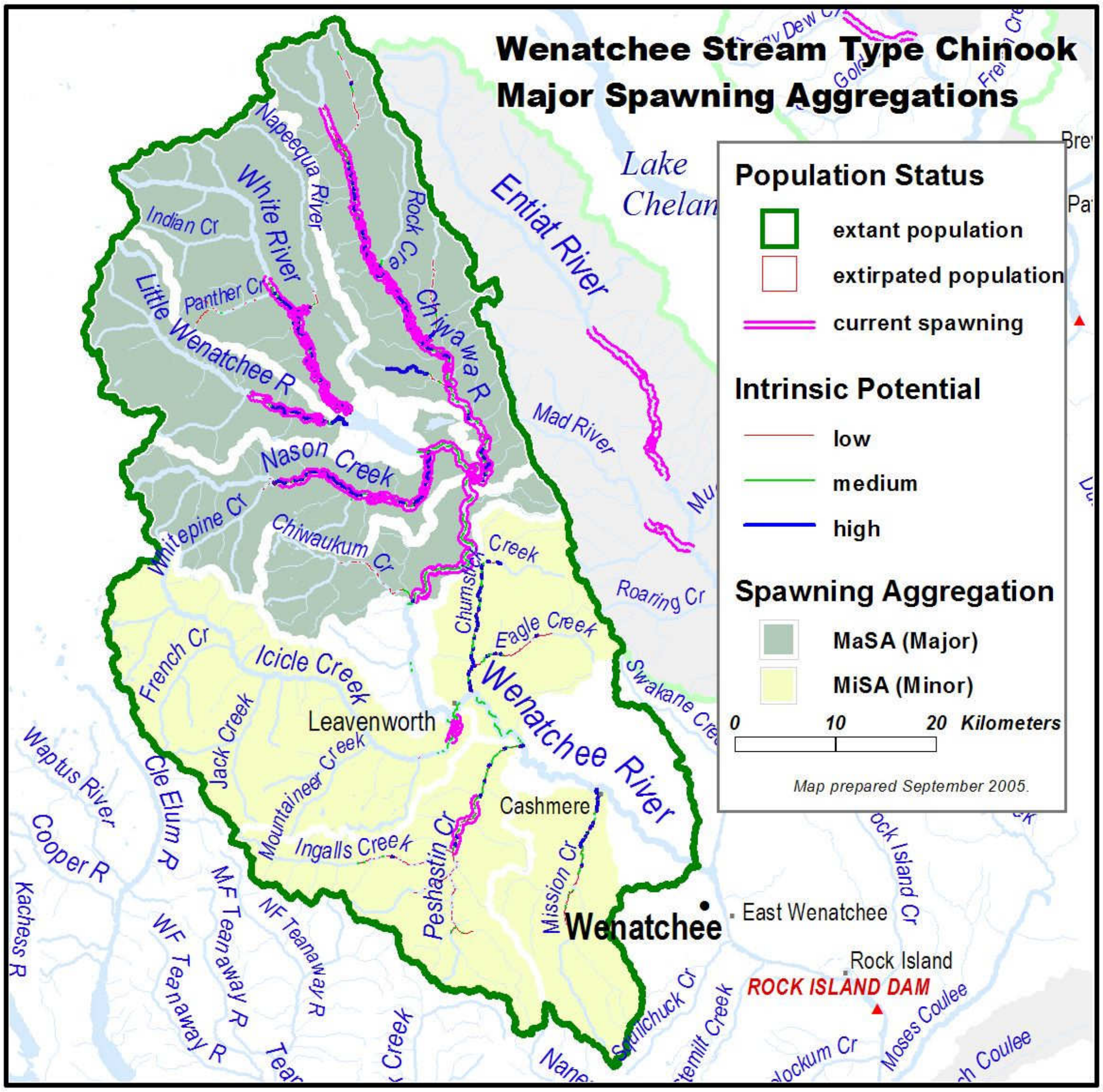


Figure 4.3 Distribution of major and minor spawning areas of spring Chinook in the Wenatchee Subbasin

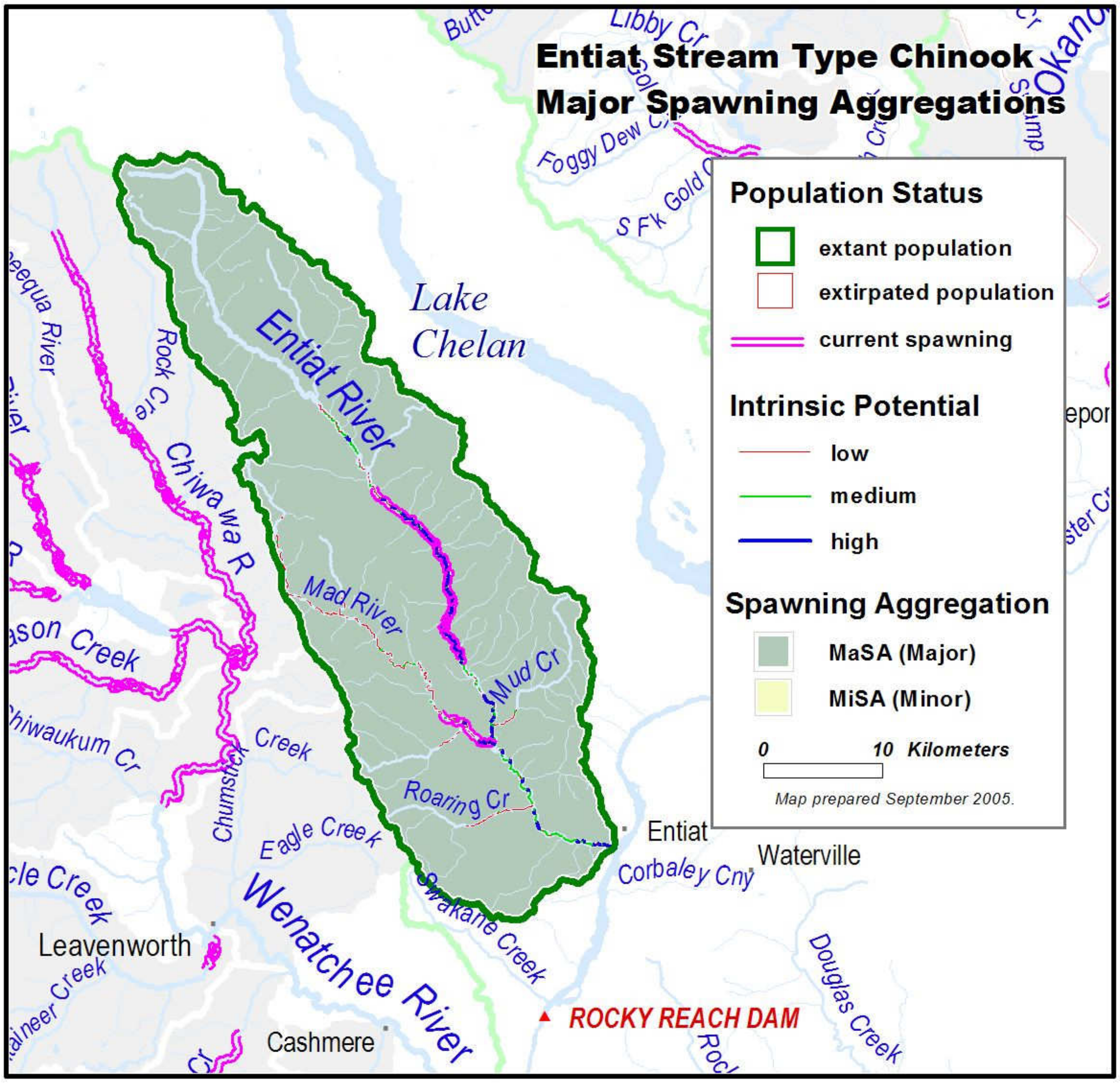


Figure 4.4 Distribution of major and minor spawning areas of spring Chinook in the Entiat Subbasin

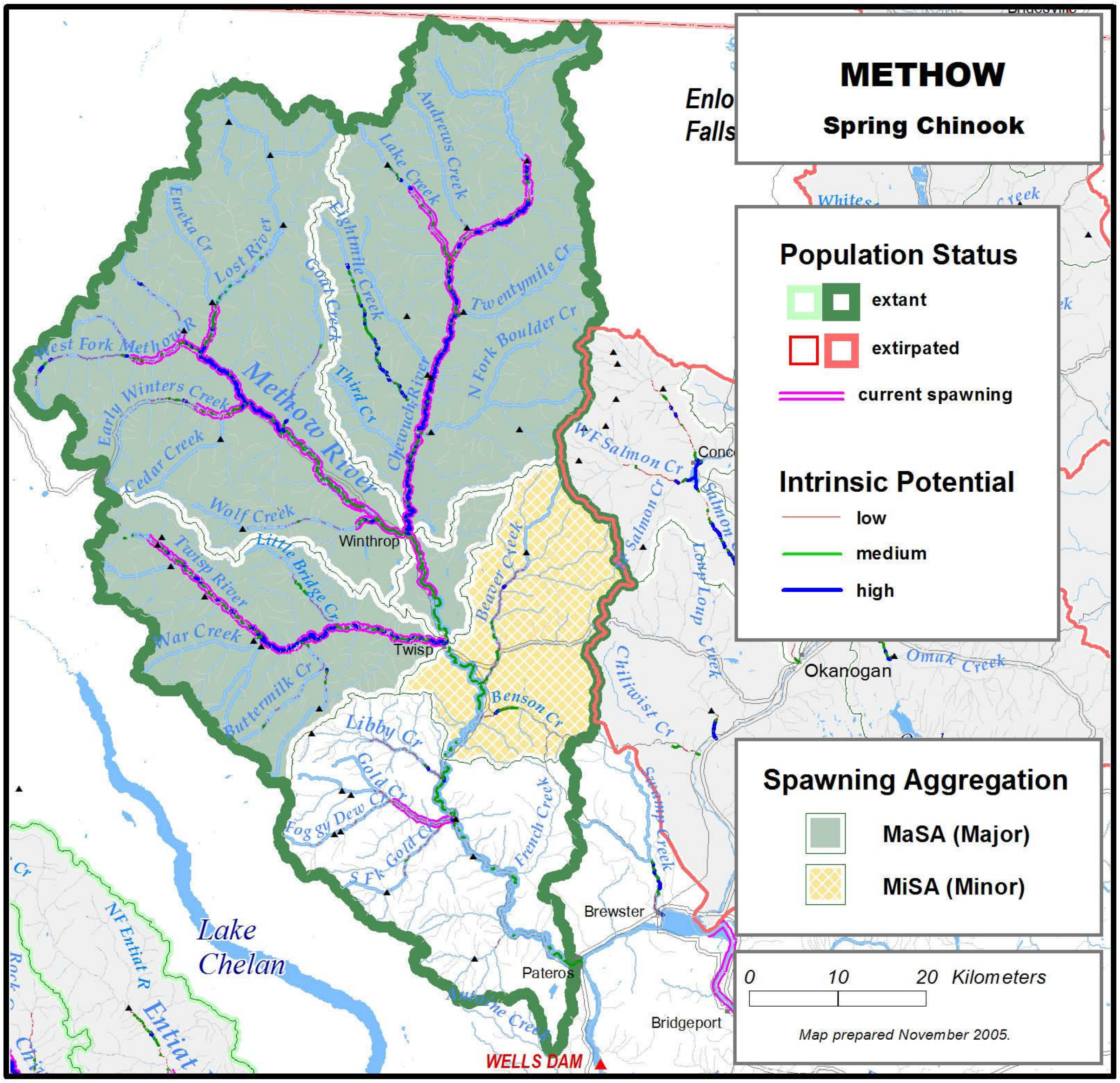


Figure 4.5 Distribution of major and minor spawning areas of spring Chinook in the Methow Subbasin

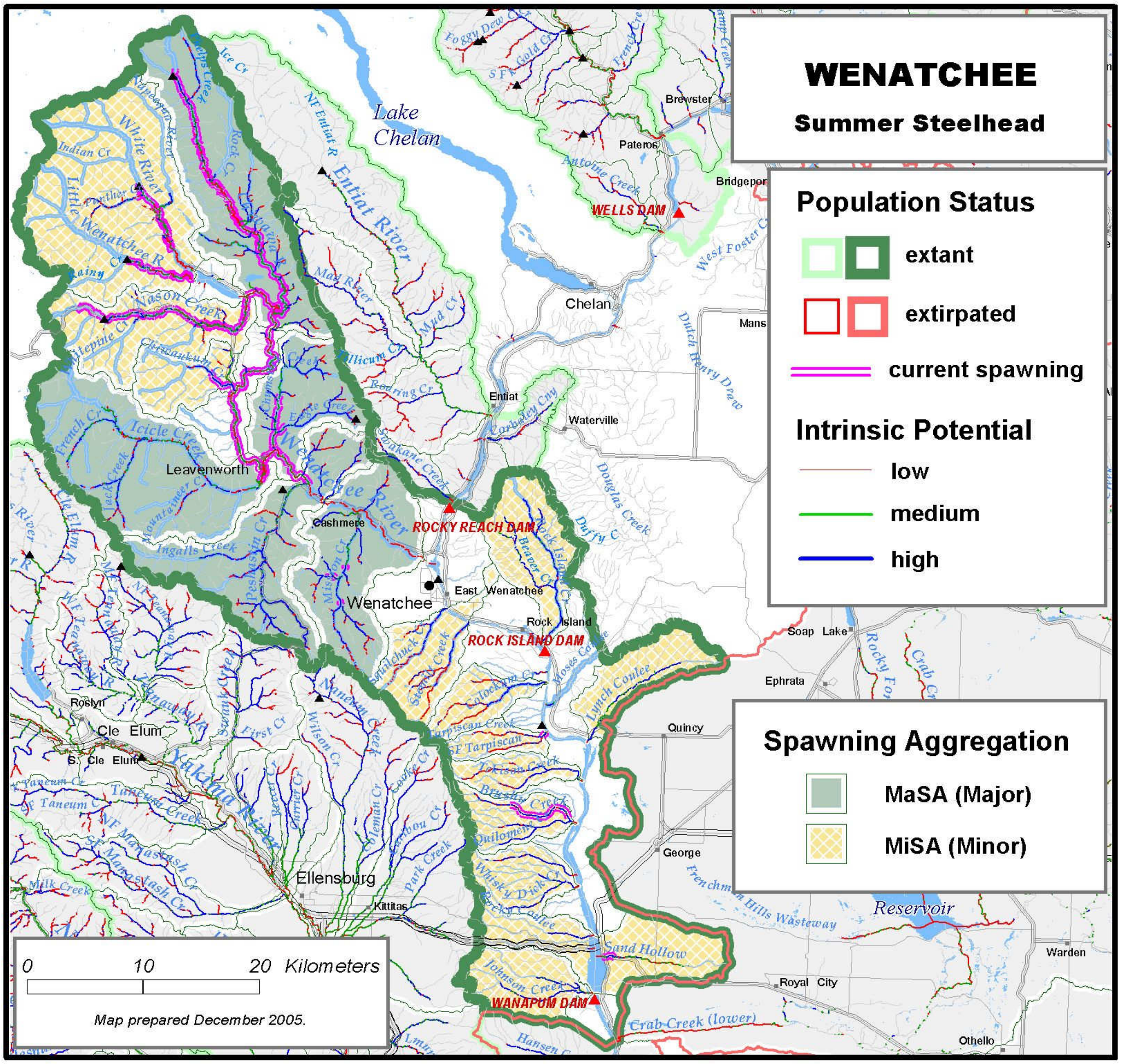


Figure 4.6 Distribution of major and minor spawning areas of steelhead in the Wenatchee Subbasin

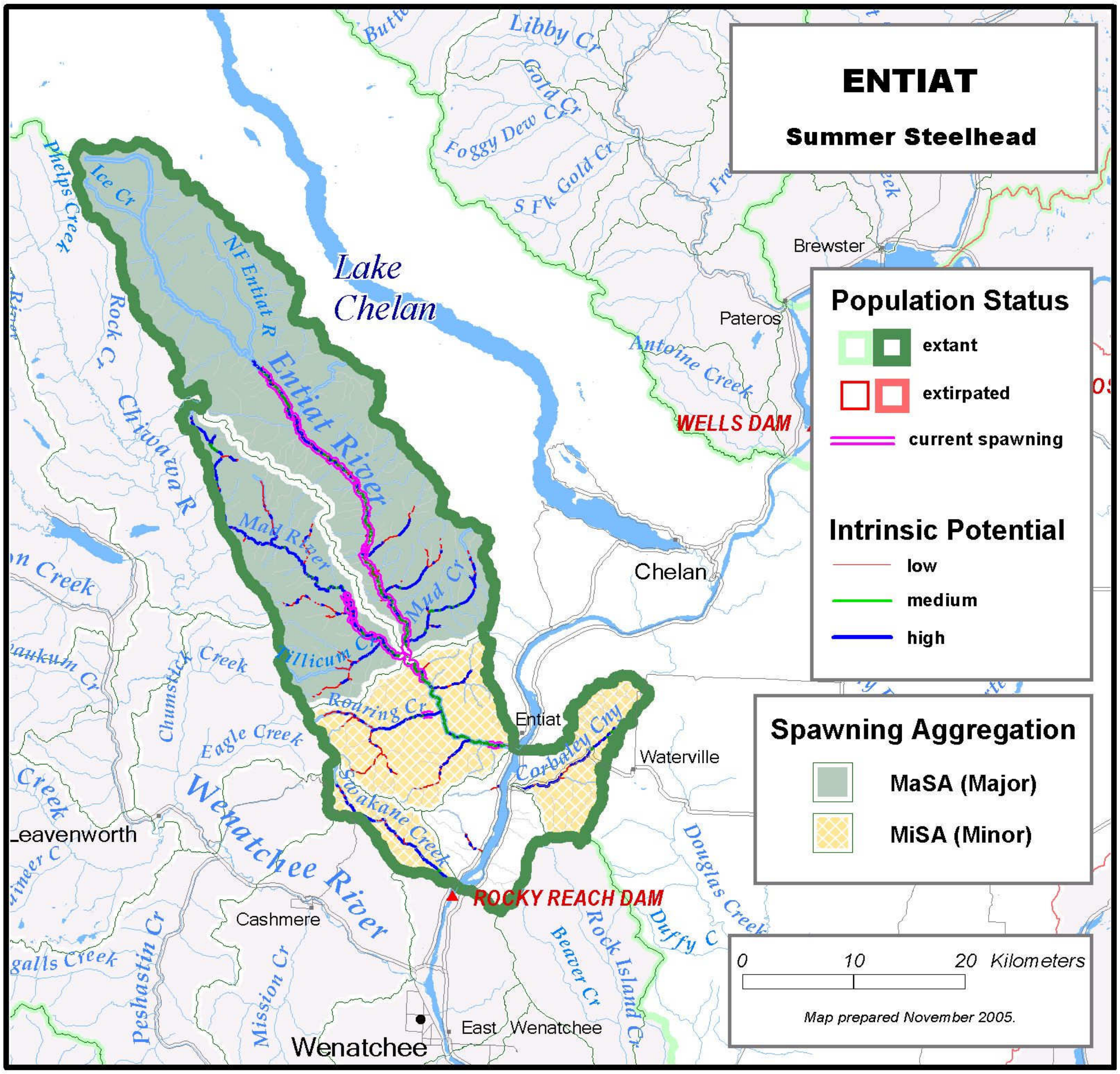


Figure 4.7 Distribution of major and minor spawning areas of steelhead in the Entiat Subbasin

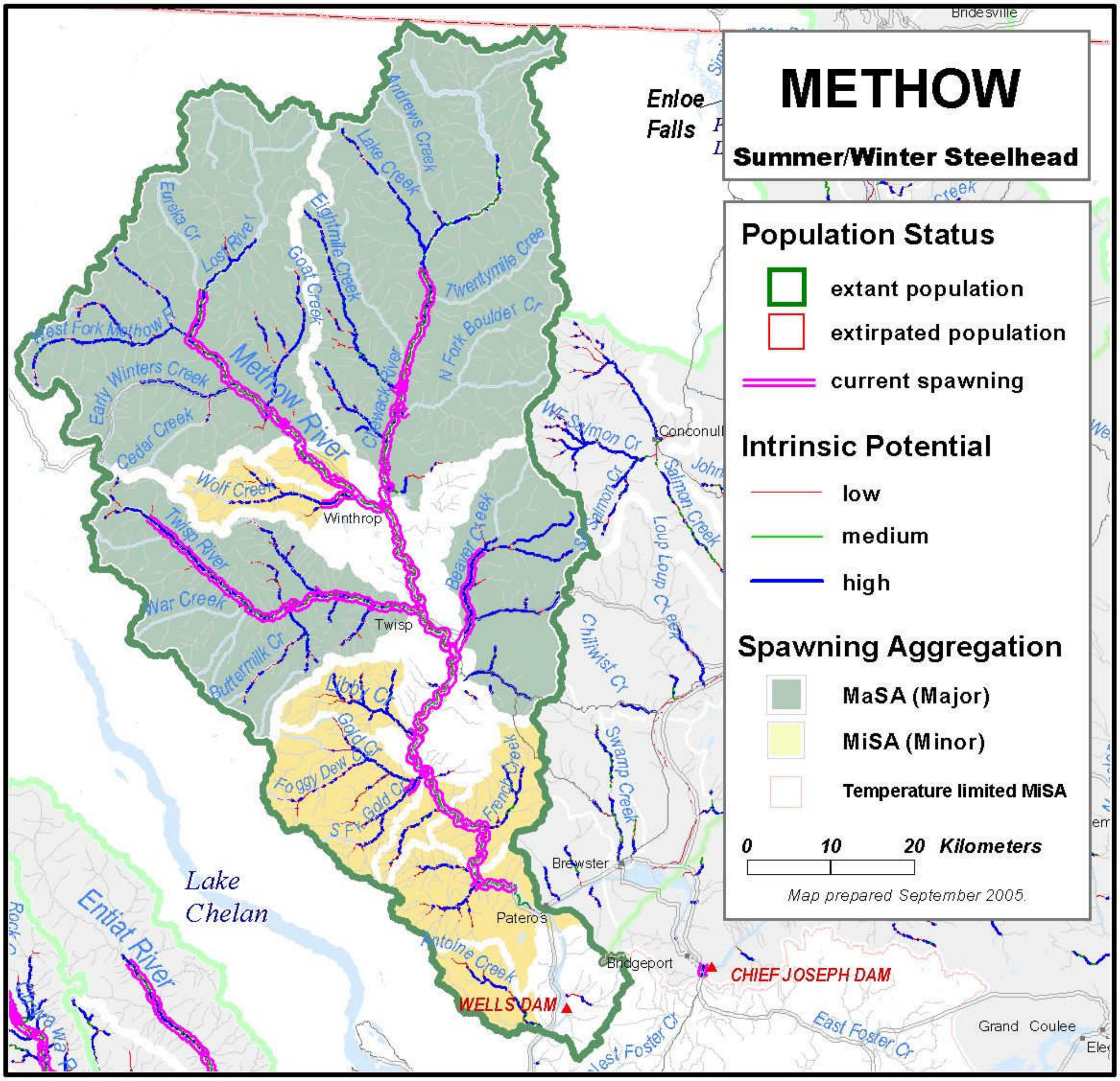


Figure 4.8 Distribution of major and minor spawning areas of steelhead in the Methow Subbasin

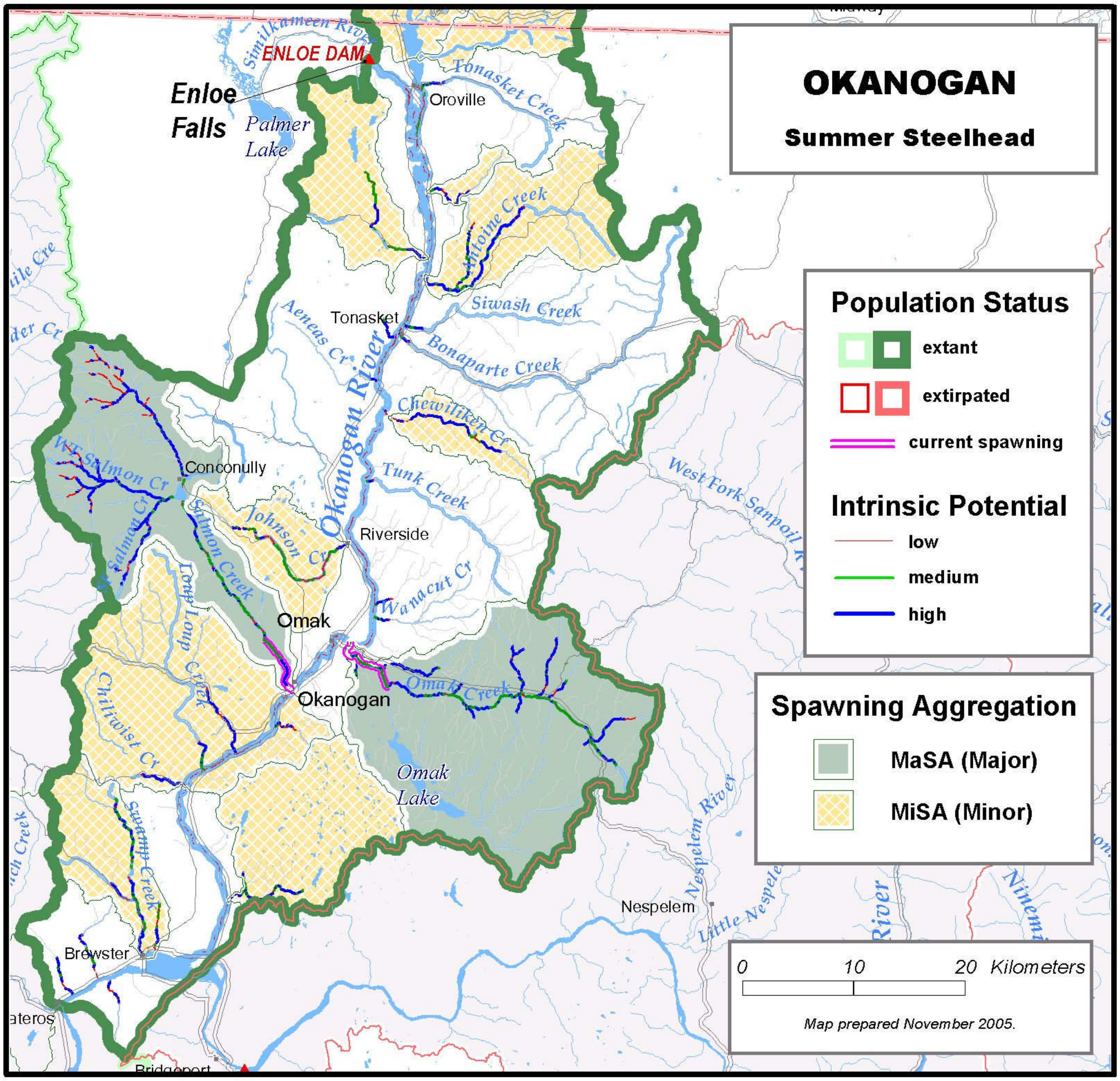


Figure 4.9 Distribution of major and minor spawning areas of steelhead in the Okanogan Subbasin

5 Strategy for Recovery

5.1 Overview	**5.4 Hydro Project Actions**
5.2 Harvest Actions	**5.5 Habitat Actions**
5.3 Hatchery Actions	**5.6 Integration of Actions**

This section of the recovery plan recommends recovery actions that are necessary to achieve the goals and objectives of the plan. It identifies and describes all recommended actions that will alleviate known threats and restore spring Chinook, steelhead, and bull trout populations in the Upper Columbia Basin to viable and sustainable levels. This section will provide guidance to resource managers, resource users, and landowners regarding the goals of the plan and actions needed to achieve recovery.

5.1 Overview

This plan recommends recovery actions for all Hs (Harvest, Hatchery, Hydro, and Habitat) that affect populations of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. Some of the H-specific actions identified in this plan were developed in other forums or processes and are incorporated with little or no modification. Several have already been implemented to the benefit of one or more of the VSP parameters (abundance, productivity, spatial structure, and diversity) of populations in the Upper Columbia Basin. Actions already implemented must be continued, monitored, refined, and expanded depending on new information derived from monitoring and evaluation and evolving science. However, it is clear that additional actions are necessary to achieve recovery of these populations.

The following guidelines, as modified by the UCSRB, were applied in selecting and describing recovery actions across Hs (NMFS 2004).

- Recovery actions should be discrete and action oriented.
- Whenever possible, recovery actions should be site-specific, as per ESA Section 4(f)(1)(B)(i).
- Recovery actions should be feasible, have broad public support, and have adequate funding.
- The plan should include both near-term (those that prevent population extinction or decline) and long-term (those that lead to recovery) actions.

As noted above, a number of forums have already identified and implemented actions intended to improve the status of listed Upper Columbia Basin species and will continue to do so. For example, subbasin and watershed plans identified actions within each of the subbasins that would benefit ESA-listed species in the Upper Columbia Basin. Similarly, specific actions that will benefit listed species have been identified in either Habitat Conservation Plans or Settlement Agreements for the hydropower projects owned by the PUDs in the Upper Columbia Basin and in Biological Opinions covering operations of the Federal Columbia River Power System (FCRPS). Harvest management regimes governing specific mainstem Columbia River fisheries have been developed and applied by the ***U.S. v Oregon*** parties since before the ESA listings of Upper Columbia Chinook and steelhead, and refined several times since the listings. Similarly, hatchery management has been reformed significantly throughout the Columbia Basin since the ESA listings. These hatchery reforms, described in detailed Hatchery and Genetics Management Plans (HGMPs) are designed to address requirements of the ESA, but also represent an evolving scientific understanding of the positive and negative effects of hatcheries on the viability of naturally produced populations. Most, if not all, of the above plans have been evaluated in ESA consultations that resulted in the issuance of Biological Opinions and when necessary, ESA permits.

Most of the actions identified in those forums meet the guidelines listed above, as do the additional actions identified in this plan. However, habitat-related actions identified in subbasin and watershed plans usually lacked prioritization. In this plan, actions were prioritized based on professional opinion, public input, and EDT modeling. This plan relied heavily on the priority of habitat actions identified in the Upper Columbia Regional Technical Team (UCRTT) Biological Strategy (UCRTT 2003). This is covered in more detail in Sections 5.5 and 8.3. It is presumed that actions within all sectors (i.e., all Hs) are necessary to achieve recovery (see Section 5.6), but because different sectors involve different parties, different decision-making processes, and different timelines, this plan respects those differences and does not attempt to prioritize actions across Hs. Actions within each sector, however, have been identified by those parties and processes and are described and categorized in this plan as short-term (those that prevent extinction or decline of populations) and long-term (those that lead to recovery) actions.

In the sections that follow, the plan provides general background information for each sector (H), describes the threats posed by that sector and how it limits recovery, and lists recovery objectives. Actions that have already been implemented and their benefits to VSP parameters of listed populations are identified. Next, the plan describes and prioritizes additional actions that are recommended for recovery of each population. To the extent possible, the recommended actions are tied directly to specific limiting factors, threats, and VSP parameters. Finally, the plan identifies the responsible parties for implementing the actions, how agency coordination will occur, and how implementation will be overseen and achieved.

5.2 Harvest Actions

5.2.1 Background

Fishing has had a significant negative effect on the abundance of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin (see Section 3.4) in the last 150 years. Currently, salmon, steelhead, and bull trout fisheries everywhere are managed with much greater sensitivity to the needs of natural populations, particularly when those populations have been listed under the ESA. Because of the prevalence of listed fish throughout the Columbia Basin, all fisheries in the mainstem Columbia are tightly constrained to limit harvest on listed salmon and steelhead, including Upper Columbia spring Chinook and steelhead. Fisheries in tributaries to the Columbia, including those in the Upper Columbia region, are tightly constrained or, in many cases, closed altogether. For example, there have been no directed fisheries on naturally produced spring Chinook or steelhead in the Upper Columbia Basin for over 20 years. A carefully managed steelhead fishery does occur upstream from Rocky Reach Dam, including the Methow and Okanogan subbasins (but excluding the Entiat). This fishery is directed at surplus hatchery steelhead and is designed to prevent seeding of the habitat with excess numbers of hatchery spawners and increasing the proportion of naturally produced spawners. Ocean catch records (Pacific Fishery Management Council) indicate that virtually no Upper Columbia spring Chinook or steelhead are taken in ocean fisheries. There is a fishery on bull trout in the Lost River in the Methow subbasin.

Fishing seasons for the commercial fisheries in the mainstem Columbia River bordering Washington and Oregon were established by the Columbia River Compact, a bi-state management arrangement approved by Congress in 1918. Recreational fisheries are regulated by the states within their respective boundaries. Tribal ceremonial and subsistence (C&S) fisheries in the mainstem Columbia River and its tributaries are regulated by the Columbia Basin treaty tribes for their respective tribal members. Sharing of the harvest between treaty Indian and non-treaty fisheries follow principles established in ***U.S. v Washington*** and ***U.S. v Oregon*** treaty Indian fishing rights cases. Many of the specific allocation, management and conservation (rebuilding) goals, and production strategies and objectives for the various salmon and steelhead runs are found in stipulated settlement agreements and management plans developed in the ***U.S. v Oregon*** forum. These plans were developed by the treaty tribes, federal government agencies, and states of Washington, Oregon, and Idaho and approved by the federal court, which retains jurisdiction over the case. The Colville Tribes currently regulate fishing by its members within the boundaries of the Colville Reservation and the former north half of the Reservation where reserved tribal fisheries rights exist. Although they are not a party to the ***U.S. v Oregon*** case and do not participate in fisheries in the lower Columbia River, the Colville Tribes clearly have an interest in the status of salmon and steelhead runs in the Upper Columbia River Basin. All harvest plans are evaluated for impacts to listed species in an ESA consultation process prior to implementation of the fishery.

5.2.2 Limiting Factors and Threats

Harvest clearly poses a potential threat to the VSP parameters of naturally produced populations and can be a significant factor that limits recovery. The historical record of salmon fisheries amply demonstrates that excessive harvest over prolonged periods of time can reduce abundance to critical levels, selectively alter the temporal and spatial structure of populations and the size of spawners, and suppress habitat productivity by reducing the flow of essential marine-derived nutrients to freshwater rearing habitats. As described in Section 3.4, salmon throughout the Columbia River Basin share a history of excessive harvests that occurred beginning well over a century ago. Even in recent times, fishery management regimes for mixed stock fisheries, both in the ocean and in the Columbia River mainstem often were based on maximizing the catch of stronger, naturally produced stocks or of hatchery stocks. Catches in mixed stock fisheries often were maintained at high levels by harvest management regimes driven by hatchery stocks produced in large mitigation hatcheries. In combination with non-fishing factors, this pattern contributed ultimately to the listings under the ESA.

Fortunately, the worst harvest management practices of the past have been greatly curtailed or eliminated. As described in Section 5.2.4, below, current management regimes are based to the extent possible on the biological requirements and status of the affected naturally produced stocks. Some listed stocks, however, are still captured incidentally in other fisheries or are harvested by poachers. Some harvest of Upper Columbia spring Chinook and steelhead still occurs in the lower Columbia River in other fisheries. In recent years the harvest of naturally produced Upper Columbia spring Chinook has actually increased because of the larger returns of adults.[86] Harvest rates on naturally produced Upper Columbia steelhead in the lower Columbia River fisheries range up to 3.8%.

Spring Chinook, steelhead, and bull trout are also harvested illegally in their home streams and on their spawning grounds. Bull trout are caught during the sockeye fishery in Lake Wenatchee and during open seasons for mountain whitefish. Additionally, bull trout may be harvested because of misidentification. Currently, there is a fishery on bull trout on the Lost River.

Current threats that reduce the abundance of spawning adult spring Chinook, steelhead, and bull trout include incidental take on directed fisheries and illegal harvest (poaching). The reduction in abundance due to harvest means that a higher productivity is needed to maintain viable populations (see Section 4). However, because harvest is mostly non-selective, historical harvest may have reduced the productivity of naturally produced populations by removing large numbers of naturally produced fish, allowing the natural (or intrinsic) productivity of the population to be reduced by hatchery produced fish spawning in the wild. Population productivity may decrease because hatchery fish spawning in the wild tend to be less productive than the naturally produced fish (Berejikian and Ford 2004).[87] Finally, if populations are critically low in abundance, any harvest could reduce genetic and phenotypic diversity through a phenomenon known as a "population bottleneck."[88]

5.2.3 Harvest Objectives

Harvest objectives for treaty and non-treaty salmon and steelhead fisheries in the Columbia River Basin are set by the applicable state, tribal, and federal agencies. Fishery objectives from McNary Dam to the river mouth (fishing zones 1-6) are established by state, tribal, and federal parties in ***U.S. v Oregon***. In developing management plans under ***U.S. v Oregon***, the parties recognize the necessity of managing the fisheries to provide spawning escapement to the various tributary production areas, including the Upper Columbia tributaries covered in this plan. At the same time, they seek to provide meaningful treaty and non-treaty fishing opportunities in zones 1-6, targeting the more productive natural and hatchery stocks, and, where possible, allow fish to pass through to provide tributary fishing opportunities. Prior to opening fisheries, harvest plans undergo ESA consultation.

The following objectives for harvest apply not only to the Upper Columbia Basin, but also include the entire Columbia River. These objectives are intended to reduce threats associated with harvest.

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[86] Harvest of Upper Columbia spring Chinook in the lower river fisheries has ranged from 5.1% in 1999 (when the ESU was listed) to 14.6% in 2001. During the period 2001-2004, the harvest of Upper Columbia spring Chinook has averaged 12% (Joint Columbia River Management Staff 2005).
[87] The threat of decreased productivity associated with hatchery fish is addressed in Section 5.3 (Hatchery Actions).
[88] A population bottleneck occurs when a population is greatly reduced in size causing rare alleles in the population to be lost. When fewer alleles are present, there is a decline in genetic diversity and the fitness of individuals within the population may decline.

Short-Term Objectives

- Use selective harvest techniques to constrain harvest on naturally produced fish at the currently reduced rates throughout the Columbia Basin.
- Use selective harvest techniques to provide fishery opportunities in the Upper Columbia Basin that focus on hatchery-produced fish that are not needed for recovery.
- Recommend that parties of ***U.S. v Oregon*** incorporate Upper Columbia VSP criteria when formulating fishery plans affecting Upper Columbia spring Chinook and steelhead.
- Increase effective enforcement of fishery rules and regulations.
- Appropriate co-managers/fisheries management agencies should work with local stakeholders to develop tributary fisheries management goals and plans.

Long-Term Objectives

- Provide opportunities for increased tributary harvest consistent with recovery.
- Incorporate Upper Columbia VSP criteria when formulating fishery plans affecting Upper Columbia spring Chinook and steelhead.

Research and Monitoring Objectives

- Research and employ best available technology to reduce incidental mortality of non-target fish in selective fisheries.
- Monitor the effects of incidental take on naturally produced populations in the Upper Columbia Basin.
- Improve estimates of harvested fish and indirect harvest mortalities in freshwater and ocean fisheries.
- Initiate or continue monitoring and research to improve management information, such as the timing of the various run components through the major fisheries.

This plan recognizes that these objectives must balance the conservation of ESA species with the federal government's trust obligations to Native Americans, the priority of tribal reserved rights for fish and fisheries, and the idea that there is an "irreducible core" of tribal harvest that is so vital to the treaty obligation that the federal government will not eliminate it.[89] In addition, this plan integrates efforts from the following harvest programs: Pacific Fishery Management Council (PFMC), which manages Pacific Ocean fisheries in the U.S. south of Canada consistent with sustainable fishing requirements of the U.S. Magnuson-Stevens Act; the Pacific Salmon Commission (PSC), which oversees management by the domestic managers of fisheries subject to a treaty involving Alaska and Canadian fisheries; and the Columbia River mainstem and

[89] Principle 3(C) of Secretarial Order #3206 Subject: American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act identified five conservation standards that have to be met before tribal harvest can be restricted for ESA purposes. This recovery plan does not attempt to overtop the Secretarial Order.

tributary fisheries, which are regulated by the Columbia River compact (Oregon and Washington concurrent jurisdiction), the Columbia River treaty Indian tribes, the Colville Tribes, and the Washington and Oregon Fish and Wildlife Commissions.

5.2.4 Recent Harvest Actions

For listed Upper Columbia spring Chinook and steelhead, the fisheries can be divided into two geographical categories: those that occur within the Upper Columbia basin, and those that occur outside the basin. Fisheries in both areas undergo ESA consultation prior to opening. Ocean catch records (Pacific Fishery Management Council) indicate that virtually no Upper Columbia spring Chinook or steelhead are taken in ocean fisheries. For upper Columbia spring Chinook and steelhead, most of the out-of-basin harvest occurs downstream in the Columbia River in fisheries managed by the states and tribes pursuant to management plans developed in ***U.S. v Oregon***. The current management plan was recently updated by the parties and covers fisheries for the 2005-2007 seasons. It was adopted by the federal court in May 2005, following a biological opinion issued by NOAA Fisheries Service pursuant to the ESA.

Spring Chinook

Until recently there had been no fisheries directed at spring Chinook since 1977 within the Upper Columbia Basin (other than the fishery downstream from the Leavenworth National Fish Hatchery) or in the Columbia River mainstem. As noted above, almost no Columbia River spring Chinook are taken in ocean fisheries. Only in the last few years have spring Chinook runs increased sufficiently to support limited fisheries directed primarily at hatchery Chinook in the mainstem of the Columbia River. The recent increases in runs are attributed largely to improved ocean conditions and increases in hatchery production, rather than to a major improvement in the general status of the naturally produced populations of spring Chinook.

With virtually no fisheries directed at spring Chinook within the Upper Columbia Basin, the only fisheries that significantly affect Upper Columbia spring Chinook occur downstream, in Zones 1-6 of the lower Columbia River Mainstem. These fisheries occur during what is referred to in ***U.S. v Oregon*** as the winter, spring, and summer seasons, which begin in February and ends July 31 of each year. The treaty fishery occurs exclusively in Zone 6, the area between Bonneville and McNary Dams; the non-treaty commercial fisheries occur in Zones 1-5, which are downstream from Bonneville Dam. The non-treaty recreational (sport) fishery occurs in the mainstem Columbia River from below The Dalles Dam upstream to McNary Dam. All these fisheries were managed subject to the provisions of the Columbia River Fish Management Plan (CRFMP) from 1988 through 1998. The CRFMP was a stipulated agreement adopted by the Federal Court under the continuing jurisdiction of ***U.S. v Oregon***.

Although the CRFMP expired December 31, 1998, it has been extended by court order and agreements. A new three-year (2005-2007) management agreement that covers the remainder of the 2005 winter/spring/summer fishery, as well as the winter/spring/summer and fall season fisheries beginning in 2005 and continuing through December 31, 2007. NOAA Fisheries issued a biological opinion and incidental take statement after finding that the fisheries prescribed by the plan will not jeopardize the survival and recovery of the affected listed species.

The specific spring Chinook harvest rate schedule developed for the 2001-2005 plan scales the allowable harvest rate to the relative abundance of the runs of interest, in this case the listed

Upriver Columbia spring Chinook and Snake River spring/summer Chinook. As noted above, the 1988-98 CRFMP limited the treaty Indian fishery impacts at 5-7% and the non-treaty impacts at 5% of the aggregate run (hatchery plus natural) of all upriver spring Chinook (and spring/summer Chinook) at all run sizes up to a certain point (which was never reached while it was in place). It would have then allowed the harvest of 100% of the fish above that point. This relatively simple formulation implies that all natural spawners up to a certain level (the escapement goal) are equally important, and above that level have no value at all. The more recent agreements, developed in the context of a mixture of much larger, mostly hatchery runs and depressed ESA-listed runs, allow somewhat higher impacts on naturally produced fish in times of greater overall abundance, but prescribe fewer impacts when abundance declines to lower levels (relative to the 1988-98 CRFMP). Notably, the new harvest rate schedule limits impacts on naturally produced Upper Columbia River spring Chinook when their forecast abundance falls below a pre-defined critical level of 1,000 naturally produced Upper Columbia spring Chinook.[90]

The logic underlying this approach recognizes the increasingly higher biological value of naturally produced spawners as their number decreases. It also recognizes the continued added value of additional spawners even when the abundance of natural spawners increases above what formerly was the spawning escapement goal. Two of the simplifying assumptions underlying the harvest-rate schedule is that each of the Upper Columbia spring Chinook populations are affected at the same rates in the mainstem fisheries, and the abundances of all spring Chinook populations (hatchery and natural) co-vary from year to year (i.e., rise and fall in abundance at more or less the same rate). No Upper Columbia population-specific run timing data currently exist to determine the feasibility of shaping mainstem fisheries (temporally or geographically) to target or avoid specific natural populations passing through the fisheries. Similarly, there is insufficient data currently available to determine whether the several natural populations or the natural and hatchery populations co-vary. Whether these assumptions prove to be a problem in terms of achieving population-specific escapement objectives with the current harvest rate schedule will have to be determined through monitoring.

Because spring Chinook returns in recent years (since 2000, but before 2005) have been quite high relative to the recent past, the result of the new harvest rate schedule so far has been a higher average impact rate. However, if the run sizes drop to levels typical of the two decades before 2000, impact rates will be reduced.

A recent change in Columbia River fisheries management has been the emergence of “mark selectivity.” Currently, almost all salmon and steelhead produced in hatcheries and intended for harvest are mass marked by removing the adipose fin on each fish, by federal law. Marking of hatchery fish enables biologists to distinguish between hatchery and naturally produced fish in the escapements, thereby improving assessments of the status of natural populations. It also enables harvest managers to use mark-selective fishery regulations to target fisheries on returning hatchery fish that are surplus to escapement needs. Limited currently to impacts of 2% or less (depending on the annual run size) of listed upriver spring Chinook, the states

[90] The critical level of 1000 fish is inconsistent with the recovery criterion of 4500 fish (see Section 4.4). The UCSRB is concerned that such management actions implemented in the lower Columbia will hinder recovery of Upper Columbia stocks.

(Washington and Oregon) now require non-treaty commercial net and recreational fisheries to release alive all unmarked spring Chinook and steelhead caught in their lower Columbia River spring fisheries.[91] This has required the commercial fishery to switch from gill nets to "tangle nets," which, when operated properly, make it possible for the catch to be sorted while still alive and the unmarked fish to be released.

A portion of the fish caught and released from tangle nets and recreational hook-and-line gear will die. These mortalities are included in the 2% impact limit. The catch-and-release mortality rate varies for different gear types, different species, and different fishing conditions, and those values are often unknown. Catch-and-release mortality rates have been estimated from available data and are applied by the ***U.S. v Oregon*** Technical Advisory Committee (TAC) during the management of the fisheries. The TAC applies a 10% incidental mortality rate to salmon caught and released during recreational fishing activities. The TAC also applies a 1% incidental mortality rate to salmon caught and released using dipnets (although these typically are not managed to be mark-selective). Catch-and-release mortality associated with selective tangle net and gillnet fisheries during the winter and spring season are 18.5% and 30%, respectively. Estimates of catch-and-release mortality are combined with landed catch estimates when reporting the expected total mortality, and are therefore specifically accounted for in the harvest rate schedule and the biological opinion. By requiring the release of unmarked fish and allowing retention of only the marked hatchery fish, the states have been able to provide a much larger total catch to these fisheries than would be the case if the fisheries were managed to be non-selective.

Another harvest management change incorporated into the 2005-2007 ***U.S. v Oregon*** involves a revision in the dates delineating the "spring season" management period from the "summer season" management period for the mainstem Columbia River fisheries. Under the 2001-2005 Interim Management Agreement and previous agreements, the Snake River and upriver spring Chinook (which include Upper Columbia spring Chinook), and the Snake River and upriver summer Chinook were managed as separate units during the spring and summer management periods. Analysis of the run timing of spring and Snake River spring/summer Chinook indicated that 96% of upriver spring and Snake River spring/summer Chinook passed Bonneville Dam by June 15. In other words, the timing of Snake River summer Chinook is better grouped with the other spring-run fish, including the Upper Columbia spring Chinook. TAC therefore proposed modifying the spring and summer management periods so that Snake River spring/summer Chinook could be included in the spring management period. TAC proposed changing the spring management period from an end date of May 31, to an end date of June 15. By adjusting the spring/summer separation date to June 15 to better reflect the run-timing of listed summer populations of the Snake River spring/summer-run Chinook ESU, there is additional fishing opportunity on unlisted upriver summer Chinook, which apparently have later timing and can be targeted in summer season fisheries.

The current agreement includes a modified harvest rate schedule for the spring management period. The intent underlying development of the modified harvest rate schedule was to maintain harvest rates consistent with the 2001-2005 Interim Management Agreement, while accounting

[91] Some of the non-treaty fisheries in the lower river are not mark selective.

for the adjusted management period. This was done by adjusting the “breakpoints” in the harvest rate schedule by approximately 8%, which accounts for the average percent of the run passing Bonneville Dam in the June 1-15 timeframe. Because including additional days in the management period will mean larger dam counts and thus larger run sizes, it was necessary to raise the harvest breakpoints by an appropriate amount to maintain constant relative harvest rates between the two management systems (i.e., the 2001-2005 plan and the 2005-2007 plan). By making this change in the management framework, and managing Snake River spring/summer Chinook together, run reconstructions should be more accurate, leading to improved assessment of stock status and more accurate measurements of impacts on listed fish.

Steelhead

Recent changes in fishery management to protect steelhead have substantially reduced harvest risks to naturally produced steelhead populations in the Upper Columbia Basin. Harvest rates of steelhead in the lower Columbia River fisheries (both tribal and non-tribal) are generally less than 5-10% (NMFS 2001, NOAA Fisheries 2004). NOAA Fisheries does not consider harvesting hatchery steelhead at a higher rate than naturally produced steelhead a risk to the species. In fact, in the Upper Columbia Basin, harvest is used as a management tool to reduce the uncertain effects of hatchery steelhead spawning with naturally produced steelhead (NMFS 2003; Berejikian and Ford 2004). The linking of harvest with hatchery operations in a single plan is a relatively new approach to hatchery implementation.

WDFW regulates the harvest of hatchery steelhead in the Upper Columbia Basin. There is no directed fishery on naturally produced steelhead in the basin. NOAA Fisheries (2003) approved a tiered-approach to the harvest of hatchery steelhead via an ESA consultation and permit issuance. The goal of the fishery is to reduce the number of hatchery steelhead that exceed habitat seeding levels in spawning areas and to increase the proportion of naturally produced steelhead in the spawning populations. To this end, WDFW may either remove hatchery steelhead at dams or other trapping sites, or they may use recreational fisheries to selectively harvest hatchery steelhead (adipose fin-clipped fish). Under the current ESA permit, steelhead fisheries on adipose fin-clipped hatchery steelhead may be implemented in the Wenatchee, Methow, and/or Okanogan basin when naturally produced steelhead run levels meet define criteria. The current permit criteria (NMFS 2003) are:

- When the natural origin (wild) steelhead run is predicted to exceed 1,300 fish at Priest Rapids Dam and the total steelhead run is predicted to exceed 9,550 steelhead, a harvest fishery may be considered as an option to remove excess adipose fin-clipped hatchery steelhead. For a fishery to be authorized in the tributary areas, the predicted tributary escapements must meet certain minimum tier 1 criteria (**Table 5.1**; Tier 1). The mortality impact on naturally produced steelhead must not exceed the specified limits for Tier 1 in each tributary area.
- When the natural origin steelhead run is predicted to exceed 2,500 fish at Priest Rapids Dam, and the total steelhead run is predicted to exceed 10,035 steelhead, and the tributary escapements meet the minimum targets, then naturally produced steelhead mortality impacts must not exceed the limits specified for Tier 2 in each tributary area (**Table 5.1**; Tier 2).
- When the natural origin steelhead run is predicted to exceed 3,500 fish at Priest Rapids Dam, and the total steelhead run is predicted to exceed 20,000 steelhead, and the tributary

escapements meet the minimum targets, then naturally produced steelhead mortality impacts must not exceed the limits specified for Tier 3 in each tributary area (**Table 5.1**; Tier 3).

- The WDFW may remove artificially propagated steelhead at dams or other trapping sites to reduce the number of artificially propagated steelhead in the spawning areas in excess of full habitat seeding levels to increase the proportion of naturally produced steelhead in the spawning population.

Bull Trout

WDFW regulates the harvest of bull trout in the Upper Columbia Basin. Except for a fishery in the Lost River, there has been no directed fishery on bull trout in the Upper Columbia Basin since the listing of bull trout in 1998. These changes have substantially reduced legal harvest of Upper Columbia bull trout. The reduced steelhead fishery likely also benefited bull trout through reduced incidental catch of bull trout.

5.2.5 Harvest Recovery Actions

Recovery actions listed below for each population are intended to reduce threats associated with harvest, which is limited to impacts on naturally produced populations that are incidental to fisheries directed at hatchery fish or other species. This plan strengthens the likelihood that all actions and mitigation associated with harvest throughout the Columbia River are consistent with recovery of Upper Columbia spring Chinook, steelhead, and bull trout. These actions primarily address adult abundance.

Spring Chinook

Wenatchee Population

Currently, non-listed, hatchery-produced spring Chinook salmon are harvested in Icicle Creek, downstream from the Leavenworth NFH. A fishery in the Wenatchee River has not been open since the ESA listing in 1999 to protect commingled naturally produced spring Chinook in the area.

Short-term Actions

- Continue the current fishery in Icicle Creek on non-listed, hatchery produced spring Chinook when estimated hatchery adult returns exceed hatchery needs.
- Maintain a closed fishery on naturally produced spring Chinook in the Wenatchee River until naturally produced fish meet “recovery” abundance, productivity, and spatial structure/diversity criteria (2,000 naturally produced adults and spawner:spawner ratios greater than 1).
- Develop a limited fishery on surplus hatchery produced spring Chinook in the Wenatchee subbasin.
- Increase enforcement efforts to reduce poaching of spring Chinook salmon in the Wenatchee subbasin.

- Strive to make that all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Continue the fishery in Icicle Creek on hatchery-produced fish when the estimated hatchery adult returns exceed hatchery needs.
- Open a fishery on naturally produced spring Chinook on the Wenatchee River after naturally produced fish meet "recovery" abundance, productivity, and spatial structure/diversity criteria (2,000 naturally produced adults and spawner:spawner ratios greater than 1).
- In cooperation with parties of ***U.S. v Oregon***, incorporate Upper Columbia VSP criteria when formulating fishery plans affecting Upper Columbia spring Chinook.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing and promote the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- Monitor the effects of the Icicle fishery on the abundance of naturally produced spring Chinook in the Wenatchee population.
- Once a fishery on naturally produced spring Chinook opens, monitor the effects of harvest on the abundance of spring Chinook in the Wenatchee subbasin.
- Monitor the effects of incidental take of other listed and sensitive species during a spring Chinook fishery.
- Monitor the effects of any current or future hatchery fishery on naturally produced fish.

Entiat Population

Before spring Chinook were listing as endangered in 1999, WDFW opened a fishery in the Entiat only when the adult returns were high. Since the ESA listing, there has been no fishery in the Entiat River.

Short-term Actions

- Maintain a closed fishery on naturally produced spring Chinook on the Entiat River until naturally produced fish meet "recovery" abundance, productivity, and spatial/diversity criteria (500 naturally produced adults and spawner:spawner ratios greater than 1).
- Develop a limited fishery on surplus hatchery produced spring Chinook in the Entiat subbasin.
- Increase enforcement efforts to reduce poaching of spring Chinook salmon in the Entiat subbasin.

- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Open a fishery on naturally produced spring Chinook on the Entiat River after naturally produced fish meet "recovery" abundance, productivity, and spatial/diversity criteria (500 naturally produced adults and spawner:spawner ratios greater than 1).
- In cooperation with parties of ***U.S. v Oregon***, incorporate Upper Columbia VSP criteria when formulating fishery plans affecting Upper Columbia spring Chinook.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- Once a fishery on naturally produced spring Chinook opens, monitor the effects of harvest on the abundance of spring Chinook in the Entiat subbasin.
- Monitor the effects of incidental take of other listed and sensitive species during a spring Chinook fishery.
- Monitor the effects of any current or future hatchery fishery on naturally produced fish.

Methow Population

There has been no fishery for spring Chinook in the Methow subbasin for several decades.

Short-term Actions

- Maintain a closed fishery on naturally produced spring Chinook on the Methow River until naturally produced fish meet "recovery" abundance, productivity, and spatial/diversity criteria (2,000 naturally produced adults and spawner:spawner ratios greater than 1).
- Develop a limited fishery on surplus hatchery produced spring Chinook in the Methow subbasin.
- Increase enforcement efforts to reduce poaching of spring Chinook salmon in the Methow subbasin.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Open a fishery on naturally produced spring Chinook in the Methow River after naturally produced fish meet "recovery" abundance, productivity, and spatial/diversity criteria (2,000 naturally produced adults and spawner:spawner ratios greater than 1).

- In cooperation with parties of ***U.S. v Oregon***, incorporate Upper Columbia VSP criteria when formulating fishery plans affecting Upper Columbia spring Chinook.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- Once a fishery on naturally produced spring Chinook opens, monitor the effects of harvest on the abundance of spring Chinook in the Methow subbasin.
- Monitor the effects of incidental take of other listed and sensitive species during a spring Chinook fishery.
- Monitor the effects of any current or future hatchery fishery on naturally produced fish.

Upper Columbia River

Currently, the abundance of naturally produced Upper Columbia spring Chinook is too low to support a fishery.

Short-term Actions

- Maintain a closed salmonid fishery on the upper mainstem Columbia River downstream from the mouth of the Okanogan River until July when it opens for summer Chinook salmon.
- Develop a fishery on hatchery-produced spring Chinook upstream from the mouth of the Okanogan River.
- Work with parties in ***U.S. v. Oregon*** to reduce the harvest or incidental take of Upper Columbia spring Chinook in the lower Columbia River fisheries.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Open a fishery on the mainstem Upper Columbia River after naturally produced spring Chinook within each population meet "recovery" abundance, productivity, and spatial/diversity criteria.
- In cooperation with parties of ***U.S. v Oregon***, incorporate Upper Columbia VSP criteria when formulating fishery plans affecting Upper Columbia spring Chinook.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- Develop gear and handling techniques, as well as regulatory options in both commercial and sport fisheries, to minimize selective fishery impacts to naturally produced Upper Columbia spring Chinook.
- Develop or improve monitoring tools to evaluate fishery catch to assure impacts to naturally produced Upper Columbia spring Chinook are maintained within the take limits.
- Monitor lower Columbia River selective fisheries and estimate impacts to naturally produced Upper Columbia spring Chinook.
- Estimate handling mortality of released naturally produced Upper Columbia spring Chinook in the lower Columbia River fishery.
- Monitor the effects of incidental take on other listed and sensitive species during a spring Chinook fishery.

Steelhead

Wenatchee Population

Before the listing of steelhead as endangered in 1997, the Wenatchee River supported a fairly robust sport fishery. There is currently no harvest of steelhead in the Wenatchee subbasin.

Short-term Actions

- Maintain a no-harvest fishery on naturally produced steelhead in the Wenatchee subbasin until naturally produced fish meet “recovery” abundance, productivity, and spatial/diversity criteria (1,000 naturally produced adults and spawner:spawner ratios greater than 1).
- Develop a limited fishery on surplus hatchery produced steelhead in the Wenatchee subbasin.
- Maintain ban on planting hatchery produced “catchable” rainbow trout into steelhead habitat in the Wenatchee subbasin.
- Increase enforcement efforts to reduce poaching of steelhead in the Wenatchee subbasin.
- Strive to make actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Open a fishery on naturally produced steelhead in the Wenatchee subbasin after naturally produced fish meet “recovery” abundance, productivity, spatial/diversity criteria (1,000 naturally produced adults and spawner:spawner ratios greater than 1).
- Strive to make actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- After steelhead are reclassified as “threatened,” examine the effects of an experimental catch-and-release fishery on the survival of naturally produced adult steelhead in the Wenatchee River.
- Assess the population structure of ***O. mykiss*** (resident and anadromous).
- Once a fishery on naturally produced steelhead opens, monitor the effects of harvest on the abundance of steelhead in the Wenatchee subbasin.
- Monitor the effects of incidental take on other listed and sensitive species during a steelhead fishery.
- Monitor the effects of incidental take of steelhead during the whitefish fishery.

Entiat Population

Before steelhead were listed as endangered in 1997, WDFW opened a small fishery in the Entiat. Since the ESA listing, there has been no steelhead fishery in the Entiat River.

Short-term Actions

- Maintain a no-harvest fishery on naturally produced steelhead in the Entiat subbasin until naturally produced fish meet “recovery” abundance, productivity, and spatial/diversity criteria (500 naturally produced adults and spawner:spawner ratios greater than 1).
- Develop a limited fishery on wandering/straying hatchery produced steelhead in the Entiat subbasin.
- Maintain ban on planting hatchery produced “catchable” rainbow trout into steelhead habitat in the Entiat subbasin.
- Increase enforcement efforts to reduce poaching of steelhead in the Entiat subbasin.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Open a fishery on naturally produced steelhead in the Entiat subbasin after naturally produced fish meet “recovery” abundance, productivity, and spatial/diversity criteria (500 naturally produced adults and spawner:spawner ratios greater than 1).
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- After steelhead are reclassified as “threatened,” examine the effects of an experimental catch-and-release fishery on the survival of naturally produced adult steelhead in the Entiat River.

- Once a fishery on naturally produced steelhead opens, monitor the effects of harvest on the abundance of steelhead in the Entiat subbasin.
- Assess the population structure of ***O. mykiss*** (resident and anadromous).
- Examine the effects of out-of-basin hatchery steelhead on the Entiat population
- Monitor the effects of incidental take on other listed and sensitive species during a steelhead fishery.
- Monitor the effects of incidental take of steelhead during the whitefish fishery.

Methow Population

Before the ESA listing, the Methow River was a major steelhead fishery (Mullan et al. 1992; Chapman et al. 1994). There is currently a fishery on hatchery produced steelhead in the Methow River. This fishery is intended to reduce the number of hatchery produced fish that spawn with naturally produced fish.

Short-term Actions

- Maintain the current fishery on hatchery produced steelhead in the Methow River. The fishery shall follow the tiered approach developed by WDFW and NOAA Fisheries as outlined in **Table 5.1**.
- Allow no harvest on naturally produced steelhead in the Methow subbasin until naturally produced fish meet "recovery" abundance, productivity, and spatial/diversity criteria (1,000 naturally produced adults and spawner:spawner ratios greater than 1).
- Maintain ban on planting hatchery produced "catchable" rainbow trout into steelhead habitat in the Methow subbasin.
- Increase enforcement efforts to reduce poaching of steelhead in the Methow subbasin.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.
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Long-term Actions

- Open a fishery on naturally produced steelhead in the Methow subbasin after naturally produced fish meet "recovery" abundance, productivity, and spatial/diversity criteria (1,000 naturally produced adults and spawner:spawner ratios greater than 1).
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- Examine the effects of the current fishery on the survival and abundance of naturally produced adult steelhead in the Methow River.
- Once a fishery on naturally produced steelhead opens, monitor the effects of harvest on the abundance of steelhead in the Methow subbasin.
- Assess the population structure of ***O. mykiss*** (resident and anadromous).
- Monitor the effects of incidental take on other listed and sensitive species during a steelhead fishery.
- Monitor the effects of incidental take of steelhead during the whitefish fishery.

Okanogan Population

There is currently a fishery on hatchery-produced steelhead in the Okanogan River. This fishery is intended to reduce the number of hatchery-produced fish that spawn with naturally produced fish.

Short-term Actions

- Continue the current fishery on hatchery produced steelhead following the Tiered approach outlined in **Table 5.1**.[92]
- Allow no harvest of naturally produced steelhead in the Okanogan subbasin until naturally produced fish meet "recovery" abundance, productivity, and spatial/diversity criteria (500 naturally produced adults and spawner:spawner ratios greater than 1).
- Ban plantings of hatchery produced "catchable" rainbow trout into steelhead habitat in the Okanogan subbasin.
- Increase enforcement efforts to reduce poaching of steelhead in the Okanogan subbasin.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Open a fishery on naturally produced steelhead in the Okanogan subbasin after naturally produced fish meet "recovery" abundance, productivity, and spatial/diversity criteria (500 naturally produced adults and spawner:spawner ratios greater than 1).

[92] The current steelhead fishery in the Okanogan River does not allow the Colville Tribes to exercise their reserved fishery right. The Colville Tribes intend to seek a modification to their NOAA consultation on steelhead harvest to ensure the opportunity to exercise their reserved fishery right. Provided the tribal fishery targets hatchery produced steelhead, this action will not preclude recovery of steelhead in the Okanogan subbasin.

- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- Examine the effects of the current fishery on the survival and abundance of naturally produced adult steelhead in the Okanogan subbasin.
- Once a fishery on naturally produced steelhead opens, monitor the effects of harvest on the abundance of steelhead in the Okanogan subbasin.
- Assess the population structure of ***O. mykiss*** (resident and anadromous).
- Monitor the effects of incidental take on other listed and sensitive species during a steelhead fishery.
- Monitor the effects of incidental take of steelhead during the whitefish fishery.

Upper Columbia River

Currently, the abundance of naturally produced Upper Columbia steelhead is too low to support a fishery.

Short-term Actions

- Maintain fishery on hatchery-produced steelhead in the mainstem Upper Columbia River.
- Allow no harvest of naturally produced steelhead in the mainstem Upper Columbia River.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Open a fishery on naturally produced Upper Columbia steelhead in the mainstem Upper Columbia River after naturally produced fish within each population meet “recovery” abundance, productivity, and spatial/diversity criteria.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- Develop gear and handling techniques, as well as regulatory options in both commercial and sport fisheries, to minimize selective fishery impacts to naturally produced Upper Columbia steelhead.
- Develop or improve monitoring tools to evaluate fishery catch to assure impacts to naturally produced steelhead are maintained within the limits.

- Monitor Columbia River selective fisheries and estimate impacts to naturally produced Upper Columbia steelhead.
- Estimate handling mortality of released naturally produced Upper Columbia steelhead in the Columbia River fishery.
- Monitor the effects of incidental take on other listed and sensitive species during a steelhead fishery.

Bull Trout

Wenatchee Core Area

There has been no fishing for bull trout in the Wenatchee Core Area since the listing of bull trout as threatened in 1998.

Short-term Actions

- Maintain a closed fishery on bull trout in the Wenatchee Core Area until bull trout meet "recovery" abundance and productivity criteria (1,612 adult bull trout and a stable or increasing trend).
- Maintain ban on planting hatchery produced "catchable" rainbow trout into bull trout streams in the Wenatchee Core Area to reduce the probability of incidental harvest of bull trout
- Ban all plantings of brook trout within waters associated with or connected to bull trout habitat.
- Increase fisherman education during the sockeye salmon fishery in Lake Wenatchee.
- Increase enforcement efforts to reduce poaching of bull trout in the Wenatchee Core Area.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Open a fishery in the Wenatchee Core Area after bull trout meet "recovery" abundance and productivity criteria (1,612 adults and a stable or increasing trend).
- Ban all plantings of brook trout within waters associated with or connected to bull trout habitat.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- Examine the effects of an experimental catch-and-release fishery on the survival of adult bull trout in the Wenatchee Core Area once bull trout reach "recovery" criteria.
- Examine the effects of the mainstem bait fishery on bull trout.

- Monitor the incidental catch of bull trout in the Lake Wenatchee sockeye fishery and in the whitefish fishery.
- Once a fishery on bull trout opens, monitor the effects of harvest on the abundance of bull trout in the Wenatchee Core Area.
- Monitor the effects of incidental take on other listed and sensitive species during a bull trout fishery.

Entiat Core Area

There has been no fishing for bull trout in the Entiat Core Area since the listing of bull trout as threatened in 1998.

Short-term Actions

- Maintain a closed fishery on bull trout in the Entiat Core Area until bull trout meet "recovery" abundance and productivity criteria (298 adult bull trout and a stable or increasing trend).
- Maintain ban on planting hatchery produced "catchable" rainbow trout into bull trout streams in the Entiat Core Area to reduce the probability of incidental harvest of bull trout.
- Ban all plantings of brook trout within waters associated with or connected to bull trout habitat.
- Increase enforcement efforts to reduce poaching of bull trout in the Entiat Core Area.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Open a fishery in the Entiat Core Area after bull trout meet "recovery" abundance and productivity criteria (298 adults and a stable or increasing trend).
- Ban all plantings of brook trout within waters associated with or connected to bull trout habitat.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- Examine the effects of an experimental catch-and-release fishery on the survival of adult bull trout in the Entiat Core Area once bull trout reach "recovery" criteria.
- Monitor the incidental catch of bull trout in the whitefish fishery on the Entiat Core Area.
- Once a fishery on bull trout opens, monitor the effects of harvest on the abundance of bull trout in the Entiat Core Area.

- Monitor the effects of incidental take on other listed and sensitive species during a bull trout fishery.

Methow Core Area

Except for a small fishery in the Lost River watershed, there has been no fishing for bull trout in the Methow Core Area since the listing of bull trout as threatened in 1998.

Short-term Actions

- Maintain ban on planting hatchery produced "catchable" rainbow trout into bull trout streams in the Methow Core Area to reduce the probability of incidental harvest of bull trout.
- Ban all plantings of brook trout within waters associated with or connected to bull trout habitat.
- Increase enforcement efforts to reduce poaching of bull trout in the Methow Core Area.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Long-term Actions

- Open a fishery in the Methow Core Area after bull trout meet "recovery" abundance and productivity criteria (1,234 adults and a stable or increasing trend).
- Ban all plantings of brook trout within waters associated with or connected to bull trout habitat.
- Strive to make all actions and mitigation associated with harvest throughout the Columbia River, identified through ESA Consultation, consistent with advancing the recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Research and Monitoring Actions

- Examine the effects of an experimental catch-and-release fishery on the survival of adult bull trout in the Methow Core Area once bull trout reach "recovery" criteria.
- Monitor and evaluate the fishery in the Upper Lost River.
- Monitor the incidental catch of bull trout in the steelhead and whitefish fisheries on the Methow Core Area.
- Once a fishery on bull trout opens, monitor the effects of harvest on the abundance of bull trout in the Methow Core Area.
- Monitor the effects of incidental take on other listed and sensitive species during a bull trout fishery.

5.2.6 Responsible Parties

WDFW, the Yakama Nation, and the Colville Tribes are responsible for managing, regulating, enforcing, and monitoring their respective fisheries within the Upper Columbia River Basin.

NOAA Fisheries and the USFWS are responsible for administering the requirements of the ESA on salmon and steelhead, and bull trout, respectively, which includes issuing biological opinions, approving management plans, and specifying allowable levels of take in fisheries. WDFW has authority within the State of Washington to enforce regulations pertaining to any fishery, while tribes regulate fisheries on tribal lands.

5.2.7 Coordination and Commitments

This plan assumes that an Implementation Team, made up of representatives from various federal and state agencies, tribes, counties, and stakeholders will engage in discussions associated with harvest actions. This team will be involved in all issues related to harvest policies and recovery actions. Harvest actions outside the Upper Columbia Basin will continue to fall under the purview of the parties pursuant to the ongoing ***U.S. v Oregon*** litigation. If necessary, the Implementation Team may establish a technical committee made up of harvest managers and scientists to provide technical advice to the Implementation Team, review monitoring and research actions associated with harvest, and identify gaps and additional research needs. To the extent possible, existing entities (WDFW, tribal fisheries staff, the ***U.S. v Oregon*** Technical Advisory Committee, and federal agencies) should be relied upon to provide scientific and technical advice regarding harvest and its impacts. The Implementation Team will work with parties in ***U.S. v. Oregon*** to coordinate any harvest actions implemented within the Columbia River fishery with other harvest plans affecting Upper Columbia populations.

5.2.8 Compliance

For harvest regulations to achieve their objectives, it is important that monitoring and evaluation occur in places where actions are targeted. The federal and state agencies and the tribes are responsible for monitoring harvest in the Upper Columbia Basin. In the steelhead fishery, WDFW monitors the total take of steelhead and person-days to determine when the allowable "take" is met (this is based on catch rate, the presumed naturally produced component, and post-release mortality). The fishery is closed after the calculated take is reached.

The Icicle fishery is the only fishery targeting spring Chinook in the Upper Columbia Basin. This fishery targets non-listed, hatchery produced spring Chinook. It opens only after it is estimated that the run size exceeds the needs of the Leavenworth NFH. WDFW and the USFWS monitor the catch and extract biological information on fish caught.

Additional effort is needed to monitor the illegal capture of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. This effort is necessary to better understand the fraction of the adult population harvested illegally. This effort will likely require additional conservation enforcement officers.

5.3 Hatchery Actions

5.3.1 Background

Hatcheries in the Upper Columbia Basin began operations as early as the late 1800s. The first hatcheries that released spring Chinook in the Upper Columbia Basin began operation in 1899 on the Wenatchee River (Chiwaukum Creek) and near the confluence of the Twisp River on the Methow River. These hatcheries, operated by Washington Department of Fish and Game, were built to replenish salmon (primarily Chinook and coho) runs that had virtually been eliminated by the 1890's. Craig and Suomela (1941) commented:

> It appears evident that the Washington State fisheries authorities have from time to time made attempts to introduce exotic populations of salmon to the Wenatchee River...and that they carried on this program from many years before the Grand Coulee fish salvage activities made necessary the transfer of strange runs of fish to that river.

The Leavenworth National Fish Hatchery Complex was constructed between 1938 and 1940. The Complex consists of three large hatchery facilities, Leavenworth National Fish Hatchery (LNFH), Entiat National Fish Hatchery (ENFH), and Winthrop National Fish Hatchery (WNFH), which are operated by the USFWS. They were constructed as mitigation facilities to compensate for the loss of spawning and rearing habitat caused by the construction of Grand Coulee Dam. The facility planned for the Okanogan River was never constructed. These programs were authorized as part of the Grand Coulee Fish Maintenance Project (GCFMP) on April 3, 1937, and reauthorized by the Mitchell Act (52 Stat. 345) on May 11, 1938. Both the Entiat and Leavenworth facilities currently produce non-listed, out-of-basin spring Chinook. The Winthrop National Fish Hatchery produces listed spring Chinook and steelhead.

The WDFW began continuous artificial propagation of summer Chinook and steelhead in the Upper Columbia River basin in the 1960’s at Wells (Douglas PUD) and Chelan Hatcheries (construction of Rocky Reach; Chelan PUD). These early propagation programs were intended to provide fish mainly for harvest; ecological consequences of these programs were not a high priority. In 1989, new artificial propagation programs were funded by Chelan PUD as mitigation for Rock Island Dam. In 1991, Douglas PUD began funding artificial propagation programs of spring Chinook salmon in the Methow basin as mitigation for Wells Dam.

In 2004, HCP agreements among Chelan PUD, Douglas PUD, NOAA Fisheries, USFWS, WDFW, the Colville Tribes, and the Yakama Nation formalized funding and actions setting the stage for continued operation of both the hatchery programs initiated in the 1960’s and the relatively newer programs started in 1989 and 1991. Among the mechanisms for change defined in the HCPs was the creation of Hatchery Committees (one for each HCP) that were tasked with oversight of the artificial propagation programs. A settlement agreement with Grant PUD has proposed additional artificial propagation within the Upper Columbia Basin.[93]

Current artificial propagation programs operated by the Colville Tribes include a spring Chinook and steelhead program as well as plans for a summer Chinook program. Spring Chinook were provided from Leavenworth National Fish Hatchery and acclimated and released in the Okanogan subbasin as an interim, isolated harvest program to support tribal ceremonial and subsistence fishing and provide information for a proposed long-term integrated recovery program. Steelhead are propagated and released in the Okanogan subbasin as an integrated

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[93] It is important to note that the HCPs and Grant Settlement Agreement call for robust monitoring and evaluation plans to answer some of the outstanding scientific questions concerning hatchery programs and their affect on naturally reproducing populations. These M&E Plans test hypotheses concerning questions like the relative reproductive success of natural spawning hatchery descendents, effects on productivity, and others. The use of a reference condition is paramount in understanding these potential effects.

harvest program. The tribes have initiated a local broodstock program and will be starting a kelt reconditioning program to create a comprehensive integrated recovery program for steelhead.

Other species, such as sockeye, summer Chinook, and coho salmon are produced within state and/or federal facilities. In the Wenatchee subbasin, summer Chinook and sockeye are produced in facilities operated by WDFW, while coho salmon are reared at the Leavenworth National Fish Hatchery for the Yakama Nation to assess the feasibility of reintroducing coho into the Upper Columbia Basin. In the Methow subbasin, a state-operated facility produces summer Chinook, while Winthrop National Fish Hatchery rears coho salmon for the Yakama Nation. In the Okanogan subbasin, summer Chinook are produced at the state-operated facility[94] and sockeye in various Canadian facilities.

Current Hatchery Operations

As of 2005, the Upper Columbia Basin has seven large hatchery facilities and twelve smaller rearing or acclimation facilities (**Table 5.2**). In sum, these facilities, operated by state, tribal, and federal entities, include about 22 artificial propagation programs in the Upper Columbia Basin. What follows is a description of the current status of these programs and an assessment of their effects on listed populations and ESUs. The assessment of each artificial propagation program and their relationship to the ESUs was conducted by NMFS (2004). It is important to note that the majority of the hatchery programs in the Upper Columbia Basin were developed to mitigate for fish losses at dams. Additionally, hatchery programs undergo ESA consultation to maintain consistency with the recovery of ESA-listed species.

Wenatchee Subbasin

The Wenatchee spring Chinook population is affected by several artificial propagation programs that release spring Chinook within the Wenatchee subbasin. The Chiwawa River and White River are integrated with the local population and are included in the ESU. The LNFH spring Chinook program releases an out-of-basin stock that is not included in the ESU because their origin is a mixture of Upper Columbia and Snake River spring Chinook stocks captured at Bonneville Dam during the period 1955 through 1964 (Waples et al. 2004; Campton, in press).

Chiwawa River Spring Chinook Program

Artificial propagation of Chiwawa River spring Chinook began in 1989 as mitigation for Rock Island Dam. The program is guided by a committee with representatives from co-managers and the funding entity (CPUD 2002). A comprehensive monitoring and evaluation plan consistent with recommendations from the Independent Scientific Advisory Board is in place to guide the operation of the program. The goal developed by the HCP Hatchery Committee is:

> recovery of ESA listed species by increasing the abundance of the natural adult population, while ensuring appropriate spatial distribution, genetic stock integrity, and adult spawner productivity.

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[94] The Colville Tribes have proposed to expand the conservation aspects of this program to increase the abundance, productivity, and diversity of summer Chinook in the Okanogan subbasin.

The program was initiated as an integrated supplementation program using locally derived spring Chinook returning to the Chiwawa River. Since the mid-1990s, when adult runs were at record low numbers, some hatchery produced Chinook returning from this program were collected for broodstock. However, a minimum of 30% of the annual broodstock has remained naturally produced fish. The Chiwawa River is the only source for natural origin broodstock. A weir is used to collect adult broodstock from the Chiwawa River. Spring Chinook not collected for broodstock are released unharmed upstream of the weir. Tumwater Dam on the Wenatchee River is used to collect returning hatchery produced fish for broodstock. Before gametes from fish collected at Tumwater Dam are incorporated into the program, coded-wire tags are extracted and read to allow only fish from the Chiwawa Program to be used.

Monitoring of this program includes periodic genetic analysis of hatchery and naturally produced fish. Based only on first-year adult returns, naturally and hatchery produced fish were genetically similar (Ford et al. 2001). The life-history characteristics of run timing and spawn timing were also similar. However, differences exist in age-at-return (Tonseth et al. 2002). Fifty-six percent of the naturally produced fish return at age five; only 15% of the hatchery fish return at age five. The fecundity (eggs per female) of these hatchery fish is less than the naturally produced fish as a result of the younger age at return.

The program is intended to increase the number of adults on the spawning grounds and subsequently lead to an increase in natural production. Releases have averaged from zero fish in 1995 and in 1999 to about 364,000 yearling Chinook salmon smolts out of a target production level of 672,000. However, co-managers agree that 672,000 smolts likely exceed the biological capacity of the basin (BAMP 1998). Reduction in the production level is being contemplated within the appropriate forums. A new program is being initiated in Nason Creek, as part of the Priest Rapids Settlement Agreement that coupled with a reduction of the Chiwawa program production level would balance supplementation levels with habitat capacity. External marking of smolts released by removal of the adipose fin has occurred in most, but not all years. All release groups have been 100% coded-wire tagged.

The performance of the program is assessed through a monitoring and evaluation program that includes both within hatchery monitoring and natural environment monitoring. With respect to recovery of natural populations, the natural environmental monitoring will likely provide more insight on the impacts of the hatchery program on the natural population. Redd counts and carcasses sampled on the spawning grounds were used to assess program fish returns and spatial distribution relative to naturally produced spawners. Adult returns from the program contributed an average of 44% of the natural spawning population from 1993 through 2003. Smolt release to adult return has averaged 0.42% (1993-2003 returns). These data suggest that the program has increased the number of spawners and that hatchery produced spawners may have commingled with naturally produced adults on the spawning grounds. An average 28% of the returning Chiwawa-program adults have strayed to other Wenatchee River tributaries (Nason Creek, White River, Little Wenatchee River, and Icicle Creek) and to areas outside the Wenatchee River subbasin including the Entiat and Methow rivers (Miller 2003; Tonseth 2003, 2004; Hamstreet and Carie 2003). Straying may be related to the rearing facility switching to Wenatchee River water during periods when ice precludes the use of Chiwawa River water.

Juvenile emigrant trapping and snorkeling is conducted to assess productivity of natural spawners. Juvenile emigration data indicate that hatchery produced fish are successfully producing juveniles (Miller 2003). Smolt-to-adult survival of hatchery fish is low compared to naturally produced fish (0.42% for hatchery fish compared to 0.63% for naturally produced fish for 1993-2000 broods). The sustained productivity of hatchery fish over several generations in the natural environment has not been demonstrated.

The Chiwawa spring Chinook salmon program has returned adult salmon to the spawning grounds since 1993. These fish appear to have successfully reproduced and may have increased the abundance of naturally produced Chinook in the population. The productivity of hatchery-produced fish relative to naturally produced fish in the natural environment is unknown. The program operates to preserve genetic diversity by incorporating naturally produced Chinook into the broodstock annually. The program does not appear to have altered the spatial distribution of the population. If the program releases the full production level of 672,000 smolts annually, the risk of impacts on productivity and diversity will increase (BAMP 1998). The effects of Chiwawa strays within and out of the Wenatchee Basin need to be addressed because this factor decreases the diversity of the population (see Section 4).

White River Spring Chinook Program

Artificial propagation of White River spring Chinook was initiated in 1999 as a captive-broodstock program. The program is guided by a committee of co-managers and Grant PUD as the funding entity. Implementation of this program has been on a limited basis and no permanent facilities have been developed in the basin.

Eyed-eggs were collected from redds deposited by naturally spawning salmon in the White River beginning in 1999 (Petersen and Dymowska 1999). Because of unsuccessful attempts to propagate this stock, the first yearling smolt release occurred in the spring of 2004. The White River is the only source for eggs used as brood fish.

Genetic analyses of fish sampled from the White River indicate that it is a unique stock relative to other stocks throughout the Columbia River Basin. However, based on the relatively small size of the White River and the short distance to other spawning areas it was not identified as an independent population (ICBTRT 2004b). It is assumed that the eggs collected from naturally deposited redds are genetically similar to eggs remaining in redds. Because strays from the Chiwawa River Program are present on the spawning grounds, this assumption should be verified through genetic sampling. Because this program is new and has not had time to produce adult returns, information regarding life history characteristics, smolt to adult survival, and ability to successfully reproduce in the natural environment is not available.

The White River program is designed to be integrated with the natural population and is intended to increase the number of White River spring Chinook adults on the spawning grounds. After hatching, fish are reared in a hatchery facility until maturity, which can occur at three to six years. These fish are spawned and their progeny are reared to a yearling smolt stage. The smolts are tagged or marked for monitoring purposes and subsequently released into the White River. Gametes collected from naturally produced White River spring Chinook may be used to augment the gametes from the adults reared in captivity.

Program performance results are not available because only one release of juveniles has occurred. Continued operation of this program as either a captive brood program or as a program that rears fish only to the smolt stage before their release is likely because the program is identified as an action for funding under the Biological Opinion for ESA Section 7 Consultation on Interim Operations for the Priest Rapids Hydroelectric Project (NMFS 2004).

Nason Creek River Spring Chinook Program

Artificial propagation of about 250,000 Nason Creek spring Chinook yearling smolts is proposed as mitigation for the Priest Rapids Hydroelectric Project. Implementation of the program is guided by a committee with representatives from co-managers and the funding entity, Grant PUD. A comprehensive supplementation plan and monitoring and evaluation plan consistent with recommendations from the Independent Scientific Advisory Board is being developed. The goal will be similar to that of the Chiwawa program described above. Planning is underway for adult collection and juvenile rearing facilities for this program with input and cooperation from Nason Creek landowners.

As proposed, the program will be an integrated supplementation program using locally derived spring Chinook returning to Nason Creek. Monitoring of this program will include periodic genetic analysis of hatchery and naturally produced fish, various life-history characteristics such as run and spawn timing, adult redd counts and carcass surveys, and juvenile emigrant enumeration to assess productivity of natural spawners.

The program is intended to increase the number of adults on the spawning grounds and subsequently lead to an increase in natural production. As noted above, the Chiwawa program monitoring indicates that the Chiwawa program may have increased the abundance of naturally produced adults. Implementation of this program combined with a reduction in the production level of the Chiwawa program is intended to reduce the risks associated with hatchery programs and allow them to be implemented in a manner more consistent with Hatchery Scientific Review Group (HSRG), Independent Scientific Advisory Board (ISAB), and Independent Scientific Review Panel (ISRP) guidance.

Leavenworth National Fish Hatchery Spring Chinook Program

Leavenworth National Fish Hatchery has released spring Chinook into Icicle Creek since 1940, except for brood years 1967 and 1968. The program is intended to mitigate for the construction of Grand Coulee Dam by providing salmon for harvest, primarily in the Columbia River and in Icicle Creek. Chinook released from the LNFH are not part of the spring Chinook ESU.

Broodstock were originally collected from commingled upriver stocks intercepted at Rock Island Dam (1940-1943) (Cooper et. al 2002). From 1955 through 1964, about 500 spring Chinook were trapped annually at Bonneville Dam, transported to Carson National Fish Hatchery and spawned there. The progeny of those adults continue to be raised and released at Carson National Fish Hatchery and are referred to as “Carson Stock.” Recently collected genetic data indicate that these fish are a mixture of Upper Columbia and Snake River populations that are highly domesticated (Waples et al. 2004; Campton, in press). Before 1985, Carson stock eggs were imported from Carson National Fish Hatchery. Beginning in 1985, broodstock consisted of Leavenworth program adult returns that volunteer into the hatchery on Icicle Creek. Program broodstock are segregated from the natural population in the Wenatchee River basin.

The LNFH spring Chinook program is a segregated program designed to provide salmon for harvest. Recent releases have been entirely marked (adipose fin clipped and coded-wire tagged) before release. This level of marking is needed for hatchery evaluation, potential selective harvest, and to determine straying ratios onto spawning grounds.

This isolated program is funded by the Bureau of Reclamation to provide a treaty and non-treaty spring Chinook harvest. Broodstock are collected as volunteers to the hatchery facility, and little natural production occurs in Icicle Creek. Average returns (6,000+ annually) have been substantial, on average constituting 54% of all spring Chinook passing Rock Island Dam since 1985 (Carrie 2002). Tagging studies indicate that LNFH stray rates are generally low (<1%) (Pastor 2004). However, based on expanded carcass recoveries from spawning ground surveys (2001-2004), LNFH and other out-of-basin strays have comprised from 3-27% of the spawner composition upstream of Tumwater Canyon (WDFW, unpublished data).[95]

Outside of the Wenatchee subbasin, LNFH fish have been recovered at Wells Dam on the Columbia River, at the Methow Hatchery on the Methow River, at the Pelton Dam on the Deschutes River, and in the Umpqua River sport fishery (Cooper et al. 2002). Under current operations, Dam 5 on Icicle Creek (river mile 2.9) is a seasonal barrier. The LNFH, working with local citizens, is in the process of implementing a series of fish passage improvements to pass fish upstream of the facility.

The proportion of LNFH fish on spawning grounds upstream of Tumwater Canyon contributes to a high risk rating for diversity. Increased marking efforts and more intensive spawning surveys in natural production areas should provide more definitive data on straying in the future. The hatchery has relatively little effect on spatial structure because Icicle Creek was classified as a minor spawning area (ICBTRT 2004b).

Entiat Subbasin

Entiat Basin Spring Chinook Program

The Entiat National Fish Hatchery has released spring Chinook into the Entiat River annually since 1975. The program is intended to function as a segregated program to augment harvest. Salmon released from the ENFH are not part of the spring Chinook ESU.

Carson stock provided the egg source for the ENFH. The last import of eggs or fish to the program was in 1994. Returning adults that voluntarily enter the hatchery were the primary broodstock in 1980 and continuously since 1983 (Cooper et al. 2002). Few, if any, naturally produced fish are incorporated into the broodstock.

Hatchery and naturally produced fish were historically thought to remain segregated, because hatchery fish voluntarily return to the ENFH via a fish ladder. However, there is no mechanism to guarantee that they do not migrate upstream and spawn with listed spring Chinook. A review of genetic information conducted in 2001 supported the assumption of segregation (Ford et al. 2001). However, this was not verified on the spawning grounds, as very few carcasses were sampled during the spawning ground surveys in the Entiat River in years prior to 2001. Spawning ground surveys in 2000-2003 have indicated that at least some ENFH fish have commingled on the spawning grounds with the natural population. Similarities between

[95] Low risk spawner composition is less than 2% for out-of-basin fish based on ICBTRT diversity guidelines for achieving a VSP.

hatchery-produced and naturally produced fish in terms of smolt-to-adult survival, age-at-return, and other characteristics are unknown at this time.

Before the 1998 brood, only about 30% of each brood group was adipose fin-clipped and coded-wire tagged. Beginning with the 1999 brood, each release group has been 100% adipose fin-clipped and coded-wire tagged.

The artificial propagation of an out-of-basin stock does not improve any of the VSP criteria. When ENFH fish stray into natural production areas they may adversely affect the genetic diversity of the listed population. Although the numbers of hatchery fish straying into the natural production area is low relative to the total return to the hatchery, it is unacceptably high in relationship to the small natural spawning population. The Entiat spring Chinook population was rated at high risk with respect to out-of-basin spawner composition (Section 2; Appendix B). They also may displace the listed stock occupying the same habitat and that may alter the spatial structure of the listed population. The productivity of the naturally produced population is likely reduced by the hatchery stock commingling on the spawning grounds. This could result in a lower abundance of the population intended to be protected under the ESA.

Methow Subbasin

The Methow spring Chinook population is influenced by several artificial propagation programs that release spring Chinook within the Methow subbasin. WDFW operates the Methow Hatchery as a central facility to carry out release programs of spring Chinook into three tributaries in the subbasin, the Methow, Chewuch, and Twisp Rivers. Additionally, the USFWS operates a separate, but related program that releases spring Chinook into the Methow River.

Methow Composite Stock Spring Chinook Program at the Methow Hatchery

WDFW releases Methow Composite stock into the Methow River from an acclimation pond located at the Methow Hatchery. The Methow River (mainstem) program is one-third of a total annual production level of 550,000 yearling smolts. Hence the annual production goal for the Methow River is about 184,000 smolts. WDFW Hatchery Programs began in 1992 with broodstock collected from adult returns in the Chewuch and Twisp rivers. A transition to rearing the Methow Composite stock, which is a combination of Chewuch River and Methow River stocks, began in 1998. The performance of the program is evaluated through an associated monitoring and evaluation program.

The Methow Hatchery has actively managed broodstock collection and mating to maintain stock structure of separate populations in the Chewuch, Twisp, and Methow Rivers. Initially, broodstock was intended to include only naturally produced fish to develop a fully integrated natural population. The initial maintenance of tributary stocks has been difficult because of low adult returns to the basin and presence of out-of-basin stocks. In 1995, all broodstock were collected at the Methow Hatchery outfall or were transferred from WNFH. In 1996 and 1998, the entire run was collected at Wells Dam because the total run of spring Chinook salmon to the Methow River was very small. In 1997, 1999, and 2000, broodstock were collected at Wells Dam and as voluntary returns to the Methow Hatchery outfall. In the remaining years, broodstock was collected from tributary traps and the Methow Hatchery outfall.

Broodstock collection at locations other than tributary traps was not conducive to preserving genetic diversity. Starting in 1996, scale reading, elemental scale analysis, and reading of coded-wire tags were used to identify salmon from the tributary populations. Specific mating was done each year to preserve the tributary genetic diversity and reduce the incorporation of Carson stock fish into the Methow Hatchery programs. In 1998, broodstock from the Chewuch and Methow rivers was combined to develop the Methow Composite stock. Some Carson stock were included in the Methow Composite stock. Since its inception, the Methow Composite stock has consisted of 88% hatchery fish.

The similarity of hatchery and naturally produced fish has varied among release groups. Several brood groups have been influenced (both intentionally and unintentionally) by out-of-basin spring Chinook released from WNFH. Genetic analysis indicates that some release groups were similar to the Carson stock. Considering the substantial changes in the implementation of the Methow River program, studies to evaluate the genetic characteristics of returning adults is warranted. Age-at-return of hatchery Chinook is younger than naturally produced Chinook. Twenty percent and 70% of hatchery produced fish return as three and four year olds, respectively, compared to naturally produced fish for which return percentages are 9, 37, and 55 for three, four, and five year olds, respectively (combined data from all Methow Hatchery broodstock 1992-2003, N = 1,892 hatchery produced fish and N = 525 naturally produced fish) (M. Humling, WDFW, personal communication).

The Methow Hatchery was designed to enhance the natural production of spring Chinook in the Chewuch, Methow, and Twisp rivers without changing genetic characteristics (Bartlett and Bugert 1994). The annual production level of the Methow Hatchery as a whole was initially set at 738,000 and subsequently reduced to 550,000 smolts in 1998 because of a change in rearing criteria. The production level of 550,000 smolts is generally intended to be equally divided among the three release ponds. This results in a production level of about 184,000 smolts for release into the Methow River annually. Actual program releases have ranged from about 4,400 smolts in 1994 to about 332,000 smolts in 1997. In the early years of the program all smolts were marked with an adipose fin-clip and coded-wire tag. In more recent years, smolts have not been fin-clipped (to avoid selective fisheries), but they continue to be marked with coded-wire tags for monitoring purposes.

Redd counts and carcasses sampled on the spawning grounds were used to assess returns of hatchery fish and spatial distribution relative to naturally produced spawners. Adult returns from hatchery programs (Methow Hatchery and WNFH programs) contributed 96% of the natural spawning population in the Methow River during 2001-2003.

The program is intended to foster natural production by annually contributing adults to the spawning population. The collection of nearly 100% of the run in two years (due to extremely low adult returns) and difficulty in collecting naturally produced fish for broodstock has resulted in over 88% average of hatchery fish in the annual broodstocks. Smolt-to-adult return survival was 0.81% for the 1998 brood (the only complete life cycle of the Methow Composite stock) (A. Murdoch , WDFW, personal communication). Before the use of Methow Composite stock, the Methow River stock averaged a release-to-adult survival of 0.29% (A. Murdoch, WDFW, personal communication). The stray rate to other subbasins is currently unknown.

The Methow Composite spring Chinook program at the Methow Hatchery has been successful in returning adult hatchery Chinook to the spawning grounds. The reproductive success of these fish is unknown. The effects on diversity are intended to be managed by incorporating naturally produced Chinook into broodstock annually. However, achieving this objective has been difficult in many years because of low numbers of naturally produced fish returning to the subbasin and tributary traps that are relatively ineffective at capturing adults. The low effectiveness of tributary traps has led to the collection of most broodstock at the Methow Hatchery outfall. It is unlikely that substantial numbers of naturally produced Chinook return to the off-channel hatchery outfall; therefore, few naturally produced fish are collected.

The diversity of the population has likely been decreased by combining Methow River and Chewuch River stocks with Carson stocks. Although Carson stock fish are no longer included in the crossings, their lineage may be present in the broodstock for several generations. Additionally, because of low adult returns in some years, the percentage of hatchery fish on spawning grounds was high. Because the effect on productivity and diversity is unknown at this time, additional monitoring is needed.

Methow Composite Spring Chinook Program at the Winthrop National Fish Hatchery

The use of Carson stock has been phased out and replaced with Methow Composite stock at the WNFH. This facility is just downstream of the Methow Hatchery on the Methow River. The WNFH planted spring Chinook into the Methow River from 1941-1961 and from 1974 to the present.

Historically, broodstock for the WNFH were collected from Chinook that voluntarily entered the hatchery ladder. Beginning in 1998, the Methow Composite stock program was developed, and the management objective of the WNFH was modified to support conservation of the localized stocks. In 2001, access to the ladder was blocked and excess hatchery fish were forced to remain in the Methow River per the 2001 Methow Agreement between the agencies and tribes. The Methow Hatchery and WNFH have increasingly worked together in broodstock collections and spawning activities. WNFH has used few naturally produced fish for broodstock throughout its history (Cooper et al. 2002). In recent years, all of the naturally produced spring Chinook available for hatchery broodstock have been prioritized for the Methow State Fish Hatchery program (B. Cates, USFWS, personal communication).

The similarity of hatchery and naturally produced fish has varied among release groups. The recent use of the Methow Composite stock is intended to increase the similarity of hatchery and naturally produced fish. Considering the substantial program changes, studies to evaluate the genetic profile of the fish are warranted. Age-at-return of hatchery Chinook is younger overall than it is for naturally produced Chinook.

The original intent of the WNFH was to provide spring Chinook for harvest. Since the listing of spring Chinook, the program has changed to propagating Methow Composite stock in order to contribute to the recovery of the Methow population. The annual target production level is 600,000 spring Chinook smolts. Before the 1994 brood, only a portion of the smolts were marked with adipose fin clips and coded-wire tags. Recent releases of Carson stock were 100% adipose fin clipped and coded-wire tagged. Releases of Methow Composite stock have not been fin clipped (to avoid selective fisheries), but they are coded-wire tagged for monitoring purposes.

Redd counts and carcasses sampled on spawning grounds were used to assess hatchery fish returns and spatial distribution relative to naturally produced spawners. Adult returns from hatchery programs (Methow Hatchery and Winthrop NFH programs) contributed 96% of the fish on the spawning grounds in the Methow River in recent years (Hubble and Theis 2003; Cooper et al. 2002). Smolt-to-adult return rates for Methow Composite stock released from WNFH are not yet available. The effect of hatchery spawners from WNFH on the natural production is unknown. The stray rate to other subbasins is also unknown.

Because of the recent conversion to Methow composite stock, the WNFH should have the same effects on diversity and productivity of naturally produced spring Chinook as the Methow State Fish Hatchery Program.

Chewuch River Spring Chinook Program

A Chewuch River stock was initially maintained at the Methow Hatchery, but a transition to the Methow Composite stock was initiated in 1998. Future releases will be the Methow Composite stock. This program goal is one-third of the Methow Hatchery spring Chinook program.

The first smolt releases were the progeny of naturally produced Chinook collected at Fulton Dam on the Chewuch River and elsewhere within the Chewuch River. The Chewuch River stock was used from 1992 through 1997. Starting in 1998, the program transitioned to the Methow Composite stock (Methow River and Chewuch River stocks). Exclusion of Carson stock for broodstock is achieved by conducting scale analysis and reading coded-wire tags at spawning.

The similarity of hatchery and naturally produced fish has varied among release groups. Considering the substantial changes in the implementation of the Chewuch River program, studies to evaluate the genetic characteristics of the stock are warranted. As in other programs, age-at-return of hatchery fish is younger overall than naturally produced Chinook.

The production goal for the Chewuch program is 183,000 spring Chinook smolts for release into the Chewuch River annually. Actual program releases have averaged 123,970 since the program was started in 1992. The average production achieved is less than the target level because of low run sizes, ineffective traps, and the prioritization of maintaining stock integrity over achieving a target production level. In the early years of the program, all smolts were marked with adipose fin clips and coded-wire tags. In more recent years, smolts have not been fin clipped (to avoid selective fisheries), but they continue to receive coded-wire tags for monitoring purposes.

Redd counts and carcasses sampled on the spawning grounds were used to assess hatchery fish returns and spatial distribution relative to naturally produced spawners. Adult returns from the program contributed 64% of the broodstock over the last six years and 81% in the most recent three years. Smolt-to-adult return rates averaged 0.09% (1992-1997) (A. Murdoch, WDFW, personal communication). Smolts released from the Chewuch Pond tend to return to the Chewuch River or stray into the Methow or Twisp Rivers. The stray rate to other subbasins is unknown.

The Chewuch spring Chinook program has been successful in returning adult salmon to the Chewuch River spawning grounds. The reproductive success of these fish is unknown. The effects on diversity are minimized by incorporating naturally produced salmon into the broodstock annually. However, achieving this objective has been difficult in many years for several reasons, including low numbers of naturally produced fish returning to the basin and tributary traps that were ineffective. Maintaining and improving the performance of this program will be an important step in moving the population towards viability, while maintaining sufficient abundance to avoid extinction.

The spatial distribution of spring Chinook in the Chewuch River does not appear to have been affected by the program. Hatchery produced adults returning to the Chewuch River commingle with naturally produced returns. The diversity of the population may have decreased by combining the Chewuch stock with the Methow Composite. Before 1998, the Chewuch stock was maintained as a separate stock that incorporated a substantial number of naturally produced fish into the broodstock annually. Additionally, the collection of all adults in several return years has resulted in natural spawner populations being composed almost exclusively of hatchery fish. The effect on productivity and diversity of the natural population is unknown at this time. Additional monitoring in the natural environment is needed to fully understand the effects of this program.

Twisp River Spring Chinook Program

Artificial propagation of the Twisp River stock began in 1992. This program goal is one-third of the WDFW Methow Hatchery spring Chinook program.

The Twisp River spring Chinook program has remained segregated from the other stocks. In 1992-1994 and again in 2001-2003, broodstock were collected using a weir placed in the Twisp River. During the years when spring Chinook broodstock were collected at Wells Dam (1996-1999), Twisp stock were identified using scale analysis and coded-wire tag reading. Additionally, some 1996 brood fish of Twisp stock were retained at the Methow Hatchery as a captive broodstock program, which was incorporated in subsequent broods as the fish matured in captivity. An average of 57% of the broodstock has been hatchery fish from 2001-2003. Occasionally, when no fresh milt was available, preserved milt was used to fertilize eggs.

The production goal of the Twisp program is 183,000 spring Chinook smolts for release into the Twisp River annually. Actual program releases have averaged 66,700 smolts in the past three years. The lower production levels have resulted from low run sizes, ineffective traps, disease management, and maintaining stock integrity. In the early years of the program all smolts were marked with adipose fin-clips and coded-wire tags. In more recent years, smolts have not been fin-clipped (to avoid selective fisheries), but they continue to receive coded-wire tags for monitoring purposes. This supplementation program is designed to enhance natural production annually for an indefinite period.

Redd counts and carcasses sampled on spawning grounds were used to assess hatchery fish returns and spatial distribution. The naturally spawning population consisted of 47% of hatchery fish over the last six years and 33% in the most recent three years (A. Murdoch, WDFW, personal communication). Age-at-return of hatchery produced Chinook is younger overall than naturally produced Chinook. Smolt-to-adult return rates averaged 0.14% (1992-1997) (A. Murdoch, WDW, personal communication). Smolts released from the Twisp Pond tend to return to the Twisp River or stray into the Methow River or Chewuch River at a relatively low rate. The stray rate to other subbasins is unknown.

The Twisp spring Chinook program has been successful in returning adult Chinook to the spawning grounds. The effects on diversity have been minimized by incorporating naturally produced Chinook. The spatial distribution of the naturally produced returns may not be affected by hatchery operations. Additional monitoring is needed to understand the effects of this program. Maintaining and improving the performance of the hatchery program will be an important step in moving the population towards viability.

5.3.2 Limiting Factors and Threats

Historic hatchery practices affected the abundance, productivity, spatial structure, and diversity of populations in the Upper Columbia Basin (see Section 3.5). Beginning with the GCFMP, adults were intercepted at Rock Island Dam and planted in various tributaries in the Upper Columbia Basin. This planting of adults may have reduced genetic diversity and possibly also affected abundance and productivity of native populations of spring Chinook and steelhead.[96] The use of out-of-basin stocks may also have contributed to a reduction of population diversity in areas where they contributed to natural spawning.

Both the Entiat and Leavenworth National Fish Hatcheries are intended to function as "segregated" programs producing spring Chinook that are not part of the ESU. Although recent monitoring indicates straying contributes to "high risk" levels in some years and there is concern that the Entiat stock may have introgressed with, or replaced, the locally derived spring Chinook population (Ford et al. 2004). The Winthrop National Fish Hatchery recently moved to the use of local stock. The extent that out-of-basin stock has introgressed with local stock remains unknown in the Methow subbasin.

Although state-operated programs currently emphasize use of locally derived stocks in the tributaries, they can still pose a risk, depending on the implementation of hatchery practices (such as broodstock management, timing of trapping, adult collection locations, juvenile release locations, straying, etc.). For example, the supplementation program in the Chiwawa Basin may be affecting the age-at-return of spring Chinook. Currently, 56% of the naturally produced fish return at age five, while only 15% of the hatchery produced fish return at age five. The return of younger-aged hatchery produced fish may affect reproductive potential and ultimately productivity of naturally produced fish. There is also concern that the large proportion of Wells Hatchery steelhead spawning naturally in the Methow and Okanogan subbasins may pose risks to the DPS's diversity by decreasing local adaptation (NMFS 2004). The reproductive success of hatchery fish produced in supplementation programs that spawn naturally in the wild remains unknown.

The primary threat associated with some past and present hatchery programs within the Upper Columbia Basin may be the introgression of out-of-basin stock into local populations, especially within the Entiat and Winthrop subbasins. This threat may have reduced the diversity of spring Chinook and steelhead in the Upper Columbia Basin. Additional threats include using out-of-basin stock to expand the spatial distribution of extant populations within subbasins[97] and the blocking of fish passage at adult collection facilities. The effects of hatchery practices in the Upper Columbia Basin on productivity are currently unknown. Research on reproductive success of hatchery-produced fish that spawn in the wild is needed to assess effects on productivity.

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[96] At the time of plantings, Chinook and steelhead populations in the tributaries had been virtually decimated (Fish and Hanavan 1948).

[97] The use of out-of-basin stock to reintroduce a species that is extinct in a subbasin is not considered a threat in this plan, because there is no native stock available if the population is extinct. The reintroduction of an out-of-basin stock of spring Chinook into the Okanogan subbasin is an example.

5.3.3 Hatchery Objectives

The following objectives for hatchery programs apply to both the federal and state-operated facilities in the Upper Columbia Basin. This list is not to be considered all-inclusive. The identified objectives are intended to be consistent with other plans and are intended to reduce the threats associated with hatchery production in the Upper Columbia Basin while meeting other obligations.

Short-Term Objectives

- Continue to use artificial production to maintain critically depressed populations in a manner that is consistent with recovery and avoids extinction.
- Use artificial production to seed unused, accessible habitats.[98]
- Use artificial production to provide for tribal and non-tribal fishery obligations as consistent with recovery criteria.
- Use harvest or other methods to reduce the proportion of hatchery-produced fish in naturally spawning populations (see Section 5.2).
- To the extent possible use local broodstocks in hatchery programs.
- To the extent possible, integrate federal, state, and tribal-operated hatchery programs that use locally derived stocks.[99]
- Reduce the amount of in-basin straying from current hatchery programs.

Long-Term Objectives

- Phase out the use of out-of-basin stock in the federal programs at Leavenworth and Entiat National Fish Hatcheries if continued research indicates that the programs threaten recovery of listed fish and those threats cannot be minimized through operational or other changes.
- Help develop ongoing hatchery programs that are consistent with recovery.
- Provide for tribal and non-tribal fishery obligations.
- Use harvest or other methods to reduce the proportion of hatchery-produced fish in naturally spawning populations (see Section 5.2).
- Manage hatcheries to achieve sufficient natural productivity and diversity to de-list populations and to avert re-listing of populations.

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[98] Hatchery fish should not be introduced into unused habitat unless the habitat is suitable for spawning and rearing of the fish. Therefore, the habitat in degraded streams needs to be restored or improved before hatchery fish are introduced into the stream.

[99] Because state and federal hatchery programs have different objectives and obligations, the programs cannot be fully integrated. However, they can develop common broodstock protocols and production levels that optimize recovery of naturally produced fish.

Research and Monitoring Objectives

- Employ the best available technology to monitor the effects of hatchery releases on natural populations and production (e.g., PUD and Colville Tribes Hatchery Monitoring Programs).
- Develop marking programs to assure that hatchery produced fish are identifiable for harvest management, escapement goals, and reproductive success studies.
- Evaluate existing programs and redesign as necessary so that artificial production does not pose a threat to recovery.
- Integrate and coordinate monitoring activities between federal, state, and tribal programs.
- Examine the reproductive success of naturally produced and hatchery produced spring Chinook and steelhead spawning in the wild.
- Examine steelhead kelt reconditioning and their reproductive success.
- Continue studies to assess the effects of the coho reintroduction program.
- Examine the interactions (competition and predation) between naturally produced and hatchery produced steelhead.
- Continue to examine residualism of hatchery-produced steelhead.
- Examine the feasibility of reintroducing bull trout (including ESA status of introduced stock) into the Chelan and Okanogan subbasins.
- Examine the feasibility (including ESA status of introduced stock) of reintroducing spring Chinook into the Okanogan subbasin.

This plan recognizes the need to balance recovery objectives with legal obligations and mandates under Habitat Conservation Plans (HCPs), the Mitchell Act, federal government and tribal agreements, Hatchery and Genetic Management Plans (HGMPs), ***U.S. v. Oregon***, and relicensing agreements. For example, these recovery objectives are consistent with the Biological Assessment and Management Plan (BAMP) developed by parties negotiating the HCPs for Chelan and Douglas PUDs. BAMP identified the following overriding objectives for hatchery programs associated with the HCPs within the Upper Columbia Basin.

- Contribute to the rebuilding and recovery of naturally spawning populations throughout the Upper Columbia Basin to the point that these populations can be self-sustaining, support harvest, while maintaining genetic and ecologic integrity.
- Compensate the resource for a 7% per hydroproject unavoidable loss as needed to meet the No Net Impact standard of the HCPs.
- Compensate the resource for the original construction impacts of the Upper Columbia River PUD dams in a manner that is consistent with recovery efforts for natural salmonids.

The recovery objectives are also sensitive to the Mitchell Act, which calls for the conservation of the fishery resources of the Columbia River; establishment, operation, and maintenance of one or more stations; and for the conduct of necessary investigations, surveys, stream improvements, and stocking operations for these purposes. The recovery objectives also consider agreements between tribes and federal agencies, including the coho reintroduction feasibility studies conducted by the Yakama Nation, the Chief Joseph Dam Hatchery Program, and ***U.S. v. Oregon***. One goal of the Chief Joseph Dam Hatchery Program is to reintroduce extirpated spring Chinook into select waters in the Okanogan subbasin. This is an experimental program designed to restore naturally produced spring Chinook and to provide a stable ceremonial and subsistence fishery and recreational fishery in the Okanogan subbasin. Another goal is to restore steelhead in their historical habitats in the Okanogan subbasin and create harvestable surpluses for tribal ceremonial and subsistence fisheries and for recreational harvest.

5.3.4 Recent Hatchery Actions

Changes in hatchery programs have and will continue to reduce risks to naturally produced spring Chinook and steelhead in the Upper Columbia Basin. There are several processes that have changed the way that hatchery programs in the Upper Columbia Basin are implemented. What follows is a brief summary of those processes.

The HGMP process is designed to describe existing artificial production programs, identify necessary or recommended modifications of those programs, and help achieve consistency of those programs with the Endangered Species Act. The HGMP process addresses anadromous salmon and steelhead programs and bull trout.[100]

The Artificial Production Review and Evaluation (APRE) process seeks to document progress toward hatchery reform in the Columbia Basin. The NPCC used consultants and Columbia Basin fishery managers to analyze existing programs and recommend reforms. A draft report has been submitted to the Council and the region. The APRE process includes both anadromous and non-anadromous fish in its analysis.

The Pacific Coastal Salmon Recovery Fund (PCSRF) was established in 2000 to provide grants to the states and tribes to assist state, tribal and local salmon conservation and recovery efforts. The goal of the PCSRF is to make significant contributions to the conservation, restoration, and sustainability of Pacific salmon and their habitat. The PCSRF's enhancement objective is to conduct activities that enhance depressed stocks of naturally produced anadromous salmonids through hatchery supplementation, reduction in fishing effort on depressed naturally produced stocks, or enhancement of Pacific salmon fisheries on healthy stocks in Alaska. This includes supplementation and salmon fishery enhancements.

In 1988, under the authority of ***U.S. v. Oregon***, the states of Washington, Oregon, and Idaho, federal fishery agencies, and the treaty tribes agreed to the Columbia River Fish Management Plan (CRFMP), which was a detailed harvest and fish production process. The CRFMP expired in 1998 and is currently operating under an interim agreement. The fish production section reflects current production levels for harvest management and recovery purposes.

Current ESA Section 10 Permits for listed summer steelhead (Permit #1395); listed spring Chinook (Permit #1196), and non-listed anadromous fish (Permit # 1347) also direct artificial production activities associated with the habitat conservation plans. Douglas PUD, Chelan PUD,

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[100] Bull trout are covered under Section 15 of the HGMPs.

and WDFW are co-permittees; therefore, provisions within the permits and associated Biological Opinions are incorporated into the hatchery programs undertaken in the HCPs.

Under current settlement agreements and stipulations (FERC processes), the three mid-Columbia PUDs pay for implementation of hatchery programs within the Upper Columbia Basin. These programs determine the levels of hatchery production needed to mitigate for the construction and continued operation of the PUD dams. These are conservation programs designed to contribute to the recovery of listed spring Chinook and steelhead.

Habitat Conservation Plans (HCPs) and the Priest Rapids Salmon and Steelhead Settlement Agreement were signed by Douglas and Chelan PUDs (HCPs) and Grant PUD (Settlement Agreement), WDFW, USFWS, NOAA Fisheries, the Yakama Nation, and the Colville Confederated Tribes. The overriding goal of the HCPs and the Settlement Agreement is to achieve no-net impact (NNI)[101] on anadromous salmonids as they pass Wells (Douglas PUD), Rocky Reach, and Rock Island (Chelan PUD), Wanapum, and Priest Rapids (Grant PUD) dams. One of the main objectives of the hatchery component of NNI is to provide species specific hatchery programs that may include contributing to the rebuilding and recovery of naturally reproducing populations in their native habitats, while maintaining genetic and ecologic integrity, and supporting harvest.

The Biological Assessment and Management Plan (BAMP) was developed by parties negotiating the HCPs in the late 1990s. The BAMP was developed to document guidelines and recommendations on methods to determine hatchery production levels and evaluation programs. It is used within the HCP as a guiding document for the hatchery programs.

All of these processes have affected the hatchery programs within the Upper Columbia Basin in one way or another. For example, the Winthop National Fish Hatchery changed their production to be integrated with the listed component, while options for changes in operations at the other two federal facilities are being discussed. NOAA Fisheries has concluded that the locally derived fish produced in hatcheries are essential for recovery of spring Chinook and steelhead DPSs.

Additional changes resulting from various processes includes production of tributary-specific stocks of hatchery steelhead that reduce the potential effects of hatchery fish on naturally produced fish, re-initiation of sport harvest on hatchery steelhead to reduce potential effects of hatchery fish on naturally produced fish, and development of standardized monitoring and evaluation plans for hatchery programs in the Upper Columbia Basin. Although these actions are intended to contribute to recovery of listed species, additional actions are needed to meet recovery objectives.

5.3.5 Hatchery Recovery Actions

Recovery actions listed below for each population are intended to reduce threats associated with hatchery practices in the Upper Columbia Basin. These actions primarily address threats

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[101] NNI refers to achieving a virtual 100% survival of anadromous salmonids as they pass the mainstem projects. This is achieved through at least 91% survival of adults and juveniles (or 93% for juveniles) passing the projects, and a maximum 7% compensation through hatchery programs and 2% contribution through a tributary fund, which will fund projects to improve salmonid habitat in the tributaries.

associated with VSP criteria for productivity, diversity, and spatial structure. Actions and mitigation associated with hatcheries throughout the Upper Columbia River Basin should not preclude the recovery of Upper Columbia spring Chinook, steelhead, and bull trout. Additionally, future hatchery facilities will support recovery goals, and minimize and mitigate any impacts (including goals within other Hs). This list should not be considered all inclusive and specific actions will be determined and negotiated by the responsible parties.

Spring Chinook

Wenatchee Population

Within the Wenatchee subbasin, spring and summer Chinook, sockeye, steelhead, and coho salmon are planted for various mitigation programs (**Table 5.3**). The Leavenworth National Fish Hatchery (LNFH) and the Rock Island Fish Hatchery Complex (RIFHC) propagate fish in the Wenatchee subbasin.

Short-term Actions

- LNFH—Continue to release spring Chinook into Icicle Creek to provide treaty and non-treaty harvest opportunities.
- RIFHC—Continue to propagate locally derived stock consistent with low to moderate risk VSP criteria for major spawning areas in the Wenatchee subbasin.
- Reduce the amount of in-basin straying from current hatchery programs.
- Provide fish passage at Dam 5 on Icicle Creek provided that LNFH change to local spring Chinook stock and there is suitable spawning and rearing habitat upstream of the hatchery.
- Reduce or eliminate presence of out-of-basin stock (Carson spring Chinook) on spawning grounds.
- Employ mechanisms to manage hatchery returns on spawning grounds in balance with naturally produced fish, e.g., tribal and sport fisheries, removal at Tumwater Dam and Chiwawa weir, and other methods may be used to remove hatchery fish in excess of management objectives.
- Size hatchery programs appropriately for available habitat given survival trends.

Long-term Actions

- LNFH—Release spring Chinook into Icicle Creek to provide for treaty and non-treaty harvest opportunities.
- RIFHC—Continue to propagate locally derived stock in the Wenatchee subbasin to mitigate for losses at Rock Island Dam and to supplement natural production.
- To the extent possible, integrate federal and state hatchery programs that use locally derived spring Chinook in the Wenatchee subbasin.
- Continue to propagate locally derived stock consistent with low to moderate risk VSP criteria for major spawning areas in the Wenatchee subbasin.

- Modify hatchery programs to minimize adverse impacts of hatchery fish on naturally produced fish while maintaining production levels identified in various agreements.

Research and Monitoring Actions

- Develop an integrated and coordinated monitoring program that uses the best available technology and captures all artificial propagation programs in the subbasin.
- Develop a coordinated marking program so that all hatchery produced spring Chinook in the Wenatchee subbasin are marked to aid harvest management, monitoring, and research.
- Continue to assess the degree that out-of-basin stock from the LNFH spawn with native spring Chinook in the wild.
- Assess the reproductive success of hatchery produced spring Chinook that spawn in the wild.
- Monitor the genetic integrity of naturally produced spring Chinook in the Wenatchee subbasin.
- Determine if supplementation programs in the Wenatchee subbasin affect the VSP parameters of spring Chinook.
- Continue to evaluate the effects of coho reintroduction on recovery of spring Chinook in the Wenatchee subbasin.

Entiat Population

Currently, the spring Chinook program at the Entiat National Fish Hatchery is the only hatchery program within the Entiat subbasin (**Table 5.4**).

Short-term Actions

- Reduce or eliminate presence of out-of-basin stock on spawning grounds.
- Reduce the amount of in-basin straying from current hatchery programs.

Long-term Actions

- Reduce or eliminate presence of out-of-basin stock on spawning grounds.
- If propagation occurs, use locally derived stock consistent with low to moderate risk VSP criteria for major spawning areas in the Entiat subbasin.

Research and Monitoring Actions

- Examine the feasibility and need for the hatchery program to keep the Entiat population from going extinct.
- If a propagation program is necessary, determine the most appropriate “locally derived” stock to use.
- Continue to monitor the genetic integrity of the naturally produced spring Chinook salmon in the subbasin.

- If any spring Chinook hatchery releases continue, assess the reproductive success of ENFH spring Chinook that spawn in the wild.

Methow Population

Artificial production of anadromous fish in the Methow subbasin includes spring Chinook, summer Chinook, steelhead, and coho salmon (**Table 5.5**). The Winthrop National Fish Hatchery (WNFH) and the Methow Fish Hatchery Complex (MFHC) propagate fish in the Methow subbasin.

Short-term Actions

- Increase the use of naturally produced spring Chinook in the hatchery program.
- Incorporate naturally produced fish in broodstock to maintain genetic integration with naturally produced stock
- Employ mechanisms to manage hatchery returns on spawning grounds in balance with naturally produced fish
- Reduce or eliminate presence of out-of-basin stock on spawning grounds.
- To the extent possible, integrate and coordinate federal and state hatchery programs that use locally derived spring Chinook in the Methow subbasin.

Long-term Actions

- WNFH—Continue to propagate locally derived stock in the Methow subbasin to provide for harvest opportunities as natural production increases, incorporate natural spawners into the broodstock.
- MFHC—Continue to propagate locally derived stock in the Methow subbasin to mitigate for losses at Wells Dam and to supplement natural production.
- Propagate locally derived stock consistent with low to moderate risk VSP criteria for major spawning areas in the Methow subbasin.
- Modify hatchery programs to minimize adverse impacts of hatchery fish on naturally produced fish while maintaining production levels identified in various agreements.

Research and Monitoring Actions

- Continue an integrated and coordinated monitoring program that uses the best available technology and captures all artificial propagation programs in the subbasin.
- Continue a coordinated marking program so that all hatchery produced spring Chinook in the Methow subbasin are marked to aid harvest management, monitoring, and research.
- Assess the reproductive success of hatchery-produced spring Chinook that spawn in the wild.
- Monitor the genetic integrity of naturally produced spring Chinook in the Methow subbasin.
- Determine if natural production in the Methow subbasin is increasing from the artificial propagation programs in the subbasin.

- Determine if supplementation programs in the Methow subbasin affect the VSP parameters of spring Chinook.
- Continue to evaluate the effects of coho reintroduction on recovery of spring Chinook in the Methow subbasin.

Okanogan Population

Currently, there are releases of summer Chinook, steelhead, and experimental programs for spring Chinook and sockeye (in Canada) in the Okanogan subbasin (**Table 5.7**). Spring Chinook were extirpated from the Okanogan subbasin before the 1930s. Although there has not been a formal mitigation program for spring Chinook, there is currently an experimental spring Chinook propagation program in the Okanogan subbasin through a cooperative agreement between NOAA Fisheries, USFWS, Colville Tribes, and WDFW. This is an interim segregated program designed to support tribal ceremonial and subsistence fishing and provide information for a proposed, long-term integrated recovery program.

Short-term Actions

- Introduce spring Chinook into the Okanogan subbasin in a manner that does not increase ESA liabilities for landowners.
- Manage the program such that the stock does not stray into other subbasins and do not threaten the diversity of extant populations.

Long-term Actions

- Introduce spring Chinook into the Okanogan subbasin in a manner that does not increase ESA liabilities for landowners.
- If a viable population of spring Chinook can be established in the Okanogan subbasin, use the established local stock in the Okanogan to supplement natural production in the subbasin.
- Continue to release spring Chinook to provide for ceremonial and subsistence fishing and recreational harvest.
- Propagate locally derived stock consistent with low to moderate risk VSP criteria for major spawning areas in the Okanogan subbasin.

Research and Monitoring Actions

- Continue to examine the feasibility of establishing spring Chinook in the Okanogan subbasin.
- Develop a coordinated marking program so that all hatchery-produced spring Chinook are marked to aid harvest management, monitoring, and research.
- Determine if hatchery fish produced in this program stray into other subbasins.
- Assess the reproductive success of hatchery-produced spring Chinook that spawn in the wild.
- Use the best available technology to monitor the effectiveness of the hatchery program.

Steelhead

Wenatchee Population

There are currently no federal programs that propagate steelhead in the Wenatchee subbasin. WDFW, through the RIFHC, release steelhead as compensation for mitigation for both Rock Island and Rocky Reach dams (**Table 5.3**). All steelhead produced in this program are listed under the ESA.

Short-term Actions

- Continue to propagate locally derived steelhead in the Wenatchee subbasin under the state-operated program.
- Continue to employ mechanisms to manage hatchery returns on spawning grounds in balance with naturally produced fish
- Restore steelhead into accessible and suitable habitat if feasible.
- Reduce or eliminate presence of out-of-basin stock on spawning grounds.

Long-term Actions

- Continue to propagate locally derived steelhead in the Wenatchee subbasin to mitigate for losses at Rock Island and Rocky Reach dams and to supplement natural production.
- Propagate locally derived stock consistent with low to moderate risk VSP criteria for major spawning areas in the Wenatchee subbasin.
- Modify hatchery programs to minimize adverse impacts of hatchery fish on naturally produced fish while maintaining production levels identified in various agreements.

Research and Monitoring Actions

- Determine if natural production is increasing as a result of the RIFHC program.
- Conduct research to confirm that hatchery produced fish have no significant effect on the diversity of locally derived populations.
- Use the best available technology to monitor homing, straying, release strategies, and genetic integrity.
- Develop a coordinated marking program so that all hatchery-produced steelhead in the Wenatchee subbasin are marked to aid harvest management, monitoring, and research.
- Assess the reproductive success of hatchery-produced steelhead that spawn naturally in the wild.
- Examine the feasibility and need for steelhead kelt reconditioning in the Wenatchee subbasin.
- Determine if supplementation programs in the Wenatchee subbasin affect VSP parameters of steelhead.

- Examine interactions (competition and predation) between hatchery produced and naturally produced steelhead.
- Continue to assess residualism of hatchery-produced steelhead in the Wenatchee subbasin.
- Continue to evaluate the effects of coho reintroduction on recovery of steelhead in the Wenatchee subbasin.

Entiat Population

No hatchery-produced steelhead are currently released in the Entiat subbasin. Discontinuous stocking of the Entiat and Mad rivers occurred from 1937-1967, with annual stocking of the Entiat River from 1967-1999. The BAMP identified this subbasin as a "reference" stream, which caused the cessation of hatchery steelhead releases in the Entiat Subbasin in 1999; although the HCP Hatchery Committee has not determined at this time if this will occur. Researchers and managers intend to compare productivity between streams that receive hatchery supplementation with streams, such as those in the Entiat, that do not. Recent discussions with local stakeholders, however, have raised questions concerning the use of the Entiat as a reference stream. The designation of a reference stream will not preclude fishing.

Short-term Actions

- Maintain existing practice of not releasing hatchery-produced steelhead into the Entiat subbasin.

Long-term Actions

- If adult steelhead abundance reaches critically low numbers, initiate a hatchery supplementation program to prevent the population from going extinct.

Research and Monitoring Actions

- Determine the feasibility and need of a hatchery program to keep the Entiat steelhead population from going extinct.
- Use the best available technology to monitor the genetic integrity of steelhead in the Entiat subbasin.
- Monitor the presence of steelhead strays (i.e., steelhead produced in other programs) in the Entiat subbasin.
- Determine the efficacy of using the Entiat as a reference stream in the BAMP.

Methow Population

Hatchery produced steelhead have been a dominant part of the spawning population in the Methow subbasin for many years. However, the objectives of the hatchery programs have recently changed from a strictly harvest augmentation role to the added role of recovery. Harvest is still an important objective, but emphasis has shifted in an effort to increase natural spawners.

The WNFH, operated by the USFWS, produces a small number (100,000 fish) of steelhead in the Methow subbasin (**Table 5.5**). This stock is taken from the Wells Fish Hatchery (WFH) and is listed under the ESA.

The Wells Fish Hatchery, operated by WDFW, collects steelhead from the run-at-large at the west ladder trap at Wells Dam. Starting in 2003, naturally produced fish were also collected from the east ladder trap to incorporate a larger number (33%) of naturally produced steelhead into the broodstock. Adults are spawned and reared at the WFH. WDFW annually transports and releases 350,000 steelhead smolts into the Twisp, Chewuch, and Methow rivers (**Table 5.5**).

Short-term Actions

- WFH—Coordinate with HCP Hatchery Committees in developing tributary-specific broodstock collection programs (e.g., in the Twisp, Chewuch, Methow rivers).
- Continue to employ mechanisms to manage hatchery returns on spawning grounds in balance with naturally produced fish.
- To the extent possible, integrate and coordinate federal and state hatchery programs that use locally derived steelhead in the Methow subbasin.
- Reduce or eliminate presence of out-of-basin stock on spawning grounds.

Long-term Actions

- WNFH—Propagate and externally mark locally derived stock in the Methow subbasin to supplement natural production and to provide for harvest opportunities.
- WFH—Propagate locally derived stock in the Methow subbasin to mitigate for losses at Wells Dam, to supplement natural production, and to provide harvest opportunities.
- Propagate locally derived stock consistent with low to moderate risk VSP criteria for major spawning areas in the Methow subbasin.
- Modify hatchery programs to minimize adverse impacts of hatchery fish on naturally produced fish while maintaining production levels identified in various agreements.

Research and Monitoring Actions

- Develop an integrated and coordinated monitoring program that uses the best available technology and captures all artificial propagation programs in the subbasin.
- Determine the feasibility of tributary-specific broodstock collection.
- Continue a coordinated marking program so that all hatchery-produced steelhead in the Methow subbasin are marked to aid harvest management, monitoring, and research.[102]
- Monitor the genetic integrity of naturally produced steelhead in the Methow subbasin.
- Assess the reproductive success of hatchery-produced steelhead that spawn in the wild.

[102] Only hatchery fish that are intended to support a fishery should receive adipose fin clips. Hatchery fish released for conservation or recovery purposes should be marked (e.g., elastomer tag), but not fin clipped. This will reduce the probability that these fish are harvested.

- Determine if natural production in the Methow subbasin is increasing from the artificial propagation programs in the subbasin.
- Determine if supplementation programs in the Methow subbasin affect VSP parameters of steelhead.
- Examine interactions (competition and predation) between hatchery produced and naturally produced steelhead.
- Continue to assess residualism of hatchery-produced steelhead in the Methow subbasin.
- Examine the feasibility and need of steelhead kelt reconditioning in the Methow subbasin.
- Continue to evaluate the effects of coho reintroduction on recovery of steelhead in the Methow subbasin.

Okanogan Population

Steelhead released into the Okanogan subbasin are spawned and reared at the WFH, operated by WDFW. Juvenile hatchery produced steelhead are transported to the Okanogan subbasin and scatter planted in the Similkameen River (50,000), Omak Creek, Salmon Creek, and the Okanogan River (50,000) during spring (**Table 5.7**).

In 2003, the Colville Tribes initiated a local broodstock program, collecting steelhead returning to Omak Creek. Eggs are incubated and juvenile steelhead are reared at the Colville Trout Hatchery (CTH). This is a recovery program with the goal of releasing 20,000 smolts in the Okanogan subbasin.

Short-term Actions

- To the extent possible, use locally derived steelhead in the CTH program.
- Continue to employ mechanisms to manage hatchery returns on spawning grounds in balance with naturally produced fish.
- Finish a comprehensive steelhead HGMP for the Okanogan subbasin that promotes recovery and provides harvest opportunities.

Long-term Actions

- Propagate locally derived steelhead into the Okanogan subbasin to supplement natural production and to provide harvest opportunities.
- Propagate locally derived stock consistent with low to moderate risk VSP criteria for major spawning areas in the Okanogan subbasin.
- Modify hatchery programs to minimize adverse impacts of hatchery fish on naturally produced fish while maintaining production levels identified in various agreements.

Research and Monitoring Actions

- Determine the feasibility and need of tributary-specific broodstock collection (in addition to the Omak collection facility).

- Develop a coordinated marking program so that all hatchery produced steelhead in the Okanogan subbasin are marked to aid harvest management, monitoring, and research.
- Monitor the genetic integrity of naturally produced steelhead in the Okanogan subbasin.
- Assess the reproductive success of hatchery-produced steelhead that spawn in the wild.
- Determine if natural production in the Okanogan subbasin is increasing from the artificial propagation programs in the subbasin.
- Determine if supplementation programs in the Okanogan subbasin affect VSP parameters of steelhead.
- Examine interactions (competition and predation) between hatchery produced and naturally produced steelhead.
- Assess residualism of hatchery-produced steelhead in the Okanogan subbasin.
- Examine steelhead kelt reconditioning in the Okanogan subbasin.
- Assess the potential for reintroduction of steelhead into Canadian waters.

Bull Trout

There are currently no hatchery programs for bull trout in the Upper Columbia Basin. However, there is a possibility that hatchery programs for other species may have affected the abundance, productivity, spatial structure, and diversity of bull trout in the Upper Columbia Basin.

Wenatchee Core Area

There is no bull trout hatchery program in the Wenatchee Core Area. However, the stocking of brook trout negatively affects the abundance, productivity, spatial structure, and diversity of bull trout in the core area (USFWS 2002).

Short-term Actions

- Eliminate stocking brook trout within waterways associated with or connected to bull trout habitat.
- Develop a multi-agency approved process for a brook trout removal program in bull trout core areas.

Long-term Actions

- Eliminate stocking brook trout within waterways associated with or connected to bull trout habitat.

Research and Monitoring Actions

- Examine the extent that brook trout have hybridized with bull trout in the Wenatchee Core Area.
- Continue collection of trend and redd count data.

Entiat Core Area

There is no bull trout hatchery program in the Entiat Core Area. However, the stocking of brook trout negatively affects the abundance, productivity, spatial structure, and diversity of bull trout in the core area (USFWS 2002).

Short-term Actions

- Eliminate stocking brook trout within waterways associated with or connected to bull trout habitat.
- Develop a multi-agency approved process for a brook trout removal program in bull trout core areas.

Long-term Actions

- Eliminate stocking brook trout within waterways associated with or connected to bull trout habitat.

Research and Monitoring Actions

- Examine the extent that brook trout have hybridized with bull trout in the Entiat Core Area.
- Continue collection of trend and redd count data.

Lake Chelan Core Area

There is no bull trout hatchery program in the Lake Chelan Core Area and the presence of bull trout in the core area remains unknown. Bull trout have not been observed in the core area for decades.

Short-term Actions

- None

Long-term Actions

- None

Research and Monitoring Actions

- Examine the effectiveness and feasibility of using fish transfers and hatcheries to assist in possible reintroduction of bull trout into the Lake Chelan Core Area

Methow Core Area

There is no bull trout hatchery program in the Methow Core Area. However, the stocking of brook trout negatively affects the abundance, productivity, spatial structure, and diversity of bull trout in the core area (USFWS 2002).

Short-term Actions

- Eliminate stocking brook trout within waterways associated with or connected to bull trout habitat.

- Develop a multi-agency approved process for a brook trout removal program in bull trout core areas.

Long-term Actions

- Eliminate stocking brook trout within waterways associated with or connected to bull trout habitat.

Research and Monitoring Actions

- Assess the feasibility of using Patterson Lake bull trout to reestablish local populations of bull trout in the Methow Core Area.
- Examine the extent that brook trout have hybridized with bull trout in the Methow Core Area.
- Continue collection of trend and redd count data.

Okanogan Core Area

There is no bull trout hatchery program in the Okanogan Core Area and the presence of bull trout in the core area is unknown. Bull trout have not been observed in tributaries in the core area for decades. However, bull trout have been occasionally observed in the mainstem Okanogan River (BioAnalysts 2003).

Short-term Actions

- None

Long-term Actions

- None

Research and Monitoring Actions

- Examine the effectiveness and feasibility of using fish transfers and hatcheries to assist in possible reintroduction of bull trout into the Okanogan subbasin.

5.3.6 Responsible Parties

WDFW, USFWS, NOAA Fisheries, the Yakama Nation, and the Colville Tribes are primarily responsible for regulating hatchery activities in the Upper Columbia Basin.

5.3.7 Coordination and Commitments

This plan assumes that an Implementation Team, made up of representatives from various federal and state agencies, tribes, counties, and stakeholders will engage in discussions associated with hatchery actions. This Team will be involved in all issues related to hatchery policies and recovery actions, and will work within the framework of the HCPs for Chelan and Douglas PUDs, Section 7 consultations, the Mitchell Act, HGMPs, ***U.S. v. Oregon***, and federal trust responsibilities to the tribes. If necessary, the Implementation Team may establish a technical committee made up of hatchery managers and scientists to provide technical advice to the Team, review monitoring and research actions associated with hatchery practices, and identify gaps and additional research needs.

The PUDs (state facilities) and federal government (federal facilities) are the primary entities responsible for funding the hatchery programs in the Upper Columbia Basin. Habitat conservation plans and binding mitigation agreements increase the likelihood that these programs have secure funding and will continue operating into the future.

5.3.8 Compliance

Hatchery activities are currently monitored through processes like the HCPs, HGMPs, and Section 7 and 10 consultations. WDFW, USFWS, and tribes are primarily responsible for monitoring the progress and success of hatchery programs in the Upper Columbia Basin. These programs also have evaluation goals and check-ins that provide production targets for the various programs. This recovery plan encourages greater coordination among federal, state, and tribal programs and integration of monitoring programs.

5.4 Hydro Project Actions

5.4.1 Background

Construction of mainstem dams downstream from the Grand Coulee project began with Rock Island in 1933 and culminated with the completion of John Day Dam in 1968. Currently, seven mainstem dams lie between the Wenatchee River and the ocean, eight downstream from the Entiat River, and nine between the Methow/Okanogan systems and the ocean. Dam-related losses can be substantial. Some of the losses result from the physical effects of dams on juvenile/smolt and adult passage; others derive from altered limnological conditions that increase predation by fish and birds.

This recovery plan identifies actions specific to the five hydroelectric projects in the Upper Columbia Basin (Wells Dam, Rocky Reach Dam, Rock Island Dam, Wanapum Dam, and Priest Rapids Dam) and to existing hydroelectric projects in tributaries. No specific recovery actions are identified for federal hydroelectric projects upstream from Wells Dam or downstream from Priest Rapids Dam. However, this plan does recognize that recovery of Upper Columbia stocks may depend upon changes in the operations of federal hydroelectric projects. Hydroelectric projects within tributaries of the Upper Columbia Basin include Trinity, Tumwater, Dryden, Lake Chelan, and Enloe dams. Only the Lake Chelan Hydroelectric Project and Trinity (a small project on Phelps Creek) are currently generating electricity. The other projects have been decommissioned. There are several dams within the Wenatchee, Methow, and Okanogan subbasins that function as irrigation diversions. Actions associated with these projects are addressed in Section 5.5 (Habitat Actions).

5.4.2 Limiting Factors and Threats

The development of hydroelectric projects on the Columbia River has significantly reduced the abundance and spatial structure of spring Chinook, steelhead, and bull trout in the Upper Columbia River Basin (see Section 3.6). In general, hydroelectric projects have affected four major habitat factors: upstream and downstream fish passage, ecosystem structure and function, flows, and water quality. Grand Coulee and Chief Joseph dams have no facilities for upstream passage and thus have had a large effect on the abundance and spatial structure of fish in the Upper Columbia Basin. The five non-federal hydroelectric projects downstream of Chief Joseph Dam on the Columbia River (Wells Dam, Rocky Reach Dam, Rock Island Dam, Wanapum

Dam, and Priest Rapids Dam) have affected the four major factors to a lesser degree, because of modified operations and the presence of fish passage facilities.

The five hydroelectric projects on the mainstem in the Upper Columbia Basin have affected volumes and hourly flow fluctuations in the Columbia River, but to a much lesser degree than Grand Coulee Dam, which primarily controls seasonal, weekly, and daily flows in the Upper Columbia River. Water quality is also affected by dams and their operations. Because the five non-federal hydroelectric projects are "run-of-the-river" dams, they have little effect on water temperatures, compared to Grand Coulee Dam. However, these projects have created localized pockets of high water temperatures along the reservoir shorelines. During spill, these projects can cause gas supersaturation, which may lead to gas bubble trauma in fish. The hydroelectric projects have also replaced riverine habitat by creating impoundments. These modifications have resulted in changes in the habitat and resident fish populations, which affect food web patterns, competition, and predation pressures.

Hydroelectric projects create obstacles that migrating fish must pass. As a result, the more obvious potential effects of hydroelectric projects are observed on juvenile/smolt and adult fish passage, which may affect fish survival and migration timing. There is little evidence that the projects have significantly increased mortality of adult salmon and steelhead migrating upstream through the hydrosystem on the mainstem Columbia River (Toole et al. 2004). There is speculation, however, that adults migrating upstream through the hydroelectric projects may have a lower fitness because of reduced energy reserves (depleted during migration through projects) or increased susceptibility to disease. Currently, research has not demonstrated these effects on fitness. Steelhead kelts and adult bull trout suffer an undetermined loss during downstream migration through the dams. Juveniles and smolts, on the other hand, suffer mortality at each project. Losses may occur because of direct effects of dam passage, delayed mortality, increased predation (both birds and fish), or altered limnological conditions.

The primary threat associated with the operations of the five hydroelectric projects on the Upper Columbia River is a reduction in survival (and thus abundance) of spring Chinook salmon, steelhead, and bull trout. This threat is most apparent in juvenile and smolt life stages and is a result of direct morality at dams and predation by fish and birds. Loss of fish due to gas bubble trauma in the Upper Columbia appears to be low (S. Hays, CPUD, personal communication). The effect of dam operations on rates of adult migration (i.e., delays) and thus on population productivity is poorly understood. Research is needed to assess the threat of hydroelectric projects on fish productivity.

5.4.3 Hydro Project Objectives

The following objectives for hydroelectric projects apply primarily to the projects owned by the PUDs. These objectives are consistent with the Anadromous Fish Agreement and HCPs, relicensing agreements, and Section 7 Consultations. These objectives are intended to reduce the threats associated with hydroelectric development in the Upper Columbia Basin.

Short-Term Objectives

- Continue the actions identified in the Anadromous Fish Agreement and HCPs that will achieve no net impact (NNI) for Upper Columbia steelhead and spring Chinook.

- Implement the actions identified in the Settlement Agreement (2005) and Section 7 Consultation with Grant PUD that will improve spring Chinook and steelhead survival.
- Implement the actions identified in the USFWS biological/conferencing opinion with Douglas and Chelan PUDs that will improve conditions for Upper Columbia bull trout.
- Implement the actions identified in the Lake Chelan Hydroelectric Project relicensing agreement that will provide suitable spawning habitat for steelhead in the tailrace and lower Chelan River (downstream from the natural fish barriers).
- Build hydroelectric dams proposed for construction in the future in the Upper Columbia Basin that have no negative effects on spring Chinook, steelhead, and bull trout VSP parameters.
- Encourage the implementation of actions for federal hydroelectric projects identified in the remanded Federal Columbia River Power System biological opinion.

Long-Term Objectives

- Provide upstream and downstream passage for juvenile/smolt and adult life stages.
- Implement the actions identified in the Lake Chelan Comprehensive Fishery Management Plan to determine the feasibility and possible reintroduction of bull trout into the basin.
- Achieve NNI on species covered under the Anadromous Fish Agreement, HCPs, Settlement Agreements, and Section 7 Consultations.
- Maintain suitable subadult and adult bull trout rearing and passage conditions in the mainstem Upper Columbia River.
- Maintain suitable spawning habitat for steelhead in the lower Chelan River and tailrace.

Research and Monitoring Objectives

- Determine baseline survival estimates for juvenile spring Chinook and steelhead as they pass hydroelectric projects on the Upper Columbia River.
- Evaluate effects of hydroelectric projects on adult passage of spring Chinook, steelhead, and bull trout.
- Evaluate if passage through hydroelectric projects affect spawning success or fitness of spring Chinook, steelhead, and bull trout.
- Evaluate effectiveness of predator control programs.

Most of these objectives are consistent with the legal mandates of the HCPs, Section 7 Consultations, and relicensing agreements. The primary objective of the HCPs is to achieve NNI. If met, this objective would equate to a net productivity equivalent to the productivity that could be attained if these projects did not exist. The HCPs intend to meet NNI primarily through mainstem survival objectives for juvenile and adult salmonids, and through off-site mitigation with hatchery and tributary habitat improvements. The goal is to achieve combined adult and juvenile survival of 91% per project. The remaining 9% will be compensated through hatchery (7%) and tributary (2%) activities.

5.4.4 Recent Hydro Project Actions

Several actions have already been implemented to reduce threats associated with the operation of hydroelectric projects in the Upper Columbia River Basin. Importantly, the HCPs have been incorporated into Chelan and Douglas PUD Federal Energy Regulatory Commission (FERC) licenses. In addition, NOAA Fisheries issued its biological opinion on interim operations of Priest Rapids Hydroelectric Project. These agreements set the stage for implementing hydroelectric actions that are designed to result in NNI to spring Chinook and steelhead, and should improve passage conditions for bull trout.

The PUDs have also implemented downstream passage programs to enhance juvenile/smolt migration and survival. A juvenile bypass system was developed and installed at Wells Dam and recently at Rocky Reach Dam. Grant PUD is currently installing a new turbine and developing an improved fish bypass system at Wanapum Dam. They also plan on completing a new split-pier bypass at Priest Rapids Dam. These systems should increase the survival of juveniles/smolts migrating downstream through the projects. Spill is used at Rock Island, Wanapum, and Priest Rapids dams to increase juvenile/smolt survival at these projects. In addition, the PUDs have implemented measures to decrease the incidence of bird and fish predation on juvenile/smolt migrants. For example, they have bird harassment measures that reduce bird predation on juveniles and have implemented a northern pikeminnow reduction program in the project areas.

Within the Wenatchee subbasin, Chelan PUD has implemented actions that improve fish passage at both Tumwater and Dryden dams. They have also improved fish trapping at Dryden and Tumwater dams to reduce stress on fish returned to the river during broodstock trapping. These activities should reduce the threat that these projects negatively affect the spatial structure and diversity of spring Chinook, steelhead, and bull trout in the Wenatchee subbasin.

5.4.5 Hydro Project Recovery Actions

This plan strengthens the likelihood that all actions and mitigation associated with hydro projects throughout the Columbia River are consistent with recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Mainstem Columbia River

There are five hydroelectric projects on the Upper Columbia River that are addressed in this plan (Wells Dam, Rocky Reach Dam, Rock Island Dam, Wanapum Dam, and Priest Rapids Dam). Actions associated with each of these projects are identified and orchestrated through the Anadromous Fish Agreement, HCPs, and Section 7 processes. The actions identified in the agreements, HCPs, and in the Biological Opinions are adopted by reference into this plan.

Short-term Actions

- Implement or maintain actions associated with spill and fish-bypass systems identified in the Agreements, HCPs, and Section 7 Consultation to achieve a NNI on spring Chinook and steelhead.

- Implement actions identified in the USFWS Biological/Conference Opinion that address effects of Wells, Rocky Reach, and Rock Island Dam on Upper Columbia bull trout.
- Continue with bird harassment measures and northern pikeminnow reduction actions at mainstem hydroelectric projects.
- Encourage the implementation of actions for federal hydroelectric projects that will increase the survival of Upper Columbia spring Chinook and steelhead.

Long-term Actions

- Achieve and/or maintain a combined juvenile/smolt and adult survival rate of 91% per HCP project (Wells, Rocky Reach, and Rock Island dams).
- If necessary, modify operations to achieve the 91% combined juvenile/smolt and adult survival rate for the three HCP projects.
- Maintain conditions that do not adversely modify or destroy conditions for bull trout.

Research and Monitoring Actions

- Assess survival rates for juvenile/smolt spring Chinook and steelhead.
- Evaluate the efficiency and operation of bypass systems or passage facilities and spill on migrating spring Chinook, steelhead, and bull trout.
- Evaluate the effects of hydroelectric operations on sub-adult bull trout.
- Evaluate the effectiveness of bird control (lethal and non-lethal) and predatory fish control measures.
- Evaluate the effects of hydroelectric passage on reproductive success of spring Chinook, steelhead, and bull trout.

Wenatchee Subbasin

There are two decommissioned hydroelectric projects on the Wenatchee River (Dryden and Tumwater dams) and one small hydro project on Phelps Creek in the Chiwawa Basin. Both Dryden and Tumwater dams have adult fish ladders that were modified to improve adult passage in the late 1980s.

Tumwater Dam was originally used to create electricity for train passage through a tunnel near Stevens Pass. Currently, the dam is used by fishery resource agencies to count fish, capture broodstock for hatchery programs, and for other research. Various modifications have been made to the dam in the last few years to avoid fish passage delays. Resource agencies worked closely with Chelan PUD (the owner) to revise and modify tailrace conditions to quickly attract fish to the ladder at all water flows.

Dryden Dam is currently used to divert irrigation water for the Wenatchee Reclamation District. Broodstock is collected at both the right and left ladders for various hatchery programs.

The owner of the small hydroelectric project on Phelps Creek has applied for a license to generate electricity to be used for residential purposes at Trinity. The agencies are currently negotiating with the owner and are identifying operational goals that will protect spawning and rearing habitat for spring Chinook, steelhead, and bull trout in the upper Chiwawa Basin.

Short-term Actions

- Protect existing spring Chinook, steelhead, and bull trout spawning and rearing habitat in the upper Chiwawa River and Phelps Creek near the Trinity hydroelectric project.
- Maintain effective fish passage at Tumwater and Dryden dams.

Long-term Actions

- Maintain effective fish passage at Tumwater and Dryden dams.
- Maintain hatchery and tributary actions as identified in the HCPs.

Research and Monitoring Actions

- Monitor fish passage at Tumwater Dam.

Entiat Subbasin

There are currently no hydroelectric projects in the Entiat subbasin.

Short-term Actions

- None.

Long-term Actions

- Maintain hatchery and tributary actions as identified in the HCPs.

Research and Monitoring Actions

- None

Lake Chelan Subbasin

There is one hydroelectric project located on the Chelan River. The dam is located just downstream from the mouth of the lake and the powerhouse is located near the community of Chelan Falls. Chelan PUD and the resource agencies signed a settlement agreement for the relicensing of the project that identified several actions intended to improve aquatic conditions for salmon and trout in the lower Chelan River channel (downstream from the natural fish barriers) and in the tailrace. These actions should benefit the abundance and productivity of steelhead in the Upper Columbia DPS. Chelan PUD will implement these actions once NOAA Fisheries issues its biological opinion for the continued operation of the project.

Short-term Actions

- Implement the actions identified in the Lake Chelan Hydroelectric Project relicensing agreement that provide suitable spawning habitat (gravels, cover, and flows) for steelhead in the tailrace and lower Chelan River channel.

Long-term Actions

- Maintain suitable spawning habitat for steelhead in the tailrace and lower Chelan River channel.

Research and Monitoring Actions

- Monitor the use of spawning habitat by steelhead in the tailrace and lower Chelan River channel.
- Assess the effects of powerhouse shutdowns on the incubation success of steelhead in spawning gravels in the tailrace.

Methow Subbasin

There are currently no hydroelectric projects in the Methow subbasin.

Short-term Actions

- None.

Long-term Actions

- Maintain hatchery and tributary actions as identified in the HCPs.

Research and Monitoring Actions

- None

Okanogan Subbasin

There is only one hydroelectric project in the Okanogan subbasin, Enloe Dam on the Similkameen River, and it is currently decommissioned. This dam is located on or near Coyote Falls, which was an upstream fish passage barrier (Copp 1998; Vedan 2002). There is no fish passage at Enloe Dam.

Short-term Actions

- None.

Long-term Actions

- Maintain hatchery and tributary actions as identified in the HCPs.

Research and Monitoring Actions

- None

5.4.6 Responsible Parties

WDFW, WDOE, USFWS, NOAA Fisheries, Colville Tribes, Yakama Nation, Umatilla Tribe, and the PUDs are primarily responsible for overseeing and implementing hydro project activities. The PUDs are primarily responsible for funding hydro project actions.

5.4.7 Coordination and Commitments

This plan assumes that an Implementation Team, made up of representatives from various federal and state agencies, tribes, counties, and stakeholders will engage in discussions associated with hydropower actions. This Team will work with the appropriate technical committees, including the HCPs and Priest Rapids Coordinating Committees and technical committees established under the HCPs. The Implementation Team will also work closely with technical committees established under various relicensing agreements and Section 7 Consultations (e.g., Lake Chelan Hydroelectric Project, Priest Rapids Hydroelectric Project, and the Federal Columbia River Power System).

Habitat conservation plans and relicensing agreements strengthen the likelihood that these programs have secure funding and will continue operating into the future.

5.4.8 Compliance

HCPs, relicensing agreements, and Section 7 Consultations outline operating conditions, goals, and objectives that are incorporated into operating licenses. Hydro project activities are currently monitored through these agreements. The PUDs are primarily responsible to fund implementation and monitoring associated with mitigation requirements and to track progress of hydro actions in the Upper Columbia Basin. Committees established through the FERC processes will be primarily responsible for developing and coordinating the implementation of plans developed in these processes and evaluating monitoring activities.

5.5 Habitat Actions

5.5.1 Background

This plan is based on the well-established fact that spring Chinook, steelhead, and bull trout, like other salmonids, have specific habitat requirements that vary across life stages. This fact is consistent with ecological theory and is supported by numerous independent studies (e.g., see reviews in Bjornn and Reiser 1991; Rieman and McIntyre 1993; Spence et al. 1996; 62 FR 43937; 64 FR 14308; 63 FR 31647). Any land or water management action or natural event that changes habitat conditions beyond the tolerance[103] of the species results in lower life-stage survival and abundance of the species. In some cases, the range of tolerance for some species is quite narrow and relatively small changes in the habitat can have large effects on species survival. For example, bull trout spawning and juvenile rearing occurs within a narrow range of water temperatures (Goetz 1989; Rieman and McIntyre 1993; 40 FR 41162). Activities or natural events that increase water temperatures (>15°C) reduce the distribution and abundance of juvenile bull trout.

In general, spring Chinook, steelhead, and bull trout require cold, clean, connected, and complex habitat (Bjornn and Reiser 1991; Spence et al. 1996). These fish typically grow and survive best in streams with summer temperatures less than 15°C and winter temperatures greater than

[103] Tolerance represents the range of an environmental factor (e.g., temperature, fine sediment, water velocity, etc.) within which an organism or population can survive.

0°C.[104] They prefer streams that are free of toxic pollutants (e.g., heavy metals, urban runoff, and other point- and nonpoint-source pollutants) and lack high levels of fine sediments and high turbidity. These fish are most often found in complex and diverse habitats. For example, juvenile Chinook are most often associated with streams that contain large woody debris (LWD) and pools in low-gradient alluvial valleys.[105] In higher-gradient fluvial canyons, large boulders provide habitat complexity. Juvenile steelhead often rear in these higher-gradient reaches.[106] Juvenile and adult bull trout frequently inhabit side channels, stream margins, and pools with suitable cover and areas with cold hyporheic zones or groundwater upwellings. All three species require suitable stream flows for rearing, spawning, and migration. They also require a network of connected spawning and rearing habitats. Areas of suitable spawning and rearing habitats can become fragmented or disconnected by physical barriers (e.g., dams, diversions, dewatering, naturally occurring log jams), chemical barriers (e.g., pollutants), and by unnaturally warm temperatures. If any of these habitat elements are missing or compromised, then abundance, productivity, spatial structure, and diversity of the species is reduced.

Over the decade many books on salmon conservation have emerged (e.g., NRC 1996; Stouder et al. 1997; Lichatowich 1999; Knudsen et al. 2000; Lynch et al. 2002; Montgomery et al. 2003; Wissmar and Bisson 2003), and all agree that habitat restoration should be a cornerstone of any recovery program.[107] As such, this plan aims to address habitat threats by protecting and restoring ecosystem functions or processes whenever and wherever feasible and practical. This approach is science based (but considers socio-economic issues; see Sections 6 and 8) and provides a means for required habitat to be maintained long-term in a dynamic way by natural processes. The implementation of this plan will be sensitive to and consistent with local planning processes, Section 7 and 10 consultations with federal services, local landowner and tribal interests, and reserved and adjudicated rights.

This plan recognizes that at some point the implementation of habitat actions will have diminishing returns (i.e., benefits per cost analysis). In other words, at some point in the future, all improvements, through protection and restoration, will have a very limited affect on fish habitat. This plan promotes an end point of habitat improvements, that when met, will conclude the responsibility of landowner action to improve or preserve habitat.

5.5.2 Limiting Factors and Threats

Past land and water management activities within the Upper Columbia Basin have degraded habitat conditions and compromised ecological processes in some locations (for a more detailed

[104] It is important to note that local adaptation affects general temperature ranges and literature values are intended to be used as guidelines only.
[105] During a 12-year study in the Chiwawa basin, Hillman and Miller (2004) found that sites with LWD made up on average only 19% (range, 10-29%) of the total stream surface area in the basin, but supported on average 61% (range, 25-77%) of all juvenile Chinook in the basin.
[106] Habitat selected by fish is directly related to their morphology (shape). For example, Bisson et al. (1988) found that the shape of juvenile steelhead is adapted to life in fast water, whereas the shape of juvenile Chinook is adapted for slower-water. Thus, these species will have slightly different habitat requirements.
[107] This does not mean that recovery can be achieved with habitat actions only. Implementation of actions within the other Hs (Harvest, Hatcheries, and Hydropower) is also needed to achieve recovery.

discussion see Section 3.7). Habitat within many of the upper reaches of most subbasins is in relatively pristine condition (e.g., upper reaches of the Wenatchee, Entiat, and Methow subbasins). Human activities have reduced habitat complexity, connectivity, water quantity and quality, and riparian function in many stream reaches in the Upper Columbia Basin. Loss of LWD and floodplain connectivity have reduced rearing habitat for Chinook, steelhead, and bull trout in larger rivers (e.g., Wenatchee, Entiat, Methow, and Okanogan rivers). Fish management, including past introductions and persistence of non-native (exotic) fish species continues to affect habitat conditions for listed species.

This plan relied on several tools to identify and assess habitat conditions, limiting factors, and threats within the Upper Columbia Basin. This included information derived from watershed plans, subbasin plans, limiting factors analysis, the Biological Strategy (UCRTT 2003), EDT, empirical and derived data, and local knowledge and professional judgment. EDT[108] was used to identify the potential for increasing the viability of spring Chinook, steelhead, and bull trout by restoring[109] and protecting habitat in the Upper Columbia Basin. This tool, in combination with limiting factors analysis, watershed plans, subbasin plans, and the Biological Strategy also identified locations within each subbasin that would most benefit from habitat restoration and protection. The lack of data in some subbasins (e.g., Okanogan subbasin) emphasizes the importance of monitoring and adaptive management.

5.5.3 Habitat Objectives

The following objectives for habitat restoration apply to all streams that currently support or may support (in a restored condition) spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. These objectives are consistent with subbasin plans, watershed plans, the Biological Strategy, HCPs, and relicensing agreements and are intended to reduce threats to the habitat needs of the listed species. These objectives may be modified in response to monitoring, research, and adaptive management. These objectives will be implemented within natural, social, and economic constraints.

Short-Term Objectives

- Protect[110] existing areas where high ecological integrity and natural ecosystem processes persist.
- Restore connectivity (access) throughout the historic range where feasible and practical for each listed species.[111]

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[108] See watershed plans, subbasin plans, and Appendix F for a detailed description of the use of EDT.

[109] This plan defines "habitat restoration" as a process that involves management decisions and actions to improve habitat conditions (after Davis et al. 1984). The goal of habitat restoration is to reestablish the ability of an ecosystem to maintain its function and organization without continued human intervention. It does not mandate or even suggest returning to the historic condition (often identified as some arbitrary prior state). Restoration to a previous condition often is impossible.

[110] Protect or protection in this plan refers to ***all*** actions that safeguard required habitat features of listed species. This plan does not recommend land acquisition, unless "no net loss" of the tax base to the county in which the land is being sold is accomplished.

- Where appropriate, establish, restore, and protect stream flows (within the natural hydrologic regime and existing water rights) suitable for spawning, rearing, and migration (based on current research and modeling).
- Protect and restore water quality where feasible and practical within natural constraints.
- Increase habitat diversity in the short term by adding instream structures (e.g., LWD, rocks, etc.) where appropriate.[112]
- Protect and restore riparian habitat along spawning and rearing streams and identify long-term opportunities for riparian habitat enhancement.
- Protect and restore floodplain function and reconnection, off-channel habitat, and channel migration processes where appropriate and identify long-term opportunities for enhancing these conditions.
- Restore natural sediment delivery processes by improving road network, restoring natural floodplain connectivity, riparian health, natural bank erosion, and wood recruitment.
- Replace nutrients in tributaries that formerly were provided by salmon returning from the sea.
- Reduce the abundance and distribution of exotic species that compete and interbreed with or prey on listed species in spawning, rearing, and migration areas.[113]

Long-Term Objectives

- Protect areas with high ecological integrity and natural ecosystem processes.
- Maintain connectivity through the range of the listed species where feasible and practical.
- Maintain suitable stream flows (within natural hydrologic regimes and existing water rights) for spawning, rearing, and migration.

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[111] The distribution of steelhead throughout the Okanogan subbasin (U.S. and Canada) has been severely reduced. Although this plan has no authority to dictate recovery actions in Canada, this plan encourages U.S. managers and scientists to continue to work cooperatively with Canadian managers and scientists in identifying and implementing habitat actions that would benefit Okanogan steelhead. The process for this collaboration currently exists and has been used in subbasin planning.

[112] This plan recommends the use of instream structures (such as boulders and LWD) as an immediate, short-term action to increase habitat diversity. These structures can be used while other actions are implemented to restore proper channel and riparian function (i.e., natural watershed processes). The manual addition of instream structures is usually not a long-term recovery action and should not be used in place of riparian or other restoration activities that promote reestablishment of natural watershed processes. However, if recovery of natural watershed processes cannot be achieved, the use of instream structures is a reasonable option.

[113] This objective is identified as a critical uncertainty in this plan. Depending on the results of research, actions may be identified that directly reduce abundance and distribution of predators and competitors and/or indirectly affect their abundance and distribution by increasing habitat conditions that are favorable to listed species but unfavorable to exotic fish species.

- Protect and restore water quality where feasible and practical within natural constraints.
- Protect and restore off-channel and riparian habitat.
- Increase habitat diversity by rebuilding, maintaining, and adding instream structures (e.g., LWD, rocks, etc.) where long-term channel form and function efforts are not feasible.
- Reduce sediment recruitment where feasible and practical within natural constraints.
- Reduce the abundance and distribution of exotic species that compete and interbreed with or prey on listed species in spawning, rearing, and migration areas.

Administrative/Institutional Objectives

- Maximize restoration efficiency by concentrating habitat actions in currently productive areas with significant scope for improvement and areas where listed species will benefit (Category 1 and 2 areas described in Section 5.5.5).
- Develop incentive and collaborative programs with local stakeholders and land owners to enhance and restore habitat within productive areas.
- Encourage compliance with Federal, State, and local regulatory mechanisms designed to conserve fishery resources, maintain water quality, and protect aquatic habitat.
- Counties will continue to consider recovery needs of salmon and trout in comprehensive land-use planning processes.
- Provide information to the public on the importance of "healthy"[114] streams and the potential effects of land and water management activities on the habitat requirements of listed species.[115]
- Until recovery is achieved, improve or streamline the permitting process for conducting research and monitoring on ESA-listed species and for implementing restoration actions.
- Develop, maintain, and provide a comprehensive inventory of habitat projects and their costs and benefits (effectiveness) to the public annually.

Research and Monitoring Objectives

- Monitor the effectiveness of each "class" of habitat action implemented in the Upper Columbia Basin on listed species and community structure.[116]

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[114] "Healthy" is a relative term and is used in this plan to mean the habitat conditions necessary to sustain the listed species indefinitely.
[115] This action should include various workshops and seminars to increase the publics understanding of the ecology of the species and their habitat requirements.
[116] Despite a large body of knowledge about the habitat needs of fish, there still are uncertainties about which actions will be most effective. The intent of this plan is to make the best possible choice of actions based on available information and monitoring results, and modify actions as necessary.

- Accurately monitor trends in VSP parameters (including smolts/redd) at the population and subpopulation scale.
- Assess stream flows (within the natural hydrologic regime and existing water rights) suitable for spawning, rearing, and migration (based on current research and modeling).
- Implement current monitoring protocols and continue to develop standardized monitoring methods.
- Examine relationships between habitat and biological (including VSP) parameters at coarse (landscape) and fine (stream segment) scales.
- Update, revise, and refine watershed and salmonid performance assessment tools (e.g., EDT) to adaptively manage the implementation and prioritization strategy.
- Examine the effects of exotics species on listed species.
- Assess abundance and consumption rates of exotic fish that feed on listed species.
- Conduct channel migration studies within each subbasin to identify priority locations for protection and restoration.
- Examine fluvial geomorphic processes within each subbasin to assess how these processes affect habitat creation and loss.
- Inventory and assess fish passage barriers and screens within each subbasin.
- Conduct hydrologic assessments to better understand water balance and surface/groundwater relations within the subbasins.[117]

5.5.4 Recent Habitat Actions

Recent changes in land and water use practices on public and private lands are improving habitat conditions in the Upper Columbia Basin.[118] For example, the counties continue to protect and restore critical areas, including salmon and trout habitat through the Growth Management Act and the Shoreline Management Act and their associated administrative codes and local land-use regulations. Private landowners have proactively implemented many habitat restoration, conservation, and enhancement activities voluntarily (outside of planning processes) and many local stakeholders are involved in local planning efforts. The Forest Service, the largest land manager in the Upper Columbia Basin, manages spawning and rearing streams through several programs including the Northwest Forest Plan and the PACFISH/INFISH strategy. WDFW and the Department of Natural Resources also own land in the Upper Columbia Basin and have modified and continue to modify land management practices to improve habitat conditions. The tribes are also involved in habitat management and restoration. In sum, this plan recognizes that there are many areas within the subbasins of the Upper Columbia where good stewardship is

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[117] This includes studies that assess the effects of various activities that recharge aquifers that feed surface waters.
[118] In many cases the effects of these changes on environmental indicators and population VSP parameters are not clearly known.

occurring. This plan recommends that these efforts continue and that adequate funding is made available.

Table 5.8 provides a summary of habitat actions implemented within the last decade within each subbasin (excluding projects in Canada) and the mainstem Upper Columbia River and its smaller tributaries. This information was compiled from subbasin planning inventories and the Salmon Recovery Funding Board database, and categorized according to action type: acquisitions (land); assessments; passage improvements; habitat improvements; planning processes; research, monitoring, and evaluation (RME); screening; water quality; and water quantity. Undoubtedly, some projects were missed and about 20 projects could not be categorized. Several of the projects consisted of more than one action. For example, a given culvert/barrier removal project often addressed multiple culverts and barriers.

This inventory indicates that about 362 projects have been implemented within the Upper Columbia Basin within the past decade. There were at least 75 projects implemented within the Wenatchee subbasin, 69 in the Entiat, 145 in the Methow, 42 in the Okanogan, and 31 within the mainstem Upper Columbia and its smaller tributaries. These projects were implemented primarily by local entities, such as conservation and irrigation districts, with federal, state, and local government involvement.

5.5.5 Habitat Recovery Actions

This plan strengthens the likelihood that all actions and mitigation associated with habitat throughout the Columbia River are consistent with recovery of Upper Columbia spring Chinook, steelhead, and bull trout.

Approach

This plan recognizes two general types of habitat recovery actions: restoration and protection. As noted earlier, this plan defines habitat restoration as a process that involves management decisions and actions that enhance the rate of recovery of habitat conditions (after Davis et al. 1984). The goal is to reestablish the ability of the ecosystem to maintain its function and organization without continued human intervention. It does not mandate or even suggest returning to an historical condition (often identified as an hypothesized prior state). In fact, restoration to a previous condition may not be possible (NRC 1992, 1996). Habitat protection, on the other hand, includes the use of management decisions and actions to safeguard ecosystem function and required habitat features of listed species. Protection includes all actions (not just regulatory) that protect habitat conditions.

This plan considered two forms of protection: no-net-impact and passive restoration. No-net-impact protection means that (1) activities that can harm stream and riparian structure and function will not occur, or (2) activities that harm stream and riparian habitat are mitigated by restoring and protecting an “equal or greater” amount of habitat. This type of protection is generally applied to areas where increased development is likely to occur.[119] The second type of

[119] This type of protection can only be met if better standards are implemented and enforced. At this time there are institutional and social problems with improving the standards. Although NNI protection is unlikely to occur, this form of protection was included in habitat modeling.

protection, passive restoration, addresses areas that are already protected under state and federal ownership. This also includes landowners that voluntarily protect stream and riparian conditions on their properties. Under this form of protection, habitat conditions improve as management actions are designed to maintain or improve habitat forming processes.

Habitat recovery actions identified in this plan were selected based on information contained in watershed plans (under RCW 90.82), subbasin plans, the Biological Strategy, Bull Trout Draft Recovery Plan, EDT results, empirical and derived data, and local knowledge and professional judgment[120]. The process of selecting actions began by dividing each subbasin into geographic assessment units, following watershed plans and subbasin plans. Within each assessment unit, the "primary" limiting factors and causal factors or threats were identified using information contained in watershed plans, subbasin plans, the Biological Strategy, the Bull Trout Draft Recovery Plan, and EDT results. The plan then identified species and life-stage specific management objectives. Here the intent was to identify the specific life-stages and species that would benefit from addressing the primary threats within an assessment unit.

Following the identification of specific management objectives, the plan identified "classes" of restoration actions (**Table 5.9**) that addressed each objective and linked directly to "primary" limiting factors/threats.[121] Restoration classes were identified through a collaborative process that included federal, state, and local governments, tribes, and local stakeholder participation. This plan identified suites of "specific" actions for each restoration class. It does ***not***, at this time, identify which of those specific actions will be implemented within each assessment unit, nor does it identify "specific" locations within the assessment unit where an action will be implemented.[122] Rather, this plan provides a short list of specific actions that ***could*** be implemented within each restoration class (**Table 5.9**). The plan does identify the appropriate restoration classes that are needed to address the primary limiting factors and threats within assessment units.

This plan recommends that local habitat groups[123] (see Section 5.5.6) recommend appropriate specific actions from the list of actions within each restoration class. These groups are also responsible for identifying the most appropriate places to implement the actions within the assessment units. This plan recommends that these groups implement actions that will result in changes to salmon and trout performance measures (at the population scale) that are at least as

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[120] The use of professional judgment was not a haphazard approach at identifying recovery actions. Professional judgment required an indepth understanding of life-stage specific habitat requirements of the listed species and an understanding of current habitat conditions within the subbasins.

[121] This plan only identifies actions for the primary limiting factors. It does not identify actions for secondary limiting factors. Although secondary factors may limit VSP parameters of listed species, their effects are not well understood. Therefore, research actions will be identified to assess the effects of secondary factors on VSP parameters of listed species.

[122] In some areas (e.g., Wenatchee, Entiat, and Foster/Moses Coulee), Watershed Planning Groups are currently identifying and prioritizing "specific" actions within assessment units.

[123] A local habitat group exists or will be established within each of the five subbasins. As described later in this plan, these local groups will be responsible for recommending specific actions, overseeing implementation and monitoring of actions, and coordinating activities within their respective subbasin. Membership within each group is described in Section 5.5.6.

effective as the minimum restoration intensity modeled with EDT in this plan (33% intensity) (Appendix F). The 33% intensity was based on professional judgment and represented the minimum-effort scenario in EDT modeling and may not reflect what is feasible in each assessment unit. This plan anticipates that some restoration classes will be implemented at a higher intensity (e.g., 100%), while other (because of cost and feasibility) will be implemented at a lower intensity. Because not all restoration classes have the same effect on fish performance (e.g., riparian restoration has a different effect on fish performance than does water quality restoration), additional modeling, coupled with long-term monitoring, will be required to determine if the list of specific actions and intensities recommended by the local habitat groups result in equivalent potential increases in fish performance.

The final step in identifying habitat recovery actions was to assess the effects of habitat actions on the VSP parameters for spring Chinook, steelhead, and bull trout. Here the purpose was to link habitat restoration classes with specific VSP parameters. To simplify the process, the plan combined abundance and productivity (A/P) and spatial structure and diversity (SS/D) following the logic in Section 4.2.5. For each VSP parameter (A/P and SS/D) the plan determined if the implementation of an action class would have a large effect (X) or small effect (x) on the VSP parameters. Additionally, this plan integrated across the actions by comparing EDT results to VSP parameters (Appendix F). This process was informed by the known habitat requirements of the listed species and the known effects of habitat actions on the habitat requirements of the species (***sensu*** Gore 1985; Meehan 1991; Colt and White 1991; Hunter 1991; NRC 1992; Cowx 1994; Benaka 1999; Wissmar and Bisson 2003). In addition, the plan identified the amount of time (effect time) it would take for a given action to result in a change in a VSP parameter. Effect time was designated as short (1-5 years), medium (6-20 years), or long (>20 years). For example, providing passage into a stream historically used by a listed species should have a short effect time, while restoring riparian vegetation should have a long effect time.

The results of this work are summarized in Appendix G. The tables in Appendix G were organized by subbasin (a different table for each subbasin) and by geographic assessment unit (the first column in each table). Each table identifies the primary limiting factor(s) by assessment unit, the primary causal factors or threats, the management objectives, appropriate restoration classes (from **Table 5.9**), specific restoration actions (from **Table 5.9**), species affected by the action (spring Chinook, steelhead, or bull trout), contribution of the action to VSP (A/P or SS/D), and effect time. Assessment units were also ranked according to their importance to recovery (see Prioritization section below). At this time, the tables do not reflect feasibility of implementing habitat actions.

Prioritization

This plan provides the local habitat groups with a framework for prioritizing specific habitat actions. The framework is described in detail in Section 8.3. Briefly, the selection of specific actions is based on a balance between the biological benefit of the specific action and the cost and feasibility of implementing the action. Specific actions that provide a large benefit to the species and are relatively inexpensive and feasible to implement would have a higher rating than an action that has a lower biological benefit and is expensive and less feasible to implement. Because the Upper Columbia Region is highly dependent economically on agriculture, it is important that the agricultural community support the actions identified in this plan. Thus, the framework for selecting specific actions is a collaborative process, including managers, scientists, and local stakeholders. This approach has been demonstrated by the successful Entiat collaboration.

It is important to note that prioritization is simply a sequencing of actions or areas to be treated. It does not mean that actions or areas ranked as low priority will not be addressed. All classes of actions identified in Appendix G must be addressed, but because of limited annual resources, the plan must develop a method for selecting areas and actions that should be addressed first.

It is important to prioritize both the actions that will be implemented and the locations (assessment units) to be treated. The following framework for prioritizing and sequencing includes elements from watershed plans, subbasin plans, the Upper Columbia Biological Strategy, the Washington State Salmon Recovery Funding Board, and the Oregon Watershed Enhancement Board. These approaches are science-based, but also include federal, state, local government, and tribal goals and socio-economic concerns.

Categories of Actions within Subbasins

The first step in prioritizing recovery actions was to characterize the assessment units according to their contribution to recovery. In this plan, assessment units that are relatively undisturbed and provide "healthy" ecosystems were ranked highest. The intent is to protect these areas from activities that would negatively affect the structure and function of the aquatic and riparian ecosystems. Disturbance in these areas could preclude recovery or worse increase the probability of extinction. Of the assessment units in need of restoration, those that have the greatest potential for habitat improvement and recovery of multiple listed species were ranked higher than those that provide little benefit to the species.[124] Thus, this plan does not necessarily attempt to restore the degraded or most visibly altered areas, unless they will contribute significantly to VSP parameters.

The Biological Strategy (Appendix H) prepared by the UCRTT (2003) provided a useful framework for prioritizing assessment units across varied landscapes. The strategy identified four categories,[125] based on the functionality of the aquatic ecosystem and the resilience and resistance of ecosystems to disturbance. Category 1 areas were ranked highest. This does not mean that specific actions should not occur in Category 2, 3, and 4 areas until all activities in Category 1 areas are complete. Any action within Categories 2, 3, and 4 that increase the abundance, productivity, spatial structure, or diversity of listed species is encouraged and should contribute to recovery. The Biological Strategy described the categories as follows:

- ***Category 1 (Protection/Restoration)***: These areas represent systems that most closely resemble natural, fully functional aquatic ecosystems. They comprise large, connected blocks of high-quality habitat that support more than two listed species. Exotic species may be

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[124] The same unit may be recommended for both protection and restoration. This may occur because (1) an areas may be both important to the protection of an existing population and possess substantial unrealized production potential, and (2) all priority restoration areas are automatically recommended for protection in order to keep from further degrading the reach before restoration can take place and to protect its newly enhanced condition once it is restored.

[125] The UCRTT also identified a fifth category that only addressed the mainstem Columbia River.

present but are not dominant in abundance. Protecting these areas is a priority, although restoration in some areas is also needed.

- ***Category 2 (Restoration/Protection)***: These areas support important aquatic resources and are strongholds for one or more listed species. Compared to Category 1 areas, Category 2 areas have a higher level of fragmentation resulting from habitat disturbance or loss. These areas have a large number of subwatersheds where native populations have been lost or are at risk for a variety of reasons. Restoring ecosystem function and connectivity within these areas are priorities.
- ***Category 3 (Restoration)***: These areas may still contain subwatersheds that support salmonids, but they have experienced substantial degradation and are strongly fragmented by habitat loss, especially through loss of connectivity with the mainstem corridor. The priority in these areas is to rectify the primary factors that cause habitat degradation.
- ***Category 4 (Major Restoration or Minor Fish Use)***: These areas contain both functional and non-functional habitat that historically supported one or more listed species. Exotic species are numerically dominant in one or more subwatersheds. Native species are generally not present in sustainable numbers. Restoration of these areas is important, but it should not hinder restoration in the other categories.

This plan adopted the framework outlined in the Biological Strategy. The rating of the assessment units within each subbasin are shown in **Table 5.10**. Note that there are no Category 1 assessment units in the Okanogan subbasin. This is primarily because the Okanogan currently supports only one listed species. As noted earlier, the fact that there are only Category 2, 3, and 4 areas in the Okanogan does not mean that they receive fewer resources than Category 1 areas in other subbasins. Indeed, the recovery of Okanogan steelhead is required before the DPS can be de-listed. However, to the extent possible, allocating resources for habitat actions in the Okanogan subbasin should follow the sequencing of categories identified in **Table 5.10**.

Small tributaries that drain directly into the mainstem Columbia River do not clearly fit within any of the categories identified in the Biological Strategy.[126] Nevertheless, this plan identifies restoration and protection measures for these streams.

Categorize Habitat Classes and Actions

The second step was to prioritize habitat classes and actions within assessment units based on biological benefits and socioeconomic considerations. As a general rule, the highest priority is to maintain and protect all areas within an assessment unit that are currently functioning properly (i.e., they have high biological integrity, connectivity, and habitat diversity) (Doppelt et al. 1993; Williams et al. 1997). Activities within these areas that can reduce the structure and function of riparian and aquatic ecosystems should be avoided or mitigated to prevent the species from slipping into a higher risk of extinction. Protecting existing riparian areas and stream flows within assessment units allows stream migration, which improves riparian and floodplain structure and function and increases habitat diversity and complexity.

[126] It was not an objective of the Biological Strategy to rate small tributaries the drain into the mainstem Columbia River. Therefore the Strategy did not create a category for them.

After implementing protection measures, it is important to categorize habitat restoration "classes" within assessment units. Emphasis is placed on actions with long persistence times (long life span) and benefits distributed over the widest range of environmental attributes (e.g., riparian restoration reduces stream temperatures, increases large woody debris recruitment, and increases habitat diversity and channel stability). However, this plan recognizes that restoration in some locations requires immediate measures in addition to long-term actions. These immediate actions are intended to "jump start" recovery in areas where reversing the cause of habitat degradation requires a long time to achieve. Immediate actions include such things as manual addition of large woody debris or instream structures to stream channels. Ultimately, this plan recommends that all restoration classes identified in Appendix G should be implemented.

Finally, after identifying restoration classes within an assessment unit, "specific" habitat actions must be selected for implementation. As noted earlier, this plan does not identify "specific" habitat actions that will be implemented within each assessment unit. Rather it provides a non-inclusive list of specific actions that could be implemented within an assessment unit to address primary limiting factors. It is the responsibility of the local habitat groups that are most familiar with the assessment units to recommend the most appropriate habitat actions.

Habitat Modeling

This plan used EDT to assess the relative effects of implementing the restoration classes identified in Appendix G on the performance of spring Chinook and steelhead within each subbasin. EDT was not used to assess the effects of restoration classes on bull trout performance, nor was it used to assess effects in small tributaries to the Columbia River or in the Entiat for steelhead. Bull trout modeling will be conducted in the future. However, habitat actions that benefit spring Chinook and steelhead will likely benefit bull trout. ***Importantly, in this plan, EDT was used only as a planning tool; it will not be used to determine when a population has been "recovered***." Described below is a brief summary of model setup and scenario runs. A more detailed description of procedures and assumptions used in EDT modeling is presented in Appendix F.

EDT was used to integrate across all restoration classes; however, the integration results were only quantified at two implementation intensities (100% and 33%) to provide some guidance on possible increases in fish performance. Thus, this plan reports only two different habitat scenarios (Scenarios 1 and 3) for spring Chinook and steelhead within the Wenatchee and Methow subbasins and for steelhead in the Okanogan subbasin. EDT results for Entiat spring Chinook were contained in the Entiat EDT Watershed Analysis (Mobrand Biometrics, Inc. 2003) and the Entiat WRIA 46 Management Plan (CCCD 2004).

- ***Habitat Scenario 1*** assumed that all restoration classes identified in Appendix G would be implemented at full intensity.[127] **Full intensity in all assessment units is not feasible or practical, because it does not consider socioeconomic factors.** **This scenario is useful for planning purposes because it provides an upper bound on the relative benefits of implementing habitat restoration actions at maximum effort (full intensity) within each subbasin.** If recovery cannot be achieved by implementing habitat actions at full intensity,

[127] This scenario did not consider potential effects from future development (see Appendix F).

then the contribution of other Hs (Harvest, Hatcheries, and Hydropower) and out-of-basin effects must be considered in recovery planning (this plan appropriately addresses recovery actions within all Hs).

- ***Habitat Scenario 2*** was not available in time for modeling purposes. Our vision was for scenario 2 to be the chosen mix and match of action classes and intensities that were feasible in each assessment unit, based on detailed local input regarding feasibility. We left an un-modeled scenario 2 in the report to emphasize the need for subwatershed specific prescriptions of each action class. It is assumed that Scenario 2 would fall somewhere in between scenarios 1 and 3.

- ***Habitat Scenario 3*** assumed that restoration classes identified in Appendix G would be implemented at 33% intensity (see footnote 126). Obstructions and protection were modeled at full intensity. Scenario 3 assumed that all artificial obstructions would be fixed and maintained. This scenario provided an alternative level of effort without making judgments about where high and low intensities were feasible and practical. Like scenario 1, this scenario did not consider socioeconomic factors. The plan assumes that this scenario represents a lower bounds on habitat restoration actions in the subbasins and would require a greater level of recovery contributions from the other Hs and in areas out-of-basin.

The model was set up so that it would provide results for each Scenario, plus current (without harvest) and "historical" conditions (Appendix F). The "historical" condition, referred to as the "Habitat Template" in EDT, represents estimated historical habitat conditions and current Columbia River mainstem conditions. The "True Template" in EDT refers to historic habitat conditions and historic mainstem conditions (without dams). Although the Habitat Template does not represent a "true" historical condition, both it and the "current" condition provide benchmarks for comparing the results of different scenarios.

EDT provided results in terms of fish "performance." In EDT, performance was measured as relative changes in population abundance, productivity, capacity, and diversity index (Appendix F). Only abundance could be compared directly to the VSP parameters used in this plan. Productivity from EDT could not be compared directly to productivity used in this plan because EDT and viability curves relied on different stock-recruitment functions (see Appendix F). The diversity index in EDT could not be compared directly to the spatial structure and diversity parameters used in this plan, although the diversity index in EDT should correlate with some of the metrics used in evaluating spatial structure and diversity. Importantly, EDT did not consider genetic variation and the possible effects of hatchery fish on spawning grounds. These factors are important components of population diversity as described in this plan.

Because of uncertainties associated with some of the assumptions in the model and the lack of direct comparisons between most EDT performance metrics and VSP parameters, this plan avoided using EDT output as a predictor of "absolute" change. Rather, this plan used the results of EDT as an ***indicator*** of the potential change based on relative increases over current conditions and the proportion of within-subbasin potential that could be realized under two different scenarios (Appendix F).

Recovery Actions

The recovery actions listed below for each population are intended to reduce threats associated with land and water management activities in the Upper Columbia Basin. These actions address primary threats associated with population abundance, productivity, spatial structure, and diversity. Because maintaining existing water rights are important to the economy of landowners within the Upper Columbia Basin, this plan will not ask individuals or organizations to affect their water rights without empirical evidence as to the need for the recovery of listed species. To the extent allowed by law, landowners will be adequately compensated for implementing recovery actions. In addition, any land acquisition proposals in this plan will be based on the concept of no net loss of private property ownership, such as conservation easements, transfer of development rights, and other innovative approaches. Local habitat groups (in cooperation with local landowners) will prioritize and coordinate the implementation of "specific" habitat actions within assessment units.

Wenatchee Populations

The Wenatchee subbasin supports three listed species: spring Chinook, steelhead, and bull trout. Several factors, including activities driven by government policies have reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many stream reaches in the Wenatchee subbasin. However, the subbasin contains headwater areas that are in relatively pristine condition and serve as "strongholds" for listed species. The following actions are intended to reduce the primary threats to aquatic and riparian habitats and to improve conditions where feasible and practical.

Short-term Protection Actions

Use administrative and institutional rules and regulations to protect and restore stream and riparian habitats on public lands within the following assessment units:

- Middle Wenatchee
- Upper Wenatchee
- Upper Icicle Creek
- Chiwaukum
- Chiwawa River
- Lake Wenatchee
- Little Wenatchee
- White River

Short-term Restoration Actions

Implement the following actions throughout the entire Wenatchee subbasin:

- Address passage barriers.
- Address diversion screens.

- Reduce the abundance and distribution of brook trout through feasible means (e.g., increased harvest).

White River Assessment Unit (Category 1; Appendix G.1):

- Increase habitat diversity within the lower 2 miles of the White River by reconnecting the floodplain and wetlands to the river.

Little Wenatchee Assessment Unit (Category 1; Appendix G.1):

- Reduce sediment recruitment to the stream by improving road maintenance within the watershed.

Chiwawa River Assessment Unit (Category 1; Appendix G.1):

- Increase habitat quantity by restoring riparian habitat along the lower 4 miles of the Chiwawa River.
- Reduce sediment recruitment to the stream by improving road maintenance within the watershed.
- Improve fish passage in tributaries.

Upper Wenatchee Assessment Unit (Category 1; Appendix G.1):

- Increase habitat quantity in the Wenatchee River between Tumwater Canyon and Lake Wenatchee by restoring riparian habitat along the river and reconnecting side channels (where feasible).

Nason Creek Assessment Unit (Category 2; Appendix G.1):

- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers (culverts).
- Increase habitat diversity and natural channel stability by increasing in-channel large wood complexes, restoring riparian habitat, and reconnecting side channels, wetlands, and floodplains to the stream.
- Improve road maintenance to reduce fine sediment recruitment to the stream.
- Reduce high water temperatures by reconnecting side channels and the floodplain and improving riparian habitat conditions.

Chiwaukum Creek Assessment Unit (Category 2; Appendix G.1):

- Increase connectivity along Skinney Creek.
- Increase habitat diversity in Chiwaukum Creek along Tumwater Campground by restoring riparian vegetation, reconnecting the floodplain with the stream, and by increasing large woody debris within the channel.

Lower Icicle Creek Assessment Unit (Category 2; Appendix G.1):

- Increase connectivity by improving fish passage over Dam 5 in the lower Icicle Creek.[128]
- Reduce sediment recruitment by restoring riparian vegetation between the mouth of the Icicle and the boulder field (RM 0-5.4).
- Improve road maintenance to reduce fine sediment recruitment in the upper watershed.
- Increase habitat diversity and quantity by restoring riparian vegetation, reconnecting side channels, and reconnecting the floodplain with the channel in lower Icicle Creek.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in Icicle Creek.

Peshastin Creek Assessment Unit (Category 2; Appendix G.1):

- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in Peshastin Creek.
- Reduce water temperatures by increasing stream flows and restoring riparian vegetation along the stream.
- Increase habitat diversity and quantity by restoring riparian vegetation, adding instream structures and large woody debris,[129] and reconnecting side channels and the floodplain with the stream.

Lower Wenatchee Assessment Unit (Category 2; Appendix G.1):

- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the Wenatchee River.
- Reduce water temperatures by restoring riparian vegetation along the river.[130]
- Increase habitat diversity and quantity by restoring riparian habitat along the Wenatchee River, reconnecting side channels and the floodplain with the river, and increasing large woody debris in the side channels.

Mission Creek Assessment Unit (Category 3; Appendix G.1):

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[128] Action is necessary to improve passage for steelhead and bull trout. Preclude passage of out-of-basin fish (Carson stock).

[129] These actions are appropriate in the stream where the existing highway precludes restoration of riparian habitat and off-channel conditions.

[130] Both water quality and quantity will improve in the lower Wenatchee River as restoration actions are implemented throughout the subbasin.

- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers (culverts and diversions).
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in Mission Creek.
- Decrease water temperatures and improve water quality by restoring riparian vegetation along the stream.
- Reduce unnatural sediment recruitment to the stream by restoring riparian habitat and improving road maintenance.
- Increase habitat diversity and quantity by restoring riparian habitat, reconnecting side channels and the floodplain with the channel, increasing large woody debris within the channel, and by adding instream structures.

Chumstick Creek Assessment Unit (Category 3; Appendix G.1):

- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers (culverts and diversions).
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in Chumstick Creek.
- Decrease water temperatures and improve water quality by restoring riparian vegetation along the stream.
- Increase habitat diversity and quantity by restoring riparian habitat, reconnecting side channels and the floodplain with the channel, increasing large woody debris within the channel, and by adding instream structures.

Long-term Actions

- Protect and maintain stream and riparian habitats within Category 1 assessment units.
- Protect, maintain, or enhance beneficial stream and riparian habitat conditions established by implementing Short-term Actions within assessment units.
- Where feasible and practical, maintain connectivity throughout the historical distribution of the species.

Administrative/Institutional Actions

- The Wenatchee Habitat Group (in cooperation with local landowners) will prioritize and coordinate the implementation of "specific" habitat actions within assessment units.
- Revision of the Okanogan and Wenatchee National Forest Plan should compliment salmon, steelhead, and bull trout recovery.
- Local governments within Chelan County will review and adopt changes to comprehensive plans and ordinances for critical areas and shoreline master programs following the rules and dates set forth by the state legislature.

- Chelan County will evaluate local programs identified in (Appendix D) through processes such as stormwater plans.
- NOAA Fisheries, U.S. Fish and Wildlife Service, and the Army Corp of Engineers will improve the permitting process for projects specific to recovery actions by reducing the time, cost, and review process requirements.
- State agencies will improve the permitting process for projects specific to recovery actions by reducing the time, cost, and review process requirements.
- Federal and state agencies will improve their review of projects with the local governments, or permitted through local governments, in a timely manner as they pertain to various aspects of species recovery.
- Federal and state agencies shall improve permitting processes by implementing programmatic consultations for actions related to the implementation of this recovery plan.

Research and Monitoring Actions

- Monitor the effectiveness of at least three replicates of each restoration class implemented in the Wenatchee subbasin.
- Monitor trends in species abundance (redds, smolts, and adults) and distribution at the population and assessment unit scale.
- Monitor fish passage at Dryden and Tumwater dams.
- Evaluate fish passage at the boulder field in Icicle Creek.
- Examine relationships between VSP parameters and habitat conditions at coarse (landscape) and fine (stream segment) scales.
- Update baseline model runs as new and better information becomes available and conduct the scenario model run for the preferred alternative (Scenario 2) in each subbasin.
- Test assumptions and sensitivities of EDT model runs.
- Conduct hydrologic assessments to understand water balance and surface/groundwater relations within the Wenatchee subbasin.
- Continue channel migration studies in the Wenatchee subbasin.
- Assess the interaction of bull trout and sockeye salmon.
- Experiment with the use of different eradication methods for removing brook trout in areas with high densities of brook trout (upper Little Wenatchee, Big Meadow Creek, Minnow Creek, Schafer Lake, etc.).
- Assess the effects of brook trout harvest on survival of listed species.
- Examine fluvial geomorphic processes within the Wenatchee subbasin.

- Assess the contribution of small Columbia River tributaries downstream from the Wenatchee subbasin (e.g., Squilchuck, Stemilt, Colockum, Tarpiscan, Tekison, Quilomene/Brushy, and Trinidad/Lynch Coulee creeks) to Wenatchee steelhead abundance and productivity.

Expected Results

Wenatchee Spring Chinook: EDT and professional judgment were used to assess the potential contribution of habitat action classes in meeting VSP criteria. EDT predicted that under Scenarios 3 (33% intensity) and 1 (100% intensity), relative spring Chinook abundance should increase about 56% and 69%, respectively (**Figure 5.1**; Appendix F). EDT estimated relative productivity increases of 8% and 12% for Scenarios 3 and 1, respectively. Although these results indicate relative improvements in abundance and productivity, implementation of habitat classes within the Wenatchee subbasin will probably not meet minimum abundance and productivity criteria. On the other hand, these action classes are expected to meet spatial structure criteria and the diversity criteria that are related to habitat conditions and distribution. In conclusion, these results indicate that (1) it is critically important to protect existing habitat in the upper watershed; (2) although relatively small benefits in abundance and productivity may be realized by improving habitat conditions in degraded assessment units downstream from Tumwater Canyon, these areas are important for spatial structure and diversity in VSP risk assessments; and (3) recovery of Wenatchee spring Chinook will require integration of habitat actions with other Hs and actions implemented outside the ESU.

Wenatchee Steelhead: EDT and professional judgment were used to assess the potential contribution of habitat action classes in meeting VSP criteria. EDT predicted that under Scenarios 3 (33% intensity) and 1 (100% intensity), relative steelhead abundance should increase about 89% and 102%, respectively (**Figure 5.2**; Appendix F). EDT estimated relative productivity increases of 14% and 16% for Scenarios 3 and 1, respectively. Although these results indicate relative improvements in abundance and productivity, implementation of habitat classes within the Wenatchee subbasin will probably not meet minimum abundance and productivity criteria. On the other hand, these action classes are expected to meet spatial structure criteria and the diversity criteria that are related to habitat conditions and distribution. These results indicate that (1) it is critically important to protect existing habitat in the upper watershed as well as mainstem Wenatchee rearing habitat; (2) although relatively small benefits in abundance and productivity may be realized by improving habitat conditions in degraded assessment units downstream from Tumwater Canyon, these areas are important for spatial structure and diversity in VSP risk assessments; and (3) recovery of Wenatchee steelhead will require integration of habitat actions with other Hs and actions implemented outside the DPS.

Entiat Populations

The Entiat subbasin supports three listed species: spring Chinook, steelhead, and bull trout. Several factors, including activities driven by government policies have reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many stream reaches in the Entiat subbasin. However, the subbasin contains headwater areas that are in relatively pristine condition and serve as “strongholds” for listed species. The following actions are intended to reduce the primary threats to aquatic and riparian habitats and to improve conditions where feasible and practical.

Short-term Protection Actions

Use administrative and institutional rules and regulations to protect and restore stream and riparian habitats on public lands within the following assessment units:

- Upper Entiat
- Middle Entiat
- Mad River

Short-term Restoration Actions

Implement the following actions throughout the entire Entiat subbasin:

- Address passage barriers.
- Address diversion screens.
- Manage fuels to represent/restore natural ecosystem profiles and implement Northwest Forest Plan and Entiat Community Wildfire Protection Plan.

Upper Entiat Assessment Unit (Category 1; Appendix G.2):

- Increase the harvest limit on brook trout.

Middle Entiat Assessment Unit (Category 1; Appendix G.2):

- Increase habitat diversity in the middle Entiat River by restoring riparian habitat and increasing large woody debris within the channel.
- Increase connectivity in Stormy Creek by replacing or improving culverts.

Mad River Assessment Unit (Category 1; Appendix G.2):

- Increase habitat diversity and quantity within the lower 4 miles of the Mad River by restoring riparian habitat, increasing large woody debris within the channel, adding instream structures (rock structures), and by improving road maintenance.

Lower Entiat Assessment Unit (Category 2; Appendix G.2):

- Increase habitat diversity and quantity in the lower Entiat by restoring riparian habitat, adding instream structures (rock “cross vane” structures or other structures), increasing large woody debris, and reconnecting side channels and the floodplain with the river.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the Entiat River.

Long-term Actions

- Protect and maintain stream and riparian habitats within Category 1 assessment units.
- Protect, maintain, or enhance beneficial stream and riparian habitat conditions established by implementing Short-term Actions within assessment units.

- Where feasible and practical, maintain connectivity throughout the historical distribution of the species.

Administrative/Institutional Actions

- The Entiat Habitat Group (in cooperation with local landowners) will prioritize and coordinate the implementation of "specific" habitat actions within assessment units.
- Revision of the Okanogan and Wenatchee National Forest Plan should compliment salmon, steelhead, and bull trout recovery.
- Local governments within Chelan County will review and adopt changes to comprehensive plans and ordinances for critical areas and shoreline master programs following the rules and dates set forth by the state legislature.
- Chelan County will evaluate local programs identified in (Appendix D) through processes such as stormwater plans.
- NOAA Fisheries, U.S. Fish and Wildlife Service, and the Army Corp of Engineers will improve the permitting process for projects specific to recovery actions by reducing the time, cost, and review process requirements.
- Federal and state agencies will improve their review of projects with the local governments, or permitted through local governments, in a timely manner as they pertain to various aspects of species recovery.
- Federal and state agencies shall improve permitting processes by implementing programmatic consultations for actions related to the implementation of this recovery plan.

Research and Monitoring Actions

- Monitor the effectiveness of at least three replicates of each restoration class implemented in the Entiat subbasin.
- Monitor trends in species abundance (redds, smolts, and adults) and distribution at the population and assessment unit scale.
- Examine relationships between VSP parameters and habitat conditions at coarse (landscape) and fine (stream segment) scales.
- Update baseline model runs as new and better information becomes available and conduct the scenario model run for the preferred alternative (Scenario 2) in each subbasin.
- Test assumptions and sensitivities of EDT model runs.
- Examine the effects of nutrient enhancement on trophic structure in the Entiat subbasin.
- Conduct additional hydrologic assessments to understand water balance and surface/groundwater relations within the Entiat subbasin.
- Continue channel migration studies in the Entiat subbasin.
- Experiment with the use of different eradication methods for removing brook trout.

- Assess the effects of brook trout harvest on survival of listed species.
- Continue to examine fluvial geomorphic processes within the Entiat subbasin.
- Continue to assess the presence or absence of bull trout in the Upper Entiat assessment unit.

Expected Results

Entiat Spring Chinook: Mobrand Biometrics (2003) modeled the effects of five different management scenarios, which included various intensities of riparian, habitat diversity, and off-channel habitat restoration actions and protection measures. Based on the most intensive management scenario (Alternative 5 in Table 7-22 in CCCD 2004), EDT predicted that the relative increase in spring Chinook abundance would be about 36%, which probably will not meet the minimum recovery abundance of 500 naturally produced spring Chinook in the Entiat subbasin. On the other hand, these action classes are expected to meet spatial structure criteria and the diversity criteria that are related to habitat conditions and distribution. These results indicate that (1) it is critically important to protect existing habitat in the upper watershed as well as mainstem Entiat rearing habitat; (2) a greater intensity of habitat actions may be needed in the Entiat subbasin, and (3) recovery of Entiat spring Chinook will require integration of habitat actions with other Hs and actions implemented outside the ESU.

Fish performance was not evaluated using scenario modeling for steelhead or bull trout in the Entiat watershed. However, considering the baseline current and historic model runs, the Entiat could not sustain an abundance of steelhead sufficient to meet VSP minimum abundance threshold under likely recovery scenarios. Future scenario modeling will be coordinated with the Entiat Watershed Group.

Methow Populations

The Methow subbasin supports three listed species: spring Chinook, steelhead, and bull trout. Several factors, including activities driven by government policies have reduced habitat diversity, connectivity, water quantity and quality, and riparian function in many stream reaches in the Methow subbasin. However, the subbasin contains headwater areas that are in relatively pristine condition and serve as “strongholds” for listed species. The following actions are intended to reduce the primary threats to aquatic and riparian habitats and to improve conditions where feasible and practical.

Short-term Protection Actions

Use administrative and institutional rules and regulations to protect and restore stream and riparian habitats on public lands within the following assessment units:

- Upper Chewuch
- Upper Twisp
- Upper Methow
- Early Winters Creek
- Lost River

- Upper Wolf

Short-term Restoration Actions

Implement the following actions throughout the entire Methow subbasin:

- Address passage barriers.
- Address diversion screens.
- Reduce the abundance and distribution of brook trout through feasible means (e.g., increased harvest).

Upper Methow/Early Winters/Lost Assessment Unit (Category 1; Appendix G.3):

- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the lower five miles of Early Winters Creek.
- Reduce sediment load by improving road maintenance along the lower portion of the upper Methow assessment unit and the lower Lost River.
- Increase habitat diversity and quantity by restoring riparian habitat and reconnecting side channels (where feasible) between Goat Creek and the Lost River.
- Increase habitat diversity by improving streambank conditions in the lower Lost River.
- Restore natural channel migration and alluvial fan forming processes on lower Early Winters Creek.

Upper Chewuch Assessment Unit (Category 1; Appendix G.3):

- Increase habitat diversity and quantity by restoring riparian habitat throughout the assessment unit.
- Reduce sediment load by improving road maintenance along the upper Chewuch River.

Upper Twisp Assessment Unit (Category 1; Appendix G.3):

- Increase habitat diversity and quantity in the upper Twisp by restoring riparian habitat and floodplain connectivity.
- Reduce sediment load by improving road maintenance throughout the assessment unit.

Lower Chewuch Assessment Unit (Category 2; Appendix G.3):

- Increase habitat diversity and quantity in the lower Chewuch River between river miles 0 and 8 by restoring riparian habitat, reconnecting side channels and the floodplain, and adding instream structures.
- Reduce sediment load by improving road maintenance along the lower Chewuch River (actions in the upper Chewuch should also reduce sediment recruitment in the lower Chewuch).

- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the Chewuch River.
- Decrease water temperatures in the lower Chewuch River by increasing riparian vegetation, increasing stream flows, and reconnecting side channels and the floodplain with the river.

Lower Twisp Assessment Unit (Category 2; Appendix G.3):

- Increase habitat diversity and quantity in the lower Twisp River by restoring riparian habitat, reconnecting side channels and the floodplain (where feasible), and adding instream structures within the river.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the Twisp River.
- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers (culverts and diversions).

Upper-Middle Methow Assessment Unit (Category 2; Appendix G.3):

- Increase habitat diversity and quantity in the upper-middle Methow by restoring riparian habitat and reconnecting side channels and the floodplain (where feasible).
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the Methow River (addressed primarily through actions in upstream locations).

Middle Methow Assessment Unit (Category 2; Appendix G.3):

- Increase habitat diversity and quantity in the middle Methow by restoring riparian habitat, reconnecting side channels and the floodplain (where feasible), and adding instream structures (low priority action) within the river.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the Methow River.

Lower Methow Assessment Unit (Category 2; Appendix G.3):

- Increase habitat diversity and quantity in the Methow River upstream from the town of Carlton by restoring riparian habitat and reconnecting the floodplain with the river.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the Methow River (addressed primarily through actions in upstream locations).

Wolf/Hancock Creek Assessment Unit (Category 2; Appendix G.3):

- Increase habitat diversity and quantity by restoring riparian habitat, reconnecting side channels and floodplains (where feasible), and adding large woody debris and instream structures between river mile 1 and the spring in Hancock Creek.

Beaver/Bear Creek Assessment Unit (Category 3; Appendix G.3):

- Increase habitat diversity and quantity by restoring riparian habitat, reconnecting side channels and floodplains (where feasible), and adding large woody debris and instream structures within the upper Beaver Creek and Bear Creek watersheds.
- Reduce sediment load by improving road maintenance along Beaver Creek.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the streams.
- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing diversions in the lower 8 miles of Beaver Creek and culverts upstream from river mile 8 on Beaver Creek.

Gold/Libby Creek Assessment Unit (Category 3; Appendix G.3):

- Increase habitat diversity and quantity by restoring riparian habitat, reconnecting side channels and floodplains (where feasible), and adding large woody debris and instream structures within the streams.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the streams.
- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers (culverts and diversions).

Goat/Little Boulder Creek Assessment Unit (Category 3; Appendix G.3):

- Increase habitat diversity and quantity in Goat Creek by restoring riparian habitat (river mile 0 to Vanderpool Crossing), reconnecting side channels and floodplains (where feasible), and adding large woody debris and instream structures between river mile 1.5 and Vanderpool Crossing.
- Reduce sediment load by improving road maintenance along Goat Creek downstream from Vanderpool Crossing.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in the streams.
- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers (Highway 20 culvert).

Black Canyon/Squaw Creek Assessment Unit (Category 3; Appendix G.3):

- Increase habitat diversity and quantity by restoring riparian habitat, reconnecting side channels and floodplains (where feasible), and adding large woody debris and instream structures within the streams.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) in Black Canyon and Squaw Creek.
- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers (culverts and diversions).

Long-term Actions

- Protect and maintain stream and riparian habitats within Category 1 assessment units.
- Protect, maintain, or enhance beneficial stream and riparian habitat conditions established by implementing Short-term Actions within assessment units.
- Where feasible and practical, maintain connectivity throughout the historical distribution of the species.

Administrative/Institutional Actions

- The Methow Habitat Group (in cooperation with local landowners) will prioritize and coordinate the implementation of "specific" habitat actions within assessment units.
- Revision of the Okanogan and Wenatchee National Forest Plan should compliment salmon, steelhead, and bull trout recovery.
- Local governments within Okanogan County will review and adopt changes to comprehensive plans and ordinances for critical areas and shoreline master programs following the rules and dates set forth by the state legislature.
- Okanogan County will evaluate local programs identified in (Appendix D) through processes such as stormwater plans.
- NOAA Fisheries, U.S. Fish and Wildlife Service, and the Army Corp of Engineers will improve the permitting process for projects specific to recovery actions by reducing the time, cost, and review process requirements.
- Federal and state agencies will improve their review of projects with the local governments, or permitted through local governments, in a timely manner as they pertain to various aspects of species recovery.
- Federal and state agencies shall improve permitting processes by implementing programmatic consultations for actions related to the implementation of this recovery plan.

Research and Monitoring Actions

- Monitor the effectiveness of at least three replicates of each restoration class implemented in the Methow subbasin.
- Monitor trends in species abundance (redds, smolts, and adults) and distribution at the population and assessment unit scale.
- Examine relationships between VSP parameters and habitat conditions at coarse (landscape) and fine (stream segment) scales.
- Update baseline model runs as new and better information becomes available and conduct the scenario model run for the preferred alternative (Scenario 2) in each subbasin.
- Test assumptions and sensitivities of EDT model runs.

- Conduct additional hydrologic assessments to understand water balance and surface/groundwater relations within the Methow subbasin.
- Conduct channel migration studies in the Methow subbasin.
- Assess the effects of brook trout harvest on survival of listed species.
- Examine fluvial geomorphic processes within the Methow subbasin.
- Assess the contribution of the Chelan River to Methow steelhead abundance and productivity.

Expected Results

Methow Spring Chinook: EDT and professional judgment were used to assess the potential contribution of habitat action classes in meeting VSP criteria. EDT predicted that under Scenarios 3 (33% intensity) and 1 (100% intensity), relative spring Chinook abundance should increase about 54% and 124%, respectively (**Figure 5.3**; Appendix F). EDT estimated relative productivity increases of 17% and 53% for Scenarios 3 and 1, respectively. Although these results indicate relative improvements in abundance and productivity, implementation of habitat classes within the Methow subbasin will probably not meet minimum abundance and productivity criteria. On the other hand, these action classes are expected to meet spatial structure criteria and the diversity criteria that are related to habitat conditions and distribution. In conclusion, these results indicate that (1) it is critically important to protect existing habitat in the upper watershed; (2) relatively large improvements can be realized by restoring and protecting habitat in the Methow subbasin; and (3) recovery of Methow spring Chinook will require integration of habitat actions with other Hs and actions implemented outside the ESU.

Methow Steelhead: EDT and professional judgment were used to assess the potential contribution of habitat action classes in meeting VSP criteria. EDT predicted that under Scenarios 3 (33% intensity) and 1 (100% intensity), relative steelhead abundance should increase about 65% and 136%, respectively (**Figure 5.4**; Appendix F). EDT estimated relative productivity increases of 17% and 48% for Scenarios 3 and 1, respectively. Although these results indicate relative improvements in abundance and productivity, implementation of habitat classes within the Methow subbasin will probably not meet minimum abundance and productivity criteria. On the other hand, these action classes are expected to meet spatial structure criteria and the diversity criteria that are related to habitat conditions and distribution. Therefore, these results indicate that (1) it is critically important to protect existing habitat in the upper watershed; (2) relatively large improvements can be realized by restoring and protecting habitat in the Methow subbasin; and (3) recovery of Methow steelhead will require integration of habitat actions with other Hs and actions implemented outside the DPS.

Okanogan Population

The Okanogan subbasin currently supports only one listed species, steelhead. The presence of bull trout remains unknown in the Okanogan subbasin. Several factors, including activities driven by government policies have reduced habitat diversity and quantity, connectivity, water quantity and quality, and riparian function in many stream reaches in the Okanogan subbasin. The following actions are intended to reduce the primary threats to aquatic and riparian habitats and to improve conditions where feasible and practical within the U.S. portion of the Okanogan subbasin.

Short-term Protection Actions

Use administrative and institutional rules and regulations to protect and restore stream and riparian habitats on public lands within the following assessment units:

- Upper Omak

Short-term Restoration Actions

Implement the following actions throughout the U.S. portion of the Okanogan subbasin:

- Address passage barriers.
- Address diversion screens.
- Increase harvest on exotic species (e.g., bass, walleye, etc.).

Lower Okanogan Assessment Unit (Category 2; Appendix G.4):

- Increase habitat diversity and quantity by restoring riparian habitat (throughout the assessment unit) and reconnecting side channels and the floodplain (near the confluence of Salmon Creek).
- Improve fish passage by screening irrigation diversions.
- Reduce summer water temperature in the lower Okanogan River by implementing actions in tributaries and upstream assessment units.

Middle Okanogan Assessment Unit (Category 2; Appendix G.4):

- Reduce summer water temperature and sediment recruitment in the middle Okanogan River by reconnecting side channels and the floodplain with the river.

Upper Okanogan Assessment Unit (Category 2; Appendix G.4):

- Increase habitat diversity and quantity by restoring riparian habitat along the river.
- Reduce summer water temperature and sediment recruitment in the upper Okanogan River by reconnecting side channels and the floodplain with the river.

Omak and Tributaries Assessment Unit (Category 2; Appendix G.4):

- Increase habitat diversity and quantity by restoring riparian habitat and adding large woody debris and instream structures within the streams.
- Reduce sediment load by improving road maintenance along Omak Creek (especially the upper watershed).
- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers (culverts and diversions).

Lower Salmon Creek Assessment Unit (Category 3; Appendix G.4):

- Use practical and feasible means (including reconnection of side channels and the floodplain with the stream) to increase stream flows (within the natural hydrologic regime and existing water rights) within the lower 4 miles of Salmon Creek.
- Improve fish passage throughout lower Salmon Creek downstream from Conconully Dam.
- Increase habitat diversity by channel reconfiguration in the lower 4 miles of Salmon Creek.

Similkameen Assessment Unit (Category 3; Appendix G.4):

- Improve water quality (heavy metals) and sediment recruitment by removing effects of mining activities upstream from Enloe Dam.

Loup Loup Creek Assessment Unit (Category 4; Appendix G.4):

- Increase habitat diversity and quantity by restoring riparian habitat and adding large woody debris and instream structures within the stream.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) within Loup Loup Creek.
- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers (culverts and diversions).

Small Tributary Systems Assessment Unit (Category 4; Appendix G.4):

- Increase habitat diversity and quantity by restoring riparian habitat and adding large woody debris and instream structures within Bonaparte (to natural barriers), Tunk (to natural barriers), and Ninemile creeks.
- Re-establish connectivity throughout the assessment unit by removing, replacing, or fixing artificial barriers (culverts and diversions).
- Reduce sediment recruitment by improving roads particularly along Bonaparte Creek.
- Use practical and feasible means to increase stream flows (within the natural hydrologic regime and existing water rights) within tributaries.
- Work closely with Canadian biologists and managers to restore habitat conditions and increase connectivity in the Okanogan subbasin within Canada.

Long-term Actions

- Protect, maintain, or enhance beneficial stream and riparian habitat conditions established by implementing Short-term Actions within assessment units.
- Where feasible and practical, maintain connectivity throughout the historical distribution of the species.
- Work closely with Canadian managers and biologist to restore habitat conditions in the upper Okanogan subbasin.

Administrative/Institutional Actions

- The Okanogan Habitat Group (in cooperation with local landowners) will prioritize and coordinate the implementation of "specific" habitat actions within assessment units.
- Revision of the Okanogan and Wenatchee National Forest Plan should compliment salmon, steelhead, and bull trout recovery.
- Local governments within Okanogan County will review and adopt changes to comprehensive plans and ordinances for critical areas and shoreline master programs following the rules and dates set forth by the state legislature.
- Okanogan County will evaluate local programs identified in (Appendix D) through processes such as stormwater plans.
- NOAA Fisheries, U.S. Fish and Wildlife Service, and the Army Corp of Engineers will improve the permitting process for projects specific to recovery actions by reducing the time, cost, and review process requirements.
- Federal and state agencies will improve their review of projects with the local governments, or permitted through local governments, in a timely manner as they pertain to various aspects of species recovery.
- Federal and state agencies shall improve permitting processes by implementing programmatic consultations for actions related to the implementation of this recovery plan.

Research and Monitoring Actions

- Monitor the effectiveness of at least three replicates of each restoration class implemented in the Entiat subbasin.
- Monitor trends in species abundance (redds, smolts, and adults) and distribution at the population and assessment unit scale.
- Examine relationships between VSP parameters and habitat conditions at coarse (landscape) and fine (stream segment) scales.
- Investigate the effects of nutrient enrichment from development along Lake Osoyoos on fish community structure.
- Update baseline model runs as new and better information becomes available and conduct the scenario model run for the preferred alternative (Scenario 2) in each subbasin.
- Test assumptions and sensitivities of EDT model runs.
- Assess the abundance and consumption rates of exotic fish that feed on steelhead.
- Examine the feasibility of providing passage throughout upper Salmon Creek.
- Conduct hydrologic assessments to understand water balance and surface/groundwater relations within the Okanogan subbasin.
- Conduct channel migration studies in the Okanogan subbasin.

- Examine fluvial geomorphic processes within the Okanogan subbasin.
- Assess the presence or absence of bull trout in the Okanogan subbasin.
- Assess the contribution of Foster Creek to Okanogan steelhead abundance and productivity.

Expected Results

Okanogan Steelhead: EDT and professional judgment were used to assess the potential contribution of habitat action classes in meeting VSP criteria. EDT predicted that under Scenarios 3 (33% intensity) and 1 (100% intensity), relative steelhead abundance should increase about 281% and 377%, respectively (**Figure 5.5**; Appendix F). EDT estimated relative productivity increases of 49% and 66% for Scenarios 3 and 1, respectively. Although these results indicate relative improvements in abundance and productivity, implementation of habitat classes within the Okanogan subbasin will probably not meet minimum abundance and productivity criteria. On the other hand, these action classes are expected to meet spatial structure criteria and the diversity criteria that are related to habitat conditions and distribution. In conclusion, these results indicate that (1) relatively large improvements can be realized by restoring and protecting habitat in the U.S. portion of the Okanogan subbasin and (2) recovery of Okanogan steelhead will require integration of habitat actions with other Hs and actions implemented outside the DPS.

Crab Creek Population

The Crab Creek subbasin currently supports only one listed species, steelhead. As noted in Section 1.3.6, this plan does not specifically address recovery of the Crab Creek population. Recovery of the Upper Columbia steelhead DPS can be achieved without recovery of the Crab Creek population.

5.5.6 Responsible Parties

Membership within the Implementation Team will include tribes, local landowners, federal, state, local governments, and conservation districts responsible for implementing and monitoring habitat actions in the Upper Columbia Basin.

5.5.7 Coordination and Commitments

This plan assumes an Implementation Team will engage in discussions associated with habitat actions. This Team will be involved in all issues related to recovery actions, and will work within the framework of the Upper Columbia Salmon Recovery Board (UCSRB), HCPs for Chelan and Douglas PUDs, Grant PUD BiOp and Anadromous Fish Agreement, Section 7 consultations, and federal trust responsibilities to the tribes.

The Upper Columbia Basin already has a habitat technical team, known as the Upper Columbia Regional Technical Team (UCRTT) that was created by the UCSRB to recommend region-wide approaches to protect and restore salmonid habitat; develop and evaluate salmonid recovery projects; and develop, guide, and coordinate recovery monitoring plans. This plan recommends that the UCRTT serve as the habitat technical committee to the Implementation Team.

Local habitat groups will be responsible for identifying specific habitat restoration actions and coordinating activities within their respective subbasins. This plan recommends that these groups prioritize the implementation of specific actions following the strategy outlined in Section 8.0. All proposed habitat recovery actions will be coordinated with local stakeholder input and local stakeholders will be included in the development of any of the planning processes that may affect their interests. If necessary, the UCRTT could provide technical guidance and review to the local recovery groups.

The State of Washington (through the Salmon Recovery Funding Board), PUDs, Action Agencies (Bonneville Power Administration, Bureau of Reclamation, and Army Corps of Engineers), the Yakama Nation, the Colville Tribes, and various other Federal, State, and local agencies are funding and will continue to fund habitat actions in the Upper Columbia Basin. Habitat conservation plans, binding mitigation agreements, and biological opinions increase the likelihood that habitat restoration actions have funding and will continue operating into the future.

5.5.8 Compliance

Habitat actions are currently monitored through processes like the Upper Columbia Monitoring Strategy (Hillman 2004), Salmon Recovery Board, biological opinions, relicensing agreements, BPA and BOR programs, Colville Tribes monitoring program, U.S. Forest Service programs, DOE programs, and others. Under the guidance of the Upper Columbia Monitoring Strategy, adopted by the Upper Columbia Salmon Recovery Board, the UCRTT coordinates monitoring within the Upper Columbia Basin. This plan will rely on the Upper Columbia Monitoring Strategy (which is continually updated to incorporate new information) and the UCRTT to make sure that habitat recovery actions are implemented correctly, habitat actions are monitored for effectiveness,[131] and VSP parameters are measured and tracked over time to assess recovery of populations, the ESU, and the DPS.

5.6 Integration of Actions

At this time it is very difficult to assess the cumulative (sum) beneficial effects of actions across all sectors (Hs), because regionally accepted tools for adding effects across sectors are currently not available. Two investigational methods were used to estimate potential effects in this plan; a simple multiplicative approach and a modeling approach. Both approaches will be more fully developed in the future. These preliminary approaches and their results are described below. In this section the plan only addressed spring Chinook and steelhead. Methods used to assess cumulative beneficial effects on bull trout will be explored at a later date.

5.6.1 Multiplicative Approach

This approach used information from Sections 2, 3, and 5 to determine if the actions recommended within the plan are likely to achieve recovery. The simulation also used additional information and assumptions (which are outlined below) to evaluate the actions that have either been recently enacted, or recommended within the recovery plan. Below, we outline by sector the associated assumptions and information that were used to estimate the increase in productivity (survival).

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[131] The Upper Columbia Strategy does not require that all habitat actions be assessed for effectiveness. Rather, a random subset of actions from each habitat class will be monitored for effectiveness.

For all sectors, a 50% hatchery effectiveness (reproductive success) rate was assumed for steelhead. As such, the values for productivity reported here for steelhead differ from those reported in Section 2. [132] The run was reconstructed using 50% of the hatchery fish included with naturally produced fish to determine productivity values. The exercise calculated for all sectors a low and high potential increase in productivity. The lower and upper estimates were determined by modeling (e.g., EDT for habitat) or professional judgment. A more detailed discussion of this approach and preliminary results provided in Appendix I.

Harvest

As discussed in detail in Section 5.2 and in the Harvest Module (Appendix I), harvest on Upper Columbia steelhead and spring Chinook has been significantly reduced over the last several decades. As a result, there is little opportunity to reduce harvest rates beyond their current limits. The recovery actions identified in this Plan may result in a small reduction in harvest through improved management strategies, harvest methods, and marking techniques. Therefore, for the purposes of this exercise, the plan assumed a range of change in potential productivity from 0% (lower potential) to 1% (upper potential) (**Table 5.11**).

The plan also estimated potential survival benefits associated with terminating all harvest on spring Chinook and steelhead. The results indicated a potential increase of 9-10% in productivity of spring Chinook, but steelhead productivity actually decreased. The reason is because a large number of hatchery produced steelhead would escape to spawning grounds and “swamp” the spawning population. Hatchery produced steelhead currently have a lower reproductive success than naturally produced fish (the plan optimistically assumed a reproductive success of 0.5 for hatchery steelhead) and therefore would drive the productivity of the population down to low levels. Harvest on hatchery produced steelhead means fewer hatchery fish escape to spawning grounds. This results in a greater percentage of the spawning escapement consisting of naturally produced fish that are more productive than hatchery steelhead.

Hatcheries

The theoretical difference between the productivities for steelhead estimated in Section 2 was used to determine hatchery changes that contribute to productivity. The historical steelhead run was reconstructed using two different reproductive success scenarios for hatchery spawners: (1) hatchery spawners were as effective as wild spawners (100%; H = 1) and (2) hatchery spawners did not contribute to returning spawners at all (0%; H = 0).

In the Wenatchee and Entiat rivers[133], there is a 63% difference between zero contribution of hatchery spawners (return per spawner is 0.81) and 100% effectiveness (return per spawner is 0.25). In the Methow and Okanogan rivers the difference is 89% (0.89 if H = 0 and 0.09 for H = 1). Because no data currently exist in the Upper Columbia[134] to determine true hatchery spawner

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[132] Recall that in Section 2 steelhead productivity was estimated using hatchery effectiveness rates of 0% and 100%.

[133] Wenatchee-Entiat, and Methow-Okanogan returns per spawner cannot be separated because the base population (dam counts) is the same (see Appendix C for further details).

[134] There is currently a study underway to estimate spring Chinook hatchery spawner effectiveness in the Wenatchee River, and Chelan and Douglas PUDs will be determining the same for steelhead through their HCP hatchery M&E programs.

effectiveness, it was assumed in this exercise that hatchery spawners are half (50%; H = 0.5) as effective as naturally produced spawners for both steelhead and spring Chinook. It was also assumed that the relationship between 100% hatchery spawner effectiveness and 0% hatchery spawner effectiveness for steelhead applies to spring Chinook within the Wenatchee, Entiat, and Methow rivers.

In the absence of empirical data, improvements in hatchery practices may result in a 3-5% survival increase in naturally produced spring Chinook and steelhead in the Wenatchee-Entiat populations, and a 5-10% increase in the Methow-Okanogan populations (**Table 5.11**). The greater increase in the Methow-Okanogan populations reflects the recommended action of collecting local broodstock within tributaries rather than composite fish at Wells Dam. These survival changes also appear to be supported by AHA modeling results (see Appendix J).

Hydro Projects

The calculated increases in juvenile survival from the draft QAR (Cooney et al. 2000) were applied to the calculated geo-mean of returns per spawner from Section 2 for spring Chinook and steelhead. This was applied basin-specific, where applicable. The estimated increase in juvenile survival from Table 24 in Cooney et al. (2000) was used for all five PUD dams, and their estimated increase in juvenile survival in the lower Columbia River from McNary to downstream from Bonneville dam (14.5% improvement; Table 27 in Cooney et al. 2000, plus an additional improvement of 8% and 9% for steelhead and spring Chinook, respectively, based on long-term gains in the FCRPS) was also applied to the estimated increases from the HCPs on local hydro dams. This exercise assumed 1:1 increase in spawners from an increase in juvenile survival from the proposed actions (i.e., a 10% increase in juvenile survival resulted in a 10% increase in spawners). Based on this information, productivity could increase between 35-51% for spring Chinook populations and 30-40% for steelhead populations (**Table 5.11**). These estimates were used for both low and high productivity potentials.

Habitat

EDT results for the Wenatchee, Entiat[135], Methow, and Okanogan were used to determine what percent increase in productivity could be expected from implementing habitat actions recommended in the Plan. Density-independent survival changes as smolts per spawner were estimated across a range of spawner abundances less than 2,000 spawners, the minimum recovery abundance for large populations established by the ICBTRT. Because the extent to which the proposed habitat actions would be implemented was unknown, EDT modeled two different scenarios: (1) implementation intensity of 33% and (2) implementation intensity of 100% (See Appendix F). This provided a potential range of effects from recommended habitat actions. <u>**It is important to note that full intensity (100%) in all assessment units is not feasible or practical, because it does not consider socioeconomic factors.**</u> <u>**This scenario is useful for planning purposes because it provides an upper bound on the relative benefits of**</u>

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[135] In the Entiat, a different model run was used. Since the Entiat Watershed Plan has run EDT for various scenarios, we used their Scenario 5, as described in the Watershed Plan, and compared it to the "33%" run from the other subbasins. The Entiat Watershed Plan did not model steelhead and there has been no attempt to model steelhead in the Entiat.

<u>implementing habitat restoration actions at maximum effort (full intensity) within each subbasin.</u>

Under the 33% intensity scenario (lower potential), productivity of spring Chinook populations could increase 3-25% (**Table 5.11**). Under 100% intensity (upper potential), productivity of spring Chinook populations could increase 3-36% (**Table 5.11**). Productivity of Upper Columbia steelhead populations under the 33% scenario could increase 14-47%, while steelhead productivities under the 100% scenario could increase 31-64% (**Table 5.11**). Note that there is no estimate for Entiat steelhead because there was no EDT analysis completed for this population.

Integration across Sectors

To determine the total change in survival for each population, the changes in productivity (calculated as the ratio of proposed productivity to current productivity within a sector) were multiplied across sectors to estimate the total survival multiplier from the proposed actions. For Upper Columbia spring Chinook populations, survival could increase 99-137% under the lower potential productivity scenario to 107-198% under the higher potential productivity scenario (**Table 5.11**). Survival for steelhead populations could increase 85-178% under the low productivity scenario to 90-226% under the higher productivity scenario (**Table 5.11**).

5.6.2 Modeling Approach

All H Analyzer

The "All H Analyzer" (AHA), as used in this plan, describes the integration of in-basin and out-of-basin effects on salmon and steelhead. The analysis explains contributions of harvest, hatcheries, hydropower[136], and habitat data and strategies to recovery. The AHA process is an exercise that investigates (simulates) out-of-subbasin effects within the context of tributary habitat improvements.

AHA, as used in this planning exercise, simulates various recovery actions between in-basin and out-of-basin effects. This approach gives planners a means for evaluating various options. The different options include harvest regimes, modifications to existing hatchery programs, and habitat improvement actions. Listed below are preliminary results of the AHA analyses. These results provide only a relative assessment of the cumulative effects of actions among different sectors (Appendix J). SARs were held constant in all simulations.

Preliminary Results

Wenatchee spring Chinook

- Preliminary results of AHA analysis suggest that the hatchery environment may have a large effect on the fitness of naturally produced Chinook.

[136] Hydropower effects in the AHA model are captured in SARs, which include factors in addition to just hydropower effects (see Section 3.9).

- A higher level of integration may be possible under the present condition scenario by reducing the number of hatchery produced Chinook on the spawning grounds through removal at collection points or selective harvest.
- Scenario 3 habitat improvements may lead to a larger number of naturally produced returns. Additional returns of naturally produced fish may be realized if habitat improvements are coupled with removal of some hatchery produced Chinook.
- Scenario 1 habitat improvements may not have a large effect on the integration rate unless the number of hatchery produced Chinook are further reduced on spawning grounds.

Wenatchee steelhead

- Preliminary results of AHA analysis suggest that the hatchery environment may have a large effect on the fitness of naturally produced steelhead.
- A higher level of integration may be possible by reducing the number of hatchery produced steelhead on the spawning grounds through either removal at collection points or selective harvest.
- Scenario 1 habitat improvements (and their effect on the number of naturally produced fish) will probably increase returns of naturally produced fish.
- Scenario 3 habitat improvements may lead to a larger number of naturally produced returns. Additional returns could be realized if habitat improvements are combined with removal of some hatchery-produced steelhead.

Entiat spring Chinook

No AHA analysis was run on Entiat spring Chinook. This work will be conducted by the local watershed group and USFWS.

Entiat steelhead

No AHA analysis was run on Entiat steelhead. This work will be conducted by the local watershed group.

Methow spring Chinook

- Preliminary results of AHA analysis suggest that the hatchery environment may have a large effect on the fitness of naturally produced Chinook.
- A higher level of integration may be possible by reducing the number of hatchery produced Chinook on the spawning grounds through either removal at collection points or selective harvest.
- Scenario 3 habitat improvements may lead to a larger number of naturally produced returns. Additional returns could be realized if habitat improvements are combined with removal of some hatchery produced Chinook.
- Scenario 1 habitat improvements will probably increase returns of naturally produced Chinook to spawning grounds.

Methow steelhead

- Preliminary results of AHA analysis suggest that the hatchery environment may have a large effect on the fitness of naturally produced steelhead.
- A higher level of integration may be possible by reducing the number of hatchery produced steelhead on the spawning grounds through either removal at collection points or selective harvest.
- Scenario 3 habitat improvements may lead to a larger number of naturally produced returns. Additional returns could be realized if habitat improvements are combined with removal of some hatchery-produced steelhead.
- Scenario 1 habitat improvements may increase returns of naturally produced steelhead to spawning grounds.

Okanogan steelhead

- Poor productivity of the natural environment currently prevents many naturally produced steelhead from being present in the Okanogan subbasin.
- Preliminary results of AHA analysis revealed that the hatchery environment may have a large effect on the fitness of naturally produced steelhead. Potential habitat improvements should increased survival for both naturally and hatchery produced returns and thus supports the transition to an integrated program.
- Under present conditions, additional naturally produced steelhead are incorporated as broodstock, which improves integration rate. A higher level of integration may be possible by reducing the number of hatchery produced steelhead on the spawning grounds through either removal at collection points or selective harvest.
- Scenario 3 habitat improvements may lead to a larger number of naturally produced returns. Additional returns could be realized if habitat improvements are combined with removal of some hatchery-produced steelhead.
- Scenario 1 habitat improvements may allow for 100% use of naturally produced steelhead for hatchery broodstock and increase returns of naturally produced steelhead.

5.6.3 Conclusion

Both approaches suggest that the recovery actions recommended in this plan should significantly improve the survival of naturally produced spring Chinook and steelhead in the Upper Columbia Basin. In addition, recommended actions within the habitat sector should improve the spatial structure and habitat quality within major spawning areas, allowing the populations to meet spatial structure requirements. Implementing actions recommended within the hatchery sector should remove the threats associated with diversity and likely lead to a diversity status that would meet the requirements of a VSP.

It is important to note that the integration analysis did not consider potential improvements in the estuary that may improve the survival of Upper Columbia populations. Actions that reduce toxics and predation in the estuary may translate into a relatively large survival benefit for Upper

Columbia populations. These issues notwithstanding, it is highly probable that the combined actions within all sectors, including actions within the lower Columbia River and estuary, will move Upper Columbia populations to a more viable state. The monitoring and adaptive management program outlined in Section 8 will be used to demonstrate progress toward recovery of Upper Columbia ESU and DPS.

Table 5.1 Naturally produced Upper Columbia Steelhead run-size criteria and mortality take-limit for recreational harvest fisheries in the Wenatchee River, Methow River, and Okanogan Basin spawning areas. Catch-and-release mortality is assumed to be 5%. From NMFS (2003).

Tier	Priest Rapids count	Estimated escapement to tributary area	Mortality impact (%)
Wenatchee River and Columbia River between Rock Island and Rocky Reach dams			
	<837	<599	0
Tier 1	838	600	2
Tier 2	2,146	1,700	4
Tier 3	3,098	2,500	6
Methow River and Columbia River upstream from Wells Dam			
	<908	<499	0
Tier 1	804	500	2
Tier 2	2,224	1,600	4
Tier 3	3,386	2,500	6
Okanogan Basin upstream of Highway 97 Bridge			
	<175	<119	0
Tier 1	176	120	5
Tier 2	180	120	7
Tier 3	795	600	10

Table 5.2 Artificial propagation programs in the Upper Columbia Basin in 2005 listed by release basin, primary hatchery facility association, program operators, and funding source

Program	Primary Facility	Operator(s)	Funding Source(s)
Wenatchee River Basin Releases			
Chiwawa spring Chinook	Eastbank Hatchery	WDFW	CPUD
White River spring Chinook	WDFW, USFWS, and private	WDFW	GPUD
Carson spring Chinook	Leavenworth NFH	USFWS	BOR
Wenatchee coho	USFWS facilities	YN/USFWS	BPA
Wenatchee sockeye	Eastbank Hatchery	WDFW	CPUD
Wenatchee steelhead	Eastbank Hatchery	WDFW	CPUD
Wenatchee summer Chinook	Eastbank Hatchery	WDFW	CPUD
Entiat River Basin Releases			
Carson spring Chinook	Entiat NFH	USFWS	BOR
Methow River Basin Releases			
Chewuch spring Chinook	Methow Hatchery	WDFW	DPUD/CPUD/GPUD
Methow Composite spring Chinook	Methow Hatchery	WDFW	DPUD/CPUD/GPUD
Methow summer Chinook	Eastbank Hatchery	WDFW	CPUD
Methow/Okanogan coho	USFWS facilities	YN/USFWS	BPA
Twisp spring Chinook	Methow Hatchery	WDFW	DPUD/CPUD/GPUD
Wells steelhead	Wells Hatchery	WDFW	DPUD
Methow Composite spring Chinook	Winthrop NFH	USFWS	BOR
Methow summer Chinook steelhead	Winthrop NFH	USFWS	BOR
Okanogan River Basin Releases			
Colville Tribes Okanogan steelhead	Colville Tribes Hatchery	Colville Tribes	BPA
Carson spring Chinook	Leavenworth Complex	USFWS	BOR
Okanogan summer Chinook	Eastbank Hatchery	WDFW	CPUD
Wells steelhead	Wells Hatchery	WDFW	DPUD
Columbia River Releases			
Turtle Rock summer Chinook subyearlings	Eastbank Hatchery	WDFW	CPUD
Turtle Rock summer Chinook yearlings	Eastbank Hatchery	WDFW	CPUD
Wells summer Chinook subyearlings	Wells Hatchery	WDFW	DPUD
Wells summer Chinook yearlings	Wells Hatchery	WDFW	DPUD

Table 5.3 Summary of artificial anadromous fish production in the Wenatchee subbasin

Fish Species	Facility	Funding Source	ESA Listed	Current production level goals
Spring Chinook	Eastbank Fish Hatchery Complex (Chiwawa acclimation pond) (Operated by WDFW)	Chelan County PUD	Yes	672,000 (will decrease in future)
	Leavenworth National Fish Hatchery (Operated by USFWS)	Bureau of Reclamation	No	1,625,000
	Captive brood program in Manchester and Willard (Operated by Aquaseed; may expand to facility in White River Basin; and USFWS)	Grant PUD	Yes	200,000 [This obligation may be partially met by other means in the future, current production much lower (< 50,000)]
	TBD – Nason Cr. release	Grant PUD	Yes	up to 400,000 (future production)
Steelhead	Eastbank Fish Hatchery Complex (Operated by WDFW)	Chelan PUD	Yes	400,000 (will decrease in future)
Summer Chinook	Eastbank Fish Hatchery Complex (Dryden acclimation pond) (Operated by WDFW)	Chelan PUD	No	864,000 (will decrease in future)
Sockeye	Eastbank Hatchery (Lake Wenatchee net pens; Operated by WDFW)	Chelan PUD	No	200,000 (will increase up to 280,000 in future)
Coho	Leavenworth NFH (Operated by USFWS for YN)	BPA (Fish & Wildlife Program)	No	> 500,000
	Acclimation sites at Nason Creek and Icicle Creek (YN)	BPA (Fish & Wildlife Program)	No	< 500,000

Table 5.4 Summary of artificial anadromous fish production in the Entiat subbasin

Fish Species	Facility	Funding Source	ESA Listed	Production level goals
Spring Chinook	Entiat NFH (Operated by USFWS)	Bureau of Reclamation	No	400,000

Table 5.5 Summary of artificial anadromous fish production in the Methow subbasin

Fish Species	Facility	Funding Source	ESA Listed	Production level goals
Spring Chinook	Methow Fish Hatchery Acclimation sites at the Methow, Biddle, Twisp, and Chewuch Acclimation ponds (Operated by WDFW)	Douglas PUD, Chelan PUD, and Grant PUD	Yes	550,000[137]
	Winthrop NFH (Operated by USFWS)	Bureau of Reclamation	Yes	600,000
Steelhead	Wells Dam Hatchery Complex (Operated by WDFW)	Douglas County PUD and Grant County PUD	Yes	349,000[138]
	Winthrop NFH (Operated by USFWS)	Bureau of Reclamation	Yes	100,000
Summer Chinook	Wells Dam Hatchery Complex (Carlton acclimation pond) (Operated by WDFW)	Chelan County PUD, Douglas County PUD	No	400,000[139]
Coho	Winthrop NFH (Operated by USFWS for YN)	BPA (Fish & Wildlife Program)	No	250,000

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[137] Currently, 61,000 of these spring Chinook are for DPUD mitigation, 288,000 for CPUD, and 201,000 are for GPUD. In the future, the CPUD and GPUD proportion will most likely change, but the total may not, although it could be increased to over 700,000 with facility modifications.

[138] 100,000 of these fish are for GPUD.

[139] 109,000 of these fish are for DPUD mitigation and the rest are for CPUD mitigation. In the future (no later than 2013), CPUD mitigation numbers may be reduced.

Table 5.6 Broodstock collection guidelines of the Methow Basin spring Chinook supplementation plan (ESA Section 7 Draft Biological Opinion, Section 10 Permit 1196)

Wells Escapement Projection	Broodstock Collection Objective
<668	WDFW may collect 100% of Wells Dam escapement; place all fish into the adult-based supplementation program.
>668 but <964	Pass a minimum of 296 adults upstream of Wells Dam for natural spawning.
>964	Collection at levels to meet interim production level of 550,000 and 600,000 smolts at Methow Fish Hatchery and Winthrop NFH, respectively.

Table 5.7 Current artificial anadromous fish production in the Okanogan subbasin

Fish Species	Facility	Funding Source	ESA Listed	Production level goals
Spring Chinook	Omak Creek, Ellisford Pond (operated by Colville Tribes (CCT))	BPA, CCT	No	30,000-150,000 (current production is dependent on availability of Carson-stock eggs)
Steelhead	Wells hatchery, Omak Cr. (operated by CCT)	DPUD	Yes	100,000
Summer Chinook	Similkameen rearing pond (operated by WDFW)	Chelan PUD	No	576,000 (will decrease in future)
Sockeye	none	Douglas PUD	No	To compensate for loss of smolts for the operation of Wells Dam, DPUD has funded a cooperative water flow effort in the Okanogan River upstream from Lake Osoyoos, which has increased survival of incubating and downstream migration to the lake of sockeye.
	Varied, in Canada (operated by ONA, DFO)	Grant PUD, (CPUD – future), Okanogan Nations Alliance	No	The ONA are currently attempting to reintroduce sockeye fry into Skaha Lake on a 12-year experimental basis.

Table 5.8 Numbers of different habitat activities implemented within the Upper Columbia Basin within the last 10 years

Activity	Project location				
	Wenatchee	**Entiat**	**Methow**	**Okanogan**	**Mainstem & small tribs**
Acquisition	10	3	9	4	0
Assessment	14	10	13	13	16
Passage	7	9	11	1	3
Habitat improvement	13	35	46	14	2
Planning	7	4	4	0	3
RME	16	6	7	5	6
Screening	5	0	19	0	0
Water quality	2	2	3	2	1
Water quantity	1	0	33	3	0
Total	**75**	**69**	**145**	**42**	**31**

Table 5.9 Habitat action classes and a listing of potential actions associated with each action class. Note that the list of potential actions is not all-inclusive. The list is intended as a guide for local habitat groups in selecting potential actions. Additional potential actions not identified in the list may be appropriate provided they address the action class. None of the actions identified in this table are intended to, nor shall they in any way, abridge, limit, diminish, abrogate, adjudicate, or resolve any authority or Indian right protected by statute, executive order, or treaty. This language shall be deemed to modify each and every section of this recovery plan as if it were set out separately in each section.

Habitat Action Class	Relationship to VSP and Limiting Factors	List of Potential Habitat Actions
Riparian Restoration	Actions in this class generally apply to the **productivity** and **abundance** VSP parameters and address limiting and causal factors such as loss of bank stability, impacts from agriculture and livestock, increased sediment input above natural levels, elevated temperatures, depressed invertebrate production, and loss of natural LWD recruitment.	1. Plant trees and shrubs to provide shade, especially those in close proximity to streams, stream banks, and gravel/boulder bars. 2. Restore riparian buffers using incentive mechanisms provided in shoreline master programs and farm conservation plans and programs to avoid or minimize removal of native vegetation. 3. Replace invasive or non-native vegetation with native vegetation. 4. Maintain or improve fencing or fish friendly stream crossing structures to prevent livestock access to riparian zones and streams. 5. Provide alternative sites for stock watering. 6. Maintain or decommission roads and trails in riparian areas. 7. Connect off-channel habitats to improve floodplain and wetlands processes and functions. 8. Replant degraded riparian zones by reestablishing native vegetation. 9. Selectively thin, remove, and prune non-native and invasive vegetation. 10. Improve riparian conditions by increasing filtration capacity through vegetation planting, CREP enrollment, selected livestock fencing, and similar practices, including intermittent streams that contribute to priority areas. 11. Implement the most economical and effective treatment methods to control noxious weeds, including the encouragement of biological control methods where feasible and appropriate. 12. Establish stream flow requirements (within the natural hydrologic regime and existing water rights) using empirical data to protect and maintain riparian habitat. 13. Apply best management practices (BMPs) to agricultural and grazing

Habitat Action Class	Relationship to VSP and Limiting Factors	List of Potential Habitat Actions
		practices where they are proven to restore functional riparian condition. 14. Recreation management.
Side-Channel Reconnection	Actions in this class generally apply to the **productivity** and **abundance** VSP parameters and address limiting and causal factors such as loss of channel sinuosity and length, decreased habitat refugia and diversity, loss of hyporheic function associated with floodplains, increased bed scour by concentrating river energy, loss of bank stability, losses of habitat quantity and quality from agriculture and livestock activities, increased sediment input above natural levels, elevated temperature, depressed invertebrate production, and loss of natural LWD recruitment.	1. Restore and/or reconnect side-channel habitats, islands, spawning channels, and reconnect back channels to increase LWD deposition, channel complexity, and riparian areas. 2. Re-slope vertical banks and establish wetland habitats by connecting the floodplain with the channel. 3. Identify, protect, and re-establish ground-water sources. 4. Provide stream flows that water side channels and off-channel habitats.
Obstruction Restoration	Actions in this class generally apply to the **diversity, structure,** and **abundance** VSP parameters. Removing barriers addresses limiting and causal factors such as loss of habitat quantity, habitat fragmentation, decreased habitat refugia and diversity, and increased density-dependent mortality from concentrating populations into small habitat units.	1. Design and construct road culverts and screens consistent with the newest standards and guidelines. 2. Remove, modify, or replace dams, culverts, and diversions that prevent or restrict access to salmon or trout habitat and/or cause loss of habitat connectivity. 3. Address fish passage and screening concerns, as much as possible, in other restoration and protection efforts. Effectively operate and maintain culverts and other instream structures. 4. Develop tributary channels as bypass habitat around dams. 5. Convert to low-head, run-of-the-river projects. 6. Establish and provide fish passage flows (eliminate low flow barriers). 7. Reduce flow fluctuations (associated with power generation, flood control, etc.) to allow passage through shallow-water habitats.
Water Quality Restoration	Actions in this class generally apply to VSP parameters of **productivity** and **abundance**, and to a lesser degree, **diversity**. Water quality includes factors and pollutants such as chemicals, metals, temperature, Biological Oxygen Demand (BOD), and nutrients. Predation by exotic species can be decreased with improved water quality and benthic	1. Reduce Biological Oxygen Demand (BOD) by reducing nutrient inflow into lakes and streams. 2. Re-establish groundwater sources. 3. Implement existing water-quality plans.

Habitat Action Class	Relationship to VSP and Limiting Factors	List of Potential Habitat Actions
	macroinvertebrate community structure can be recovered to natural levels, improving survival and growth of salmonids.	4. Clean-up mine tailings. 5. Remove and properly dispose of arsenic contaminated sediments. 6. Use State Environmental Policy Act (SEPA) to prevent, minimize, or mitigate both immediate and long-term impacts. 7. Establish and protect riparian buffers. 8. Assess the value of vegetation removal. 9. Implement Total Maximum Daily Loads (TMDLs) that address temperature (as a pollutant). 10. Use incentives and technical assistance, such as Conservation Reserve Enhancement Program (CREP). 11. Implement education programs. 12. Implement best management farm practices. 13. Implement nonpoint source control techniques for urban areas. 14. Manage development, road construction, logging, and intensive farming in areas with high likelihood of occurrence of mass wasting (unstable slopes) and/or erosion. 15. Restore geomorphic features such as connectivity with floodplain gravels, pool-riffle sequences, meander bends, backwaters, and side channels. 16. Improve the extent, structure, and function of riparian buffers to increase their filtration capacity through increasing the density, maturity, and appropriate species composition of woody vegetation, understory vegetation planting, CREP enrollment, selected livestock fencing, and similar practices. 17. Identify jurisdictions with inadequate land use regulations and work to strengthen existing or pass new regulations that better protect the structure and function of riparian areas and wetlands. 18. Protect riparian vegetation to improve water quality through promotion of livestock BMPs such as alternative grazing rotations and the installation of alternative forms of water for livestock 19. Restore perennial vegetation in upland cultivated and non-cultivated areas with native species and reforestation.

Habitat Action Class	Relationship to VSP and Limiting Factors	List of Potential Habitat Actions
		20. Minimize surface water withdrawals (increases stream flow) through implementation of irrigation efficiencies, quantify legal withdrawals, identify and eliminate illegal withdrawals, lease of water rights and purchase of water rights that would not impact agriculture production. 21. Improve upland water infiltration through road decommissioning, reduced soil compaction, direct seeding activities, increasing native vegetation cover, and CRP participation. 22. Continue development and implementation of TMDLs and other watershed scale efforts to remedy local factors negatively influencing temperature regimes. 23. Conduct appropriate shade restoration activities where streamside shading has been reduced by anthropogenic activities (temperature attenuation). 24. Protect wetland and riparian habitats. 25. Enhance the extent and function of wetlands and wet meadows. 26. Manage sources of high-temperature inputs to surface waters. 27. Implement upland BMPs, including activities such as sediment basins on intermittent streams. 28. Monitor hatchery and other NPDES (point sources) for effluent, nutrients, contaminants, and pathogens and correct as needed. 29. Construct detention and infiltration ponds to capture runoff from roads, development, farms, and irrigation return flows. 30. Reduce hazardous fuels and materials.
Water Quantity Restoration	Actions in this class generally apply to the **productivity**, **abundance**, **diversity** and **structure** VSP parameters. Restoration actions will address limiting and causal factors such as blocked and/or impeded fish passage, loss of habitat quantity and quality, increased temperature, and benthic macroinvertebrate production.	1. Buy or lease water rights that would not impact agriculture production, implement water conservation, reconnect river channels. 2. Develop and enforce minimum in-stream flows for aquatic resources within the natural hydrologic regime and existing water rights. 3. Develop programs that assist water users and promote the efficient use of water. 4. Implement activities that promote water storage and groundwater recharge that collectively add to existing in-stream flows.

Habitat Action Class	Relationship to VSP and Limiting Factors	List of Potential Habitat Actions
		5. Put or keep water in the streams using innovative tools, such as water banking; lease or purchase senior water rights; trust water donation; water conservation and reuse; and water storage and groundwater recharge that are within the natural hydrologic regime and existing water rights. 6. Manage stormwater and reduce the extent of impervious surfaces. 7. Regulate reservoir pool levels to improve salmonid migration rates and minimize competitor and predator effects. 8. Use drawdown to create flow and turbidity conditions conducive to salmonid migration. 9. Restore perennial vegetation in upland cultivated and non-cultivated areas with native species and reforestation. 10. Educate the public on existing land use and instream work regulations (e.g., critical area ordinances, HPA requirements, DSL requirements, etc.) that limit riparian area development. 11. Improve watershed function by increasing upland water infiltration, road decommissioning, reducing soil compaction, seeding activities, increasing native vegetation cover, and CRP participation. 12. Investigate feasibility of water storage in coordination with federal, tribal, state, and local governments and stakeholders. 13. Implement shallow aquifer recharge programs. 14. Encourage beaver re-population. 15. Protect and restore springs, seeps, and wetlands that function as water storage during spring flows and provide recharge during summer drought periods. 16. Minimize surface water withdrawals through implementation of irrigation efficiencies, quantify legal withdrawals, identify and eliminate illegal withdrawals, lease of water rights, and purchase of water rights that do not impact agriculture production, with the exception of illegal withdrawals. 17. Pursue opportunities to convert surface water uses to well supplies and explore feasibility of changing surface water point of diversion from tributaries to the Columbia River.

Habitat Action Class	Relationship to VSP and Limiting Factors	List of Potential Habitat Actions
		18. Improve municipal stormwater management to minimize peak flow levels. 19. Pursue use of constructed wetlands in appropriate areas for peak flow management, infiltration, and stormwater retention.
Instream Structures	Actions in this class generally apply to the **productivity** and **abundance** VSP parameters. These actions address limiting factors and causal factors such as loss of natural stream channel complexity, refugia and hiding cover, sinuosity, stream length, loss of floodplain connectivity, unnatural width to depth ratios, embeddedness, unstable banks, increased fine sediment, loss of pool and riffle formation, and spawning gravel and natural LWD recruitment.	1. Install instream structures such as boulders and rock weirs to increase short-term pool formation and long-term habitat diversity. 2. Add rock weirs or boulders to increase channel roughness. 3. Install habitat boulders. 4. Install instream structures to slow water velocities and increase gravel retention. 5. Install any other form of instream structure that has been deemed beneficial through literature review or project demonstration.
Road Maintenance	Actions in this class generally apply to the **productivity** and **abundance** VSP parameters. Actions in this class address limiting factors and causal factors such as loss of natural stream channel complexity, sinuosity, stream length, loss of floodplain connectivity, unnatural width to depth ratios, embeddedness, unstable banks, increased sediment, loss of pool and riffle formation, and spawning gravel and LWD recruitment.	1. New development will be consistent with shoreline management guidelines, local Critical Area Ordinances, hydraulic project approval, and other state and/or local regulations or permits. 2. Establish and protect riparian buffers using incentive mechanisms provided in Critical Area Ordinances, shoreline master programs, forest practices regulations, farm conservation plans and other programs to avoid or minimize channel constriction, input of chemicals and exacerbate or create modified runoff or stormwater flow. 3. Implement road maintenance and abandonment or decommissioning plans. 4. Manage the placement of dikes and other structures that may confine or restrict side channels and disconnect habitat in floodplains. 5. Decrease sediment delivery through expanded use of sediment basins, eliminating side-casting, CRP participation, mowing of road shoulders in place of herbicide use, and/or vegetative buffers on road shoulders. 6. Implement best management practices for bridge maintenance activities to eliminate build-up of sediment and other materials. 7. Improve watershed conditions (e.g., upland water infiltration) through road decommissioning, reduced soil compaction, direct seeding activities,

Habitat Action Class	Relationship to VSP and Limiting Factors	List of Potential Habitat Actions
		increasing native vegetation cover, and/or CRP participation. 8. Decommission, modify, or relocate (i.e., setback) roads, bridges, and culverts to decrease stream confinement to the extent practicable. 9. Manage road runoff and retrofit projects to address stormwater runoff concerns. 10. Pave, decommission, or relocate roads away from streams. 11. Remove, reconstruct, or upgrade roads that are vulnerable to failure due to design or location. 12. Minimize total road density within the watershed and provide adequate drainage control for new roads. 13. Avoid road construction and soil disturbance in proximity to riparian areas, wetlands, unstable slopes, and areas where sediment related degradation has been identified. 14. Maintain drainage ditches, culverts, and other drainage structures to prevent clogging with debris and sediments.
Floodplain Restoration	Actions in this class generally apply to the **productivity**, **abundance**, **diversity**, and **structure** VSP parameters. These actions address limiting factors and causal factors such as channel incision, increased temperature, poor water quality, loss of natural stream channel and habitat complexity, sinuosity, stream length, unnatural width to depth ratios, embeddedness, unstable banks, increased fine sediments, loss of pool and riffle formation, and spawning gravel and LWD recruitment.	1. Create diverse channel patterns to enhance water circulation through floodplain gravels. 2. Use dike setbacks, removal, breaching, sloping, and/or channel reconnection to connect the channel with the floodplain. 3. Increase flood-prone areas to reduce lateral scour and flow volume in main channel and protect or improve existing spawning habitats. 4. Restore and reconnect wetlands and floodplains to the riverine system where appropriate. 5. Reconnect floodplain (off-channel) habitats where appropriate. 6. Decommission or relocate roads, low-priority dikes, bridges, and culverts to enhance floodplain connectivity. 7. Use setback levees and flood walls to recharge floodplain habitats.
Large Woody Debris	Actions in this class generally apply to the **productivity** and **abundance** VSP parameters. These actions address limiting factors and causal factors such as loss of natural stream	1. Add key pieces of wood to stabilize banks, provide hiding cover, and reestablish natural channel geomorphology (pool:riffle, width:depth,

Habitat Action Class	Relationship to VSP and Limiting Factors	List of Potential Habitat Actions
Restoration	channel complexity, refugia and hiding cover, sinuosity, stream length, loss of floodplain connectivity, unnatural width to depth ratios, embeddedness, unstable banks, increased fine sediments, loss of pool and riffle formation, and spawning gravel and natural LWD recruitment.	sediment transport, etc.). 2. Improve riparian habitats by planting native vegetation with the potential to contribute to future LWD recruitment. 3. Create side-channel habitats, islands, and reconnect back channels to increase LWD deposition, channel complexity, and riparian areas to reestablish normative processes, such that short-term fixes (placement) are only used in the interim. 4. Add rootwads, log jams, and similar structures that mimic natural formations. 5. Increase the density, maturity, and appropriate species composition of woody vegetation in riparian buffers for long-term recruitment of LWD. 6. Improve natural stream form and function (e.g., meander reconstruction in Rosgen C channels) to facilitate LWD retention. 7. Encourage beaver re-population. 8. Install LWD for short-term pool formation. 9. Add large woody debris and place in-channel engineered log jams.
Nutrient Restoration	Actions in this class generally apply to **abundance** and **productivity** VSP parameters. Nutrients, from sources such as salmon carcasses, provide food for juvenile salmon, nutrients for riparian plants and benthic macroinvertebrates. Additionally, salmon carcasses provide forage for wildlife.	1. Add hatchery salmon carcasses to stream. 2. Add nutrient analogs to streams.

Table 5.10 Rating of assessment units within each subbasin according to their potential for recovery of listed species in the Upper Columbia Basin. Ratings are from the Biological Strategy (UCRTT 2003) and range from Category 1 (highest) to Category 4 (lowest). Category 1 and 2 assessment units include areas that should be protected (see text)

Subbasin	Assessment Unit	Action Category
Wenatchee	Lower Wenatchee River	Category 2
	Mission Creek	Category 3
	Peshastin Creek	Category 2
	Chumstick Creek	Category 3
	Lower Icicle (mouth to boulder field)	Category 2
	Upper Icicle (upstream from boulder field)	Category 2
	Middle Wenatchee (Tumwater Canyon)	Category 1
	Upper Wenatchee (upstream of Tumwater)	Category 1
	Chiwaukum (includes Skinney Creek)	Category 2
	Chiwawa River	Category 1
	Nason Creek	Category 2
	Lake Wenatchee	Category 1
	Little Wenatchee River	Category 1
	White River	Category 1
Entiat	Lower Entiat River	Category 2
	Middle Entiat River	Category 1
	Upper Entiat River	Category 1
	Mad River	Category 1
Methow	Lower Methow River	Category 2
	Middle Methow River	Category 2
	Upper-Middle Methow River	Category 2
	Upper Methow/Early Winters/Lost	Category 1
	Black Canyon/Squaw Creek	Category 3
	Gold/Libby Creek	Category 3
	Beaver/Bear Creek	Category 3
	Lower Twisp	Category 2
	Upper Twisp	Category 1
	Lower Chewuch	Category 2
	Upper Chewuch	Category 1
	Wolf/Hancock Creek	Category 2

Subbasin	Assessment Unit	Action Category
	Goat/Little Boulder Creek	Category 3
Okanogan	Lower Okanogan	Category 2
	Middle Okanogan	Category 2
	Upper Okanogan	Category 2
	Loup Loup Creek	Category 4
	Lower Salmon Creek	Category 3
	Upper Salmon and Tributaries	Category 3
	Omak and Tributaries	Category 2
	Small Tributary Systems	Category 4
	Similkameen River	Category 3
	Osoyoos Lake	Category 3

Table 5.11 Summary of possible increases in survival from recommended actions identified in this plan. The numbers in red indicate minimum estimates for Entiat steelhead, because there are no productivity estimates from recommended habitat actions (see Appendix I).

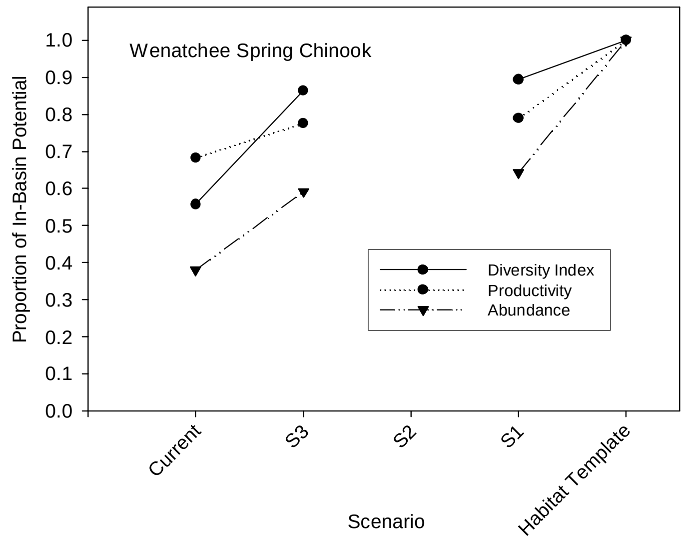
Sector	Area	Spring Chinook Productivity					Steelhead Productivity[1]				
		Current (C)	Low Potential (P)	High Potential (P)	Low P/C	High P/C	Current (C)	Low Potential (P)	High Potential (P)	Low P/C	High P/C
Harvest	Wenatchee	0.74	0.74	0.75	1.00	1.01	0.69	0.69	0.70	1.00	1.01
	Entiat	0.76	0.76	0.77	1.00	1.01	0.69	0.69	0.70	1.00	1.01
	Methow	0.51	0.51	0.52	1.00	1.01	0.91	0.91	0.92	1.00	1.01
	Okanogan	---	---	---	---	---	0.91	0.91	0.92	1.00	1.01
Hatchery	Wenatchee	0.74	0.76	0.78	1.03	1.05	0.69	0.71	0.72	1.03	1.05
	Entiat	0.76	0.78	0.80	1.03	1.05	0.69	0.71	0.72	1.03	1.05
	Methow	0.51	0.54	0.56	1.05	1.10	0.91	0.96	1.00	1.05	1.10
	Okanogan	---	---	---	---	---	0.91	0.96	1.00	1.05	1.10
Hydro[2]	Wenatchee	0.74	1.09	1.09	1.47	1.47	0.69	0.97	0.97	1.40	1.40
	Entiat	0.76	1.20	1.20	1.58	1.58	0.69	1.03	1.03	1.49	1.49
	Methow	0.51	0.84	0.84	1.65	1.65	0.91	1.36	1.36	1.49	1.49
	Okanogan	---	---	---	---	---	0.91	1.36	1.36	1.49	1.49
Habitat (33%-100%)[3]	Wenatchee	0.74	0.93	1.00	1.25	1.35	0.69	0.87	0.90	1.26	1.31
	Entiat[4]	0.76	0.78	0.78	1.03	1.03	0.69	---	---	---	---
	Methow	0.51	0.58	0.69	1.14	1.36	0.91	1.04	1.24	1.14	1.36
	Okanogan	---	---	---	---	---	0.91	1.34	1.49	1.47	1.64
Integration across all sectors	Wenatchee	0.74	1.40	1.56	1.89	2.10	0.69	1.25	1.34	1.82	1.94
	Entiat	0.76	1.27	1.31	1.67	1.72	0.69	1.06	1.09	1.53	1.58
	Methow	0.51	1.01	1.27	1.98	2.49	0.91	1.62	2.05	1.78	2.25
	Okanogan	---	---	---	---	---	0.91	2.10	2.47	2.30	2.71

[1] Productivity was based on a hatchery effectiveness of H = 0.5.

[2] The survival estimates provided here were based on the draft Quantitative Analysis Report (QAR). They include survival gains associated with long-term benefits in the FCRPS.

[3] EDT modeled two habitat improvement scenarios for the Wenatchee, Methow, and Okanogan populations: (1) 33% intensity and (2) 100% intensity (See Appendix F). The 100% intensity may not be feasible to implement because of social/economic factors.

[4] Because the Entiat was not modeled the same as the other subbasins, the total increase in productivity would be greater than shown here (See Appendix F). There was no 100% intensity scenario for the Entiat.



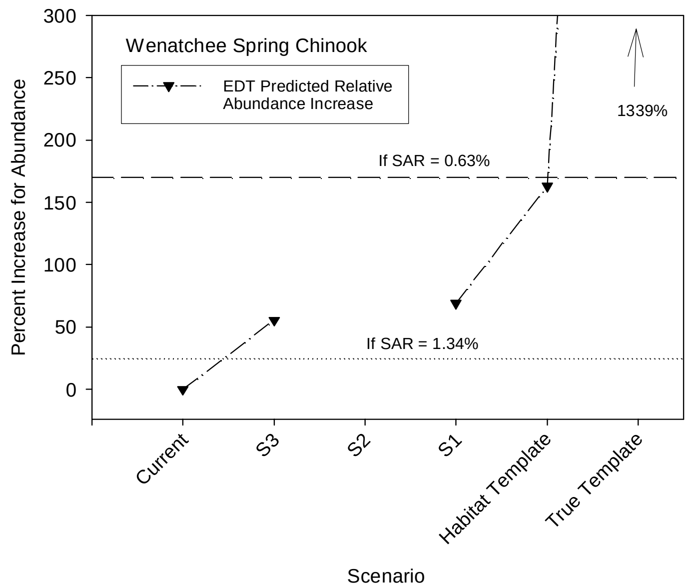


Figure 5.1 ***Top graph*** identifies the proportion of within-subbasin potential for each spring Chinook performance measure realized by each EDT modeling scenario in the Wenatchee subbasin. Scenario 1 (S1) applied the full effectiveness of restoration classes that addressed the primary limiting factors within each assessment unit, regardless of feasibility or cost. Scenario 3 (S3) was 33% the intensity of S1, with full effect of artificial barrier removal and protection. Scenario 2 (S2) is not available at this time. Habitat template indicates the estimated historical condition. ***Bottom graph*** represents the predicted abundance (spawners) based on EDT runs for spring Chinook within the Wenatchee subbasin. The dotted and dashed lines indicate the percent increase needed to reach minimum recovery abundance with SARs of 1.34% (used in EDT model runs) and 0.63% (empirical data from the Chiwawa River). See Appendix F for more details.

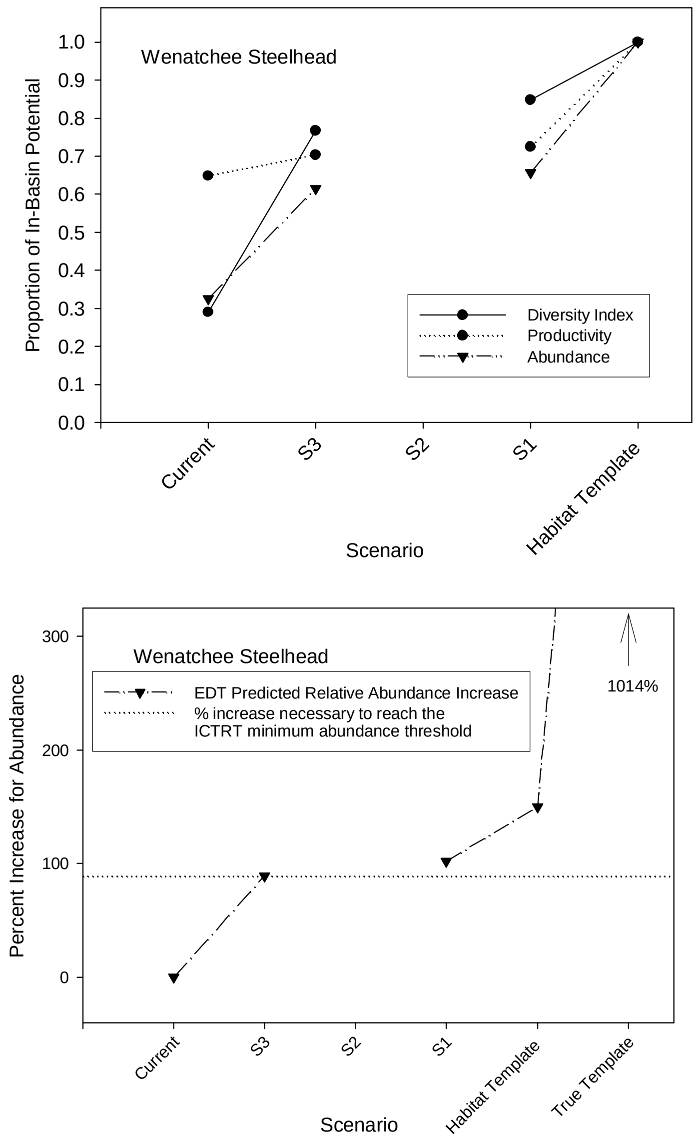


Figure 5.2 ***Top graph*** identifies the proportion of within-subbasin potential for each steelhead performance measure realized by each EDT modeling scenario in the Wenatchee subbasin. Scenario 1 (S1) applied the full effectiveness of restoration classes that addressed the primary limiting factors within each assessment unit, regardless of feasibility or cost. Scenario 3 (S3) was 33% the intensity of S1, with full effect of artificial barrier removal and protection. Scenario 2 (S2) is not available at this time. Habitat template indicates the estimated historical condition. ***Bottom graph*** represents the predicted abundance (spawners) based on EDT runs for steelhead within the Wenatchee subbasin. The model used an average SAR of 1.26%. See Appendix F for more details.

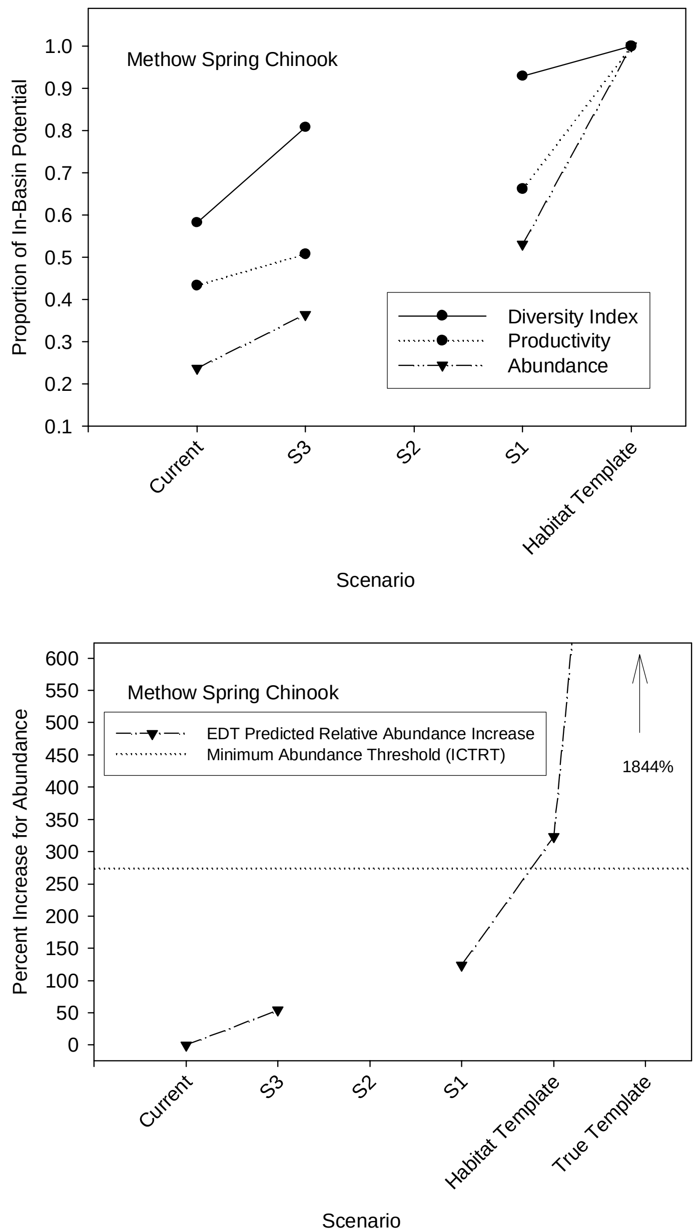
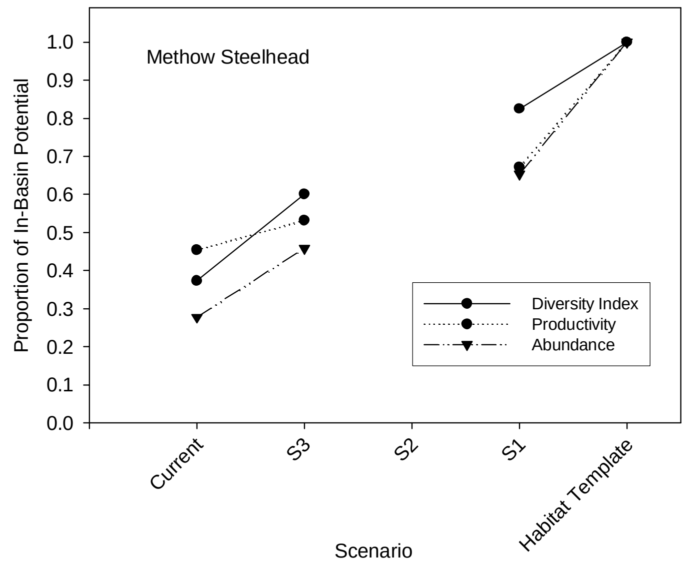


Figure 5.3 ***Top graph*** identifies the proportion of within-subbasin potential for each spring Chinook performance measure realized by each EDT modeling scenario in the Methow subbasin. Scenario 1 (S1) applied the full effectiveness of restoration classes that addressed the primary limiting factors within each assessment unit, regardless of feasibility or cost. Scenario 3 (S3) was 33% the intensity of S1, with full effect of artificial barrier removal and protection. Scenario 2 (S2) is not available at this time. Habitat template indicates the estimated historical condition. ***Bottom graph*** represents the predicted abundance (spawners) based on EDT runs for spring Chinook within the Methow subbasin. The model used an average SAR of 1.24%. See Appendix F for more details.



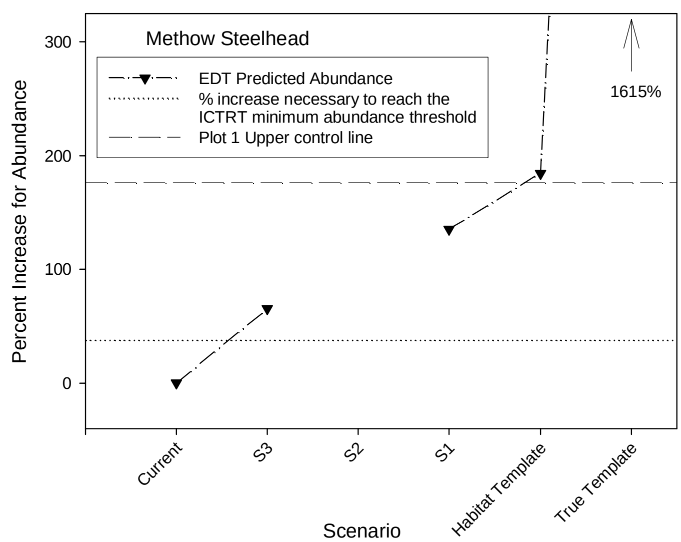
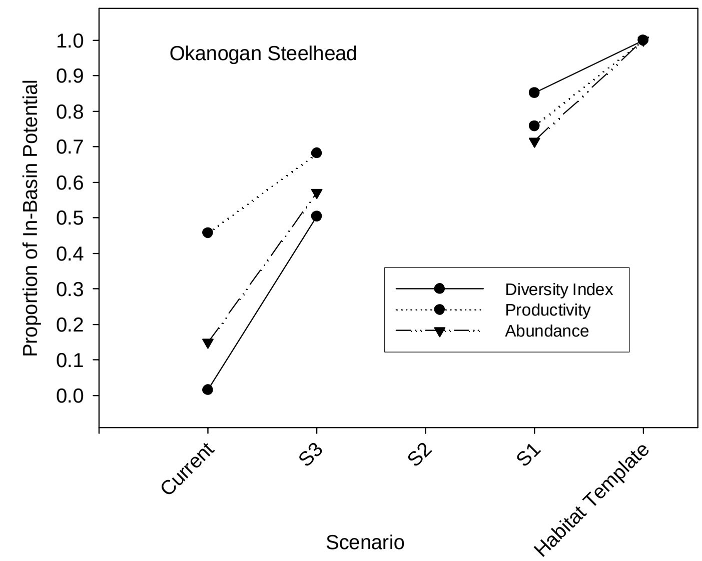


Figure 5.4 ***Top graph*** identifies the proportion of within-subbasin potential for each steelhead performance measure realized by each EDT modeling scenario in the Methow subbasin. Scenario 1 (S1) applied the full effectiveness of restoration classes that addressed the primary limiting factors within each assessment unit, regardless of feasibility or cost. Scenario 3 (S3) was 33% the intensity of S1, with full effect of artificial barrier removal and protection. Scenario 2 (S2) is not available at this time. Habitat template indicates the estimated historical condition. ***Bottom graph*** represents the predicted abundance (spawners) based on EDT runs for steelhead within the Methow subbasin. The model used an average SAR of 1.03%. See Appendix F for more details.



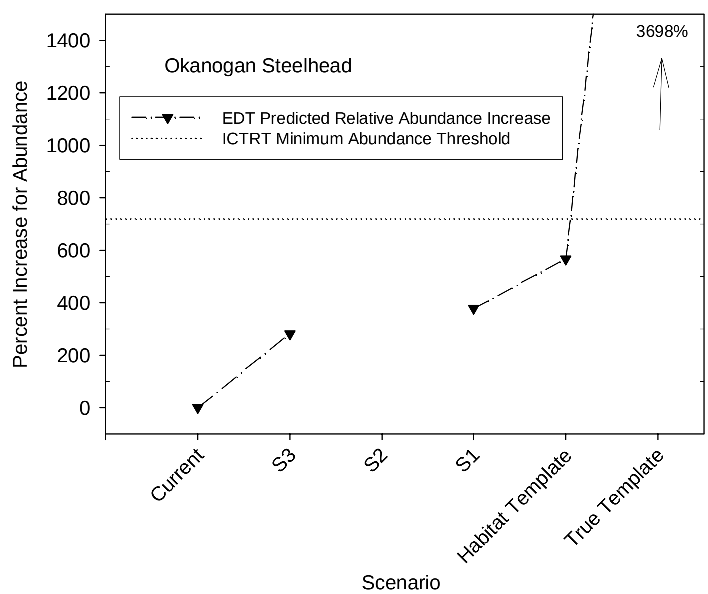


Figure 5.5 ***Top graph*** identifies the proportion of within-subbasin potential for each steelhead performance measure realized by each EDT modeling scenario in the U.S. portion of the Okanogan subbasin. Scenario 1 (S1) applied the full effectiveness of restoration classes that addressed the primary limiting factors within each assessment unit, regardless of feasibility or cost. Scenario 3 (S3) was 33% the intensity of S1, with full effect of artificial barrier removal and protection. Scenario 2 (S2) is not available at this time. Habitat template indicates the estimated historical condition. ***Bottom graph*** represents the predicted abundance (spawners) based on EDT runs for steelhead within the Okanogan subbasin. The model used an average SAR of 0.92%. See Appendix F for more details.

6 Social/Economic Considerations

6.1 Estimated Costs
6.2 Estimated Benefits
6.3 Economic Impacts of Agriculture in North Central Washington

6.1 Estimated Time and Costs

The ESA section 4(f)(1) requires that the recovery plan include ‘‘estimates of the time required and the cost to carry out those measures needed to achieve the Plan’s goal and to achieve intermediate steps toward that goal’’ (16 U.S.C. 1533[f][1]). At this time it is difficult to estimate the total cost to recover spring Chinook, steelhead, and bull trout in the Upper Columbia River Basin. The USFWS estimates that it will cost about $15 million to recover bull trout in the Upper Columbia Basin (USFWS 2002). This greatly underestimates the total cost of recovering all three listed species. Because of different life-history characteristics of each species, the UCSRB believes that it will cost at least $296 million over a 10-year period to implement habitat actions that will contribute toward recovery of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin (Table 6.1) Also, there are many uncertainties involved in predicting the course of recovery and in estimating total costs. Such uncertainties include biological and ecosystem responses to recovery actions as well as long-term and future funding. The Upper Columbia Plan states that if its recommended actions are implemented, recovery of the spring Chinook salmon ESU and the steelhead DPS is likely to occur within 10 to 30 years. The cost estimates cover work projected to occur within that first decade. This estimate includes expenditures by local, Tribal, state, and Federal governments, private business, and individuals in implementing both capital projects and non-capital work. Before the end of this first implementation period, specific actions and costs will be estimated for subsequent years, to achieve long-term goals and to proceed until a determination is made that listing is no longer necessary.

The $296 million estimate does not include costs associated with hatchery programs because these programs are funded to achieve specific program objectives, which may change based on monitoring and evaluation. The cost estimate also does not include expenses associated with implementing actions within the lower Columbia River, in the estuary, within the FCRPS, or the cost of implementing measures in the PUDs’ Habitat Conservation Plans and Settlement Agreements. Cost estimates for these items are included in two modules that NMFS developed because of the regional scope and applicability of the actions. These modules are incorporated into the Upper Columbia Plan by reference and are available on the NMFS Web site: www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other- Documents.cfm. In addition, the estimate does not include the cost of RM&E.[140]

The hydropower cost estimates will be updated over time, as the section 7 consultation on the remanded 2004 FCRPS BiOp is completed. The estuary recovery costs could be further refined following public comment on the ESA recovery plan for the three listed lower Columbia ESUs and one listed Lower Columbia steelhead DPS in 2007. There are virtually no estimated costs for recovery actions associated with harvest to report at this time. This is because no actions are

[140] RME would include costs of conducting critical uncertainty research in all sectors, monitoring effects of actions within all sectors, monitoring the status and trend of performance measures in all sectors, and monitoring the implementation and compliance of all actions within all sectors.

currently proposed that go beyond those already being implemented through ***U.S. v. Oregon*** and other harvest management forums. In the event that additional harvest actions are implemented through these forums, those costs will be added during the implementation phase of this recovery plan. All cost estimates will be refined and updated over time.

The Upper Columbia Plan estimates it may cost a total of $10 million to cover agency and organization staffing costs during the first 10 years of plan implementation ($1 million/year), and it is conceivable that this level of effort will need to continue for the Plan’s duration. Also, continued actions in the management of habitat, hatcheries, and harvest, including both capital and non-capital costs, will likely warrant additional expenditures beyond the first 10 years. Although it is not practicable to accurately estimate the total cost of recovery, it appears that most of the costs will occur in the first 10 years. Annual costs are expected to be lower for the remaining years, thus the total for the entire period (years 11-20) may possibly range from $150 million to $200 million.

6.1.1 Methodology for Cost Estimates

The cost estimates for this recovery plan are similar in methodology for developing the revised cost estimates. The initial project lists sent to EFC identified more than 400 projects on lists compiled by teams in each of the five watersheds that comprise the Upper Columbia salmon recovery region (Methow, Okanogan, Entiat, Mainstem Columbia Tributaries, and Wenatchee). While each list had fields for cost information for each project, allowing the identification of project size, unit costs, and total costs, in the great majority of cases (85-90%) at least one of the key factors was missing, and many projects on each list (35-40%) had no cost information whatsoever.

A taxonomy for Upper Columbia projects was developed and each project was assigned to one of 29 project categories (**Table 6.1**). A small group of projects (30-40) were insufficiently defined to allow categorization and were put in a miscellany category for later analysis. The first substantive analysis occurred by comparing cost estimates within each category. This analysis indicated that (1) methodologies used to estimate costs were significantly different among watersheds, and (2) that some cost information included in the lists was very preliminary and needed further refinement. The conclusion was that greater work was needed to upgrade cost estimates than was originally anticipated, with particular emphasis on development of reliable unit costs by project category.

Cost estimates were made based on an application of a range of unit costs per appropriate areal units (per acre, square foot, lineal foot, etc.). Unit costs were derived based on credible project estimates from the Upper Columbia, the experience of staff, and other source materials, including the ***Primer on Habitat Project Costs*** developed for the Puget Sound salmon recovery plan.

Meetings were held in each of the five watersheds of the Upper Columbia Basin to review and refine the unit cost table and to identify the size of projects that lacked the units needed to calculate costs. Meetings were held with project experts in almost all of the cost categories to discuss the appropriate units, the range in unit costs, and the factors responsible for costs being in the high or low segment of the range. The initial estimates and additional feedback from the watershed meetings led to the unit costs found in **Table 6.1**.

The project-by-project estimate of costs envisioned in the original proposal was clearly impractical because of the complexities of collecting project-specific information on each of the 400+ projects in the plan. The focus shifted to identifying average characteristics within each of the 29 categories of projects. The concept underlying this approach is that the extremely costly projects within the category will be offset by the extremely inexpensive ones, and that they will congregate around an average. This approach lacks the precision of a project-by-project analysis, but should suffice for the costs of the overall plan, the focus of this study.

Costs were then estimated for nearly every project in each category. Estimates were characterized in one of four categories:

- Projects with highly credible project-specific costs based on watershed sources;
- Projects with credible project-specific costs based on original cost estimates;
- Projects with credible project-specific costs based on unit costs and project size;
- Projects that lack the specificity needed for project-specific estimates but that are estimated based on the average size or cost of other projects in the category.

The aim in this exercise was to have enough projects in the first three categories to appropriately "calibrate" the average cost by category. One category – water quality source control – had insufficient information to allow any credible cost estimation, and will need further specificity. In addition, approximately 20 individual projects were so loosely defined as to make cost estimation impractical. Through use of these methods, the projects with reliable size and unit cost data rose from 10-15% of the total in the initial watershed lists to more than 50% in the final estimate and the number of projects with no cost information declined from 35-40% to fewer than 10%.

Although acquisitions[141] as a tool for habitat protection are not identified in the recovery plan, the UCSRB recognizes that acquisitions are occurring throughout the Upper Columbia. The estimated cost for acquisitions and maintenance of those acquired habitats was derived by considering funds historically spent on restoration and on protection. (Innovative land management techniques, best management practices, conservation easements, transfer of development rights, habitat farming agreements, and partnerships with private land owners need to be emphasized.)

6.2 Estimated Economic Benefits

Salmon and steelhead recovery will contribute to economies at the state, regional, and local levels (USDI et al. 2003). This contribution regularly exceeds the cost of salmon recovery and the economic impacts of traditional resource industries in small rural communities (Reading

[141] In general, acquisitions are not supported by the counties, because of the large amount of land currently under public ownership, removal of lands reduces the tax base, loss of economic activity, and the cost of long-term maintenance. However, the UCSRB recognizes that land acquisitions may be a tool needed for recovery if used properly and coordinated with local authorities. Other options, such as best management practices, easements, land swaps, and partnerships with private landowners should be emphasized.

2005). Many forms of investment and economic benefits are associated with salmon and steelhead recovery, including angling and its associated ancillary expenditures. In fact, over 40 categories of direct expenditures are associated with healthy (recovered) fish populations.

Economic studies have shown that restoring healthy runs of naturally produced salmon will benefit the regional economy (Institute for Fisheries Research 1996). For example, with a restored salmon fishery, Idaho alone would see almost half a billion dollars in economic benefit from sport fishing. Similarly, restored fisheries in Washington and Oregon would raise the total to almost $6 billion dollars in economic benefit to the region. In addition, the Pacific Coast Federation of Fishermen's Association estimates that restoration of Columbia and Snake River salmon would net the region an additional $500 million per year in commercial fishing revenue and as many as 25,000 new family-wage jobs (ECFF and PCFFA 1994).

In preparing to estimate economic benefits for the Upper Columbia region, recovery planners reviewed over 19 pertinent reports, most of these from published literature and nationally sanctioned reports. Additionally, experts from the Economics Department at Eastern Washington University, natural resource agency staff, and an economist from NOAA provided expert advice. The findings substantiate that in addition to direct and indirect dollars derived from tourism-related activities, an entire industry of family-wage jobs exists around salmon and steelhead recovery. In addition, a host of intrinsic benefits, such as increased property values and benefits emanating from reduced regulatory burden adds to the economics equation in tangible ways.

As described in Appendix K1, 9,586 jobs are created for Washington State citizens and that $854 million are spent each year on fishing-related activities. Using recent angler and catch data, and a comparable study from the Snake River Basin, the economic benefit to the Upper Columbia region could reach $43-$70 million per year. The Snake River basin estimated nearly $60 million in local economic benefit between 1999 and 2001.

As an example, in 2001, 938,000 anglers fished for salmon and steelhead in Washington State. These anglers spent about 5.4 million angling days and $386 per trip with each trip lasting an average of 1.3 days (USDI et al. 2003). Total expenditures exceeded $2,000 per fish harvested by including direct and indirect expenditures. However, because expenditures are incurred even when fish are not harvested, number of angling trips, whether fish are harvested or not, is the most appropriate metric in the economic equation and the final measure of economic benefit used in this plan. Salmon recovery can be viewed as an investment and an opportunity to diversify and strengthen the economy. Importantly, the general model for viewing cost versus benefits must be viewed in terms of long-term benefits derived from short-term costs.

6.3 Economic Impacts of Agriculture in North Central Washington

Agriculture is a resource-based enterprise that both draws from and enhances the natural and economic environment in the three counties of North Central Washington (NCW). All three counties are economically dependent on industries that are resource-centered: agriculture, logging and mining (the latter two in Okanogan County, primarily).

Tree fruit production is common to all three counties as the leading industry, although its makeup is not identical in all three counties. Livestock is common to Douglas and Okanogan; cereal grains are dominant in the plateau areas of Douglas County while mining is mainly found in Okanogan County.

Analysis of the impact of agriculture on NCW is difficult because of the lack of study data that accurately reflects the cumulative, interdependent nature of multipliers that impact other sectors of the economy. For this plan, one study of the tree fruit industry in NCW (Jensen 2004) was identified. The Washington Horticultural Association and the Washington Research Commission, which looks at the total impact of the tree fruit industry across economic sectors in each county and as a unit, compared to other Fruit Reporting Districts (FRDs), as well as all of Washington, Oregon and Idaho. Additionally, a WSU economics student's Master's thesis (Potter 2004) examines the economy of Okanogan County from the perspective of its resource-based industries, their exports, and their role as the driver of Okanogan's economy. Both of these studies will be cited extensively here. No study was identified that examined the economic impact of agriculture in Douglas County with implications across the various sectors of that economy.

One factor that changed forever the landscape, economy, and social structure of NCW is the introduction of irrigation water for agriculture. Without water, most of NCW would more closely resemble a desert than the center of the state's fruit production. While this seems such an obvious fact, it cannot be overlooked when estimating the economic value of the agricultural enterprise that resulted from the introduction of irrigation to the region. To fairly determine agriculture's economic impact, even the casual observer will realize that the very fabric of life in NCW is rooted in the agricultural products that are grown, processed, sold, and exported to the rest of the country and around the world. Whether examining retail sales, real estate or any other sector of the economy, it is all indebted in some way to the area's economic engine: agriculture. Employment in Agriculture (farm workers/owners) has actually increased at a rate faster than the national average for farm employment in each of the three counties of NCW (National Income Indicators Project [NIIP] 2005).

6.3.1 Situation

Okanogan is the largest county of the state but has a relatively low density of 7.5 persons per square mile (Washington) – indicative of the large amount of land (70%) that is not in private ownership and the land involved in the resource-based industries of agriculture, logging and mining (Okanogan). Livestock numbers for Okanogan County in 2005 were slightly under the five-year average of 49,500, totaling 47,500—yet this was enough to make it the leading livestock producer in the state, with an average value per head of $94/cwt (Washington Agricultural Statistics Service [WASS] 2005). Tree fruit production is the leading economic factor in the county, with 25,346 acres (WASS 2005); agriculture in total, directly accounted for a 20.4% share of the total employment (NIIP 2005) but just 16.67% of wages earned (Washington Employment Security Department [WAESD]). Mining contributed less than 1% of the county employment in 2005 and has been in decline for the past several years (Potter 2004).

Douglas County's economy is dominated by agriculture; livestock, cereal grains and tree fruits are the primary agricultural enterprises, accounting for a 22.2% share of all employment (see NIIP) and 15.26% of wages earned in the county (WAESD). The county had about 11,000 head of cattle and calves, 4,500 acres of hay, 199,800 acres for all cereal grains (mostly non-irrigated) and 14,901 acres of tree fruits (WASS 2005). The CRP program in Douglas County, with nearly 186,000 acres enrolled, has drastically reduced soil erosion and sedimentation. Before implementation, loss from rainfall runoff averaged 7.4 tons per acre per year (Foster Creek Conservation District). After putting lands into the CRP program that number has been reduced to practically zero, 0.56 tons/acre (Foster), improving water quality for all the creeks in Douglas County: Foster, Pine, Douglas, McCartney, and Rattlesnake for the Columbia River and Banks Lake (Bareither).

Chelan County's economy is somewhat more diversified outside of the resource-based sectors, but still dominated by agriculture, primarily tree fruit production on 37,212 acres (WASS 2005). Total fruit production has increased over the past thirty years (Smith 2005). On-farm jobs in Agriculture accounted for a 9.1% share of the total county employment in 2003 (NIIP 2005), but accounted for nearly 12% of total wages in the county (WAESD).

6.3.2 Economic Impacts

The total employment in NCW that is directly and indirectly related to all agriculture is not available in any study identified. The generally accepted multipliers of employment impact on the other sectors of the economy range from 1.5 to 2.3 to account for employment "ripples," but even these would not adequately account for the situation where agriculture is such a dominant feature of the economy.

Employment multipliers for agriculture in NCW:

County	***Ag's Share***[142]	***at 1.5***	***at 2.3***
Okanogan	20.4	30.6	46.92
Douglas	22.2	33.3	51.06
Chelan	9.1	13.65	20.93

While showing this range of employment share for each county gives a more balanced picture of agriculture's impact across all the sectors of the economy of each county, it is also useful to examine a specific example. Employment at fruit packing sheds is not included in the number given for agricultural employment. Nevertheless, according to Schotzko and Smith (2002), "[a]dditional employment caused by the existence of the packing industry is about 3,090 jobs, a ratio of about 1.41. In other words, for every job in the warehouse, another .41 jobs is required either in terms of providing production inputs to the warehouses (other than fruit) or in those sectors supporting the lifestyles of the employees. So, in addition to the 7,500 jobs in the warehouses, there are another 3,090 jobs in related industries or in the local communities that are due to the existence of the warehouses."

In another example, the retail sales sector of the economy accounts for 18% of employment in Chelan County (WAESD), but there is no accurate way to measure how much of that is related to sales of agricultural machinery, supplies, or services since that breakout is not available in current data. The economic impact of agriculture in NCW is obviously much larger than is indicated by the usual breakout of sector data used by the census and other statistical analyses.

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[142] (NIIP), National Income Indicators Project, Smith, Gary, PhD, ***"Shift-Share Analysis Results"*** for Chelan, Douglas and Okanogan Counties, http://www.pnreap.org/Washington/shift-share.php, Accessed August 2007.

In Okanogan and Douglas Counties, livestock is a major portion of the agricultural picture. Okanogan dominates the region with the sale of 24,548 head of cattle and calves compared to 6,204 in Douglas County for 2002 (WASS 2005); the estimated value of the combined counties' industry sales in 2002 was $17.2 million (WASS 2005). For the same year, cereal grains (wheat, barley and oats) plus hay acreage (excluding haylage, grass silage, and greenchop) in Chelan, Douglas, and Okanogan counties totaled 242,161 acres (WASS 2005) with an approximate combined farmgate value of $37,673,060 (Appendix K2). No exact figure for these values exists because of the price variations during the season for these products as well as the proprietary nature of some reporting. Rental payments for CRP contracts in 2005 for Douglas County equaled $8,390,894.

The dominant agricultural enterprise in all three counties is tree fruit production, consisting primarily of (in order of magnitude) apples, pears, cherries, peaches, apricots, nectarines, plums/prunes, and juice culls (Jensen 2004).

Tree fruit acreage in NCW	Total Acres (WASS)	Bearing Acres (2004 – Jensen)
Chelan:	37212	27253
Douglas:	14901	14064
Okanogan:	25346	21729
TOTALS:	77,459	63,046

Keeping in mind that 30% of the tree fruit bearing acres in the state of Washington are in the three counties of NCW, and to better understand the magnitude of the industry, Appendix K2 shows the production of apples only in Washington relative to the rest of the country. Appendix K2 shows Washington State's dominance in farmgate value among the Northwest states of Oregon (11%), Idaho (2%) and Washington (87%). The estimated impact of the tree fruit industry's income (as depicted in an input-output model of analysis) on the state of Washington is **$2,842,333,172[3].** The impact on the economy of NCW alone is accounted for in the following listing of impacts reaching across the broad sectoral categories (Jensen 2004).

NCW Impact Results:

Direct and Indirect Purchases by Business Sectors	$154,473,468
Total Household Income of Owners and Employees	444,297,553
Local Business Sectors Impacted by Household Expenditures	199,728,201
Total Economic Income Impact to Region	**$798,499,222**

Appendix K2 examines the impact of tree fruit agriculture in NCW extrapolated to the other sectors of the economy using IMPLAN data and applying the input-output model of analysis. One of the categories listed is "Other," and is explained as, "an array of the distribution of local household spending as an estimate of household spending on goods and services from outside the region (imports). These imports from outside the region are an important consideration for economic development opportunities."

Another area of impact is that of the income to local government in the form of property taxes flowing to city and county general funds. The only estimate that was identified taking into account the comprehensive impact of the tree fruit industry was that found in a study in 2004 done by Tom Schotzko and Tim Smith (WSU Extension, personal communication) that focused on the apple industry, but in this one measure, spoke more broadly about the larger tree fruit industry impact that included warehouses: "The combined estimate of property taxes paid by growers and warehouses, and the property tax payments generated as a result of the total economic impact of the industry is over $30 million per year. Those dollars support schools, roads, fire and police services and local government, etc." (Schotzko and Smith).

6.3.3 Analysis

Combining the value of the major agricultural enterprises in NCW, it is easy to understand the importance of these industries on the regional economy. Studies such as the one conducted on the impact of grazing cattle near riparian zones are critical in finding measures that satisfy the need to restore and maintain a healthy environment while also allowing a major agricultural enterprise to stay healthy. That study, for example, shows that, "As riparian utilization becomes more restrictive, providing off-stream water and salt may be a way that traditional grazing levels can remain while environmental objectives (reduced livestock impacts in the riparian area) are also obtained."…"initial ecological assessments…may show improvements in riparian area health" (Stillings et al. 2003). Other research has demonstrated that, "Implementing offstream water and trace-mineral salt into a grazing system can be effective in altering distribution patterns of cattle grazing a riparian meadow and its adjacent uplands and also can result in increased weight gain" (Porath et al. 2002).

While seeking the funding and other resources to achieve an environmental goal it is also necessary to fund the research that will find the ways that allow agriculture to thrive at the same time. Studies such as the two referenced above, demonstrate that discerning the best mitigation practice to achieve the necessary environmental goals is not incompatible with good agricultural practices. The key is to use good information that is research based.

To help understand the relationship between the amount of water flowing in a river and the amount of water needed for agriculture, Appendix K2 shows the amount of water used by one acre of fruit trees in one day, then for an entire season, taking into account the differences for cool, average and warm temperatures. Additionally, it indicates that additional water requirements must be added to that used by trees to account for the inefficiencies of most irrigation systems: compensating for soil differences and dry spots within the unit, loss of water in the irrigation delivery system, evaporation, etc.

A significant difficulty when discussing irrigation requirements is that agricultural scientists and natural resource scientists use two different measuring systems to account for the same resource: water. Agriculture measures the quantity of water used or needed in terms of the amount of water applied evenly to one acre of land in either inches or feet, termed Acre Inches (Acre in) or Acre Feet (Acre ft). Natural resource scientists measure the quantity of water moving down a river in cubic feet per second (cfs) or (ft^3/sec).

The major difference is the agricultural scientist is measuring a static volume whereas the natural resource scientist is measuring movement of volume in time (seconds). How these two metrics correlate was not found in the literature search. With the help of WSU's water quality specialist, Robert Simmons, this gap can be bridged in the calculations noted on the end of Appendix K2 notes A - C. In step "D", the range of water needed for irrigation, including inefficiencies, is calculated to determine the total amount of water used per acre in one season by all commercial fruit trees in NCW. Considering the total cfs of all the rivers in NCW, the amount needed for tree fruits is small.

Acres of Tree Fruit	Water needed in one season **(Ac in)** average temps	Water needed in one season **(cfs)** average temps	
		15% inefficiency	40% inefficiency
1	33.45	0.004425435	0.005388795
77,459 acres[143]	2,591,003.5	342.79	417.4

A more productive dialogue is possible when we bring together these three pieces of information: the amount of water used each month by an acre of fruit trees with irrigation inefficiencies, the conversion of this amount to cfs and monthly stream flow data. Most irrigation begins in mid-March and concludes by mid-October. The heaviest use comes in July and August when temperatures are normally highest (Appendix K2).

Appendix K2 shows the water requirements for 10,000 Acres of fruit trees. This unit of trees will allow most irrigators to determine the water needed for their districts, while the cfs number for this unit of trees can be used by natural resource agencies to more easily calculate the amount of water diverted to irrigation from any given stream, river or watershed.

Using data for the Wenatchee River at Monitor, Appendix K2 shows that each block of 10,000 acres uses less than 4% of streamflow during July and about 10% during August.

6.3.4 Conclusion

The economic studies identified either examined just one aspect of agriculture in NCW or only looked at one county. Broad statistical summaries, such as the Census of Agriculture, the Washington Agriculture Statistics Service, and the WSU National Income Indicators Project were all limited either in their scope or in their ability to cut across economic sectors to show a more accurate picture of the role played by agriculture in NCW. IMPLAN data, while obviously available, could provide this analysis, but has not been used for such a study to this point.

Combining the value of the agricultural enterprises in NCW as identified in this examination, yields the following summary:

Ag Enterprise	Annual Impact	Counties Included
Tree Fruits	$798.5 Million	Chelan, Douglas, Okanogan
Livestock	$17.2 Million	Douglas, Okanogan
Cereal Grains	$46.1Million	Douglas, Okanogan (includes CRP Pymts)
	$861.8 Million	TOTAL IMPACT IN NCW

Using the minimum economic multiplier factor of 1.5, we arrive at an estimated total impact of $1.3 Billion for the economy of NCW for one year from all agricultural activity across sectors.

[143] This number represents the total of all the tree fruit acreage in Chelan, Douglas, and Okanogan counties, combined, in 2005 (WASS).

Table 6.1 Estimated cost of salmon habitat restoration activities in the Upper Columbia Basin, listed by restoration category

Category	**Annual Cost**	**Total Cost**
Acquisitions and maintenance		$100,000,000
Conservation Easements		$34,317,000
Undefined Passage Barriers		$1,750,000
Culvert Repairs/Replacements		$4,850,000
Dam/Diversion Retrofits		$2,150,000
Range Management		$960,000
Fencing		$202,000
Large Woody Debris Placement		$3,047,500
Mainstem Channel Enhancement		$4,850,000
Mainstem Floodplain Restoration		$18,775,000
Riparian Restoration		$3,594,600
Tributary Channel Enhancement		$1,920,000
Tributary Floodplain Restoration		$19,280,000
Road Maintenance	$1,540,000	$15,400,000
Road Reconstruction		$17,160,000
Road Decommissioning		$1,205,000
Fish Screening		$1,231,000
Nutrient Enhancement		$132,000
Water Quality Source Control		TBD
Instream Flow Protection		$1,718,000
Irrigation Efficiencies		$14,415,000
Water Storage		$120,000
Well Development		$3,420,000
Miscellaneous Water Quantity		$250,000
Wildlife Management		$850,000
Education	$775,250	$7,752,500
Incentives		TBD
Major Studies and Assessments		$10,750.000
Moderate Studies and Assessments		$2,845,000
Minor Studies and Assessments		$2,370,000
Monitoring	$980,000	$9,800,000
Program Management	$1,105,000	$11,050,000
TOTAL		$296,164,600

7 Relationship to Other Efforts

There are a number of conservation and watershed planning efforts in varying stages of development and implementation that directly or indirectly protect or improve the viability of naturally produced spring Chinook, steelhead, and bull trout in the Upper Columbia Basin. Described in this section is the relationship of this plan to other conservation efforts within the Upper Columbia basin. As noted earlier, this plan built upon the foundation established by these efforts and adopted portions of those plans where appropriate.

Some of the efforts currently being developed or implemented in the basin include the mid-Columbia HCPs for the operation of Wells, Rocky Reach, and Rock Island dams; Biological Opinions on the mid-Columbia HCPs; the Federal Columbia River Power System Biological Opinion and Remand; Biological Opinion on the operation of Priest Rapids and Wanapum dams; Hatchery and Genetic Management Plans (HGMPs) for federal hatcheries; Biological Opinions on the operation of state hatcheries (designed for PUD mitigation); the USFWS Bull Trout Draft Recovery Plan; U.S. Forest Service Northwest Forest Plan; Biological Opinions on Federal Actions (USFS/BLM land management activities); Okanogan Initiative; Wy-Kan-Ush-Mi Wa-Kish-Wit (Spirit of the Salmon), The Tribal Salmon Restoration Plan; Columbia River Partnership; Washington State Forest and Fish Agreement; NPCC subbasin plans; Watershed Planning under RCW 90.82; the Lead Entity process under RCW 77.85; local comprehensive and shoreline management plans and Natural Resource Conservation Service and County Conservation Districts conservation efforts.

Any material added to this plan must be reviewed by the Board.

8 Plan Implementation

8.1 Implementation Structure	8.4 Implementation Schedule
8.2 Uncertainties	8.5 Public Education and Outreach
8.3 Monitoring and Adaptive Management	8.6 Funding Strategy

Implementation of the Proposed Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan involves addressing data gaps through research, monitoring, and evaluation; establishing schedules; engaging stakeholders and landowners; identifying responsibilities; and securing funding. Many of these elements are described in this section.

8.1 Implementation Structure

The implementation structure for the recovery plan is diagramed in **Figure 8.1**. The role of each entity is described below.

8.1.1 Upper Columbia Salmon Recovery Board

The goal of the UCSRB is to strive to implement the plan in a voluntary manner. The UCSRB is the coordinating body for the Recovery Plan. Additionally, the UCSRB will facilitate improvements in resources and authorities for the region to assist in plan implementation, such as technical assistance, funding mechanisms, permitting, monitoring and outreach. The UCSRB will hire an Implementation Leader to act as the primary point of contact for the UCSRB and attend meetings as necessary.

This is a complete Implementation Structure and includes components that the UCSRB is not currently requesting funding for (M&E, Lead Entity funded activities and adaptive management efforts).

8.1.2 Implementation Process Elements

The primary functions are to facilitate the implementation, monitoring, and adaptive management processes at specific check-in dates outlined in the recovery plan or as deemed necessary by the Implementation Team and/or the Upper Columbia Salmon Recovery Board.

8.1.3 Roles and Responsibilities of the Implementation Team

A single dedicated team is needed to help ensure that the plan is implemented. The team is composed of an Implementation Team Leader (to be determined), three Lead Entity representatives (one for each County), the Regional Technical Team, local, state, NOAA Fisheries and other federal agencies, tribal resource management agencies, local stakeholders, and others. This is not part of any regulatory/enforcement function by any agency. Also, this process does not include land-use planning processes by counties and cities. The Growth Management Act and Shoreline Management Act along with related SEPA processes have defined review and administrative procedures in state law and local jurisdictions will continue to follow those procedures.

Tasks/Responsibilities

- Track the progress of the Recovery Plan. Identify milestones, benchmarks, dates, and sequencing for the list of essential tasks (the first Implementation Team deliverable). The group will meet quarterly. Assignments to individual members or subcommittees will be based on tasks.
- Prepare progress reports for NMFS, USFWS, GSRO, the UCSRB, and the public. Provide all plan information via a dedicated web site.
- Incorporate work from the Regional Technical Team to help implement the necessary monitoring and analysis actions are occurring in the region and that they are consistent with the required performance standards and metrics leading to delisting or reclassification.

Watershed Action Teams (WAT)

A local group for each watershed – referred to as a "Watershed Action Team" – will work with the UCSRB to update the implementation schedules in the plan as a component of an adaptive management framework for recovery. The UCSRB will facilitate monitoring and evaluation efforts so that the data that are collected are consistent across the region.

The Watershed Action Teams were asked to nominate a representative to participate in a regional "Implementation Team." This group will be charged with coordinating funding sources, coordinating implementation schedules across the region and coordinating monitoring and adaptive management of the plan. The UCSRB implementation structure is identified in **Figure 8.1**.

Public Involvement

It is essential that opportunities for the public to be involved in partnership with resource managers are built into this plan. This partnership will be necessary to implement the recovery actions in a well-organized manner with the ultimate goal focused on recovery of the species in an economically sensitive and timely manner. The UCSRB recommends that the WAT be used as the primary public involvement component for reviewing projects and planning in their respective communities.

In addition, the Implementation Team as a whole will work on the following tasks:

- Provide information to each subbasin for providing public involvement activities (assist monitoring program, host and maintain Recovery Plan web site). The group will work closely with watershed planning groups and Lead Entities, RTT, and the UCSRB Board.
- Attend RTT Analysis Workshops in 2009, 2012, 2015, and every third year thereafter to provide information and data to assess the plan's progress. Present information at UCSRB meetings and to resource managers.
- Host local Adaptive Management Workshops—workshop to accept all proposals for changes to the plan in 2009, 2012, 2015, and every third year thereafter. UCSRB Board will resolve changes.

In order for this Plan to be effective in achieving its goals, it needs to be used and useful in providing guidance to relevant entities and processes. The implementation process should provide timely communication and interaction between the UCSRB, NOAA Fisheries, and other entities and processes in order to be influential and, ultimately, successful.

To facilitate the implementation of this plan, the UCSRB suggests the Implementation Team coordinate through a process such as the following framework.

Conceptual Framework:

- Project sponsors need to develop project goals, funding, permitting, legal and technical requirements.
- Local watershed citizen groups (e.g., Watershed Action Teams) engage in planning processes before project development resulting in project concepts that have a high probability of public support.
- Project concept is taken to the general public explaining project goals, funding, permitting, legal and technical requirements, and processes to date involving local watershed groups.
- Based on public input and technical review, the project is refined and draft plan is developed in consultation with local watershed citizen groups (e.g., Watershed Action Teams).

8.1.4 Regional Technical Team (RTT) Roles and Responsibilities

The RTT shall consist of persons with appropriate technical skills, who shall be appointed by the RTT chairperson, in consultation with the UCSRB Board. The RTT will function under its current operating procedures.

The RTT will have three committees including monitoring and evaluation, project review, and program review. RTT meetings are open to the public except for administrative issues.

The RTT is responsible for the technical review of the recovery plan implementation, project proposals, and research, monitoring & evaluation efforts.

8.1.5 Lead Entities

The Lead Entities, under Washington State Law, are responsible for the development of the prioritized lists of projects. The prioritization process includes the Citizen Committee and RTT review and recommendations.

8.2 Uncertainties

There are currently several major “unknowns” or “uncertainties” regarding implementation of this plan, including policy, legislation, and science. This section describes information/data gaps and discusses ways to address them.

8.2.1 Policy and Legislative Uncertainties

There is some uncertainty associated with long-term funding and authorization of actions identified in this plan. Funds from the SRFB and through the HCP process (Tributary Fund) are insufficient for the large-scale actions proposed in this plan. Funds from other sources will be required if the complete Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan is to be implemented.

The application procedures for funding under BPA's Fish and Wildlife Program or the SRFB are complex and lengthy processes. The procedures are completely different and there is no reciprocity between the processes. It is recommended that BPA, the Interagency Committee for Outdoor Recreation (IAC), HCPs Tributary Fund, and SRFB standardize their application processes so that funding of recovery actions for Chinook, steelhead, and bull trout can be streamlined to the extent possible.

Finally, assurances are needed that good-faith recovery efforts based on best scientific information available will absolve the public of culpability in regard to adverse affects on ESA-listed species. In other words, if an entity has corrected problems (threats) that have been identified as detrimental to salmonids, there must be a point at which they are no longer responsible for salmonid population problems. Currently, under ESA, assurances are legally guaranteed only under Section 7 and Section 10. The UCSRB encourages the federal agencies to explore additional opportunities for assurances. A legally binding definition of discharge of responsibility for impacts to Chinook, steelhead, and bull trout populations would increase considerably voluntary participation in recovery planning, coordination, and implementation.

8.2.2 Scientific Uncertainties

Data gaps important to recovery can be divided into two major categories: (1) those that deal with critical uncertainties and (2) gaps in knowledge about the linkages between specific actions and their effects on habitat factors and VSP parameters. Some of the data gaps can be filled through monitoring and evaluation; others must be filled through research.[144]

As described in Section 3.12 and throughout Section 5, unknown aspects of environmental conditions vital to salmonid survival are termed "critical uncertainties." In this plan, critical uncertainties are a major focus of the research, monitoring, and evaluation program (Section 8.2).

Monitoring is needed to establish linkages between specific actions and resultant environmental effects. Those linkages are complex and often not well understood. Understanding them requires input from experts from various fields. It is important that the actions recommended in this plan to benefit listed fish species in the Upper Columbia Basin be reviewed by fish ecologists, geologists, hydrologists, and other experts familiar with the recovery region.

8.3 Monitoring and Adaptive Management

Monitoring is needed to assess if actions recommended in this plan achieve their desired effects. There is a risk that the recommended actions may not be adequate to achieve the goals of the plan. To manage that risk, this plan includes critical monitoring and evaluation to assess whether actions are having the predicted results and to provide information for assessing the biological status of the species addressed.

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[144] It is important to distinguish between monitoring and research. In simple terms, monitoring measures change, while research identifies the causes (mechanisms) of the change. In some cases, both monitoring and research have very similar statistical and sampling designs, differing only in their objectives.

As part of implementing the Upper Columbia Spring Salmon and Steelhead Recovery Plan, a detailed monitoring and evaluation program will be designed and incorporated into an adaptive management framework based on the principles and concepts laid out in the NMFS guidance document, ***Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance (***available at http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other-Documents.cfm).

Designing an effective monitoring program for salmon recovery involves the following initial steps:

- Clarify the questions that need to be answered for policy and management decision making, including the entire ESU, DPS, and salmonid life cycle.
- Identify entity or entities responsible for coordinating development of this program.
- Identify:
    - Which populations and associated limiting factors to monitor
    - Metrics and indicators
    - Frequency, distribution, and intensity of monitoring
    - Tradeoffs and consequences of these choices
- Assess the degree to which existing monitoring programs are consistent with NMFS guidance (e.g., Upper Columbia Monitoring Strategy; Okanogan Basin Monitoring and Evaluation Program; Draft Monitoring and Evaluation Plan for PUD Hatchery Programs; FCRPS monitoring actions; estuary monitoring programs).
- Identify needed adjustments in existing programs, additional monitoring needs, and strategy for filling those needs.
- Develop a data management plan (See Appendix B of the NMFS guidance document).
- Prioritize research needs for critical uncertainties, testing assumptions, etc.
- Identify entities responsible for implementation.

For further discussion about designing a monitoring and evaluation program, see Appendix P.

Monitoring and evaluation are designed to test implementation, validation, status/trend, and effectiveness. Implementation monitoring determines if planned actions were implemented as intended and whether all implementation objectives are on schedule. Validation monitoring determines whether the fundamental ecological assumptions underlying the recovery plan are true. Prominent among these assumptions are the effects of specific environmental conditions on survival and abundance of listed fish species as embodied in the EDT model. Status/trend monitoring determines the current conditions (status) of the ESU and DPS (based on assessment of their component populations and major population groups), of the threats to the ESU, DPS, and populations (or the factors limiting ESU and DPS recovery), and of the changes in ESU and DPS and threat status over time. Effectiveness monitoring focuses on whether recovery actions changed the environment and/or the VSP parameters of listed fish species as predicted by the plan.

In addition to monitoring implementation, status and trends, and effectiveness within the Upper Columbia Basin, monitoring and evaluation will also address actions implemented and the status of threats and limiting factors downstream from the mouth of the Yakima River. That is, monitoring and evaluation must address the full life cycle of the listed fish and all threats and limiting factors. Factors outside the Upper Columbia Basin will have a significant effect on the success of recovery of Chinook and steelhead in the Upper Columbia Basin. These factors include commercial harvest, sport and tribal harvest, conditions in the mainstem Columbia River (including hydroelectric operations), and conditions in the estuary and ocean, including short and longer-term cycles in ocean conditions.

The Board recognizes that monitoring and evaluation of actions implemented within this plan are critical to the success of recovery. The Board fully expects State, Federal, and other entities to fund monitoring and evaluation of restoration actions.

8.3.1 Implementation Monitoring

Recovery actions implemented within the Upper Columbia Basin will be monitored to assess whether the actions were carried out as planned. This will be carried out as an administrative review and will not require environmental or biological measurements.

Implementation monitoring will address the types of actions implemented, how many were implemented, where they were implemented, and how much area or stream length was affected by the action. Indicators for implementation monitoring will include visual inspections, photographs, and field notes on numbers, location, quality, and area affected by the action. Success will be determined by comparing field notes with what was specified in the plans or proposals (detailed descriptions of engineering and design criteria). Thus, design plans and/or proposals will serve as the benchmark for implementation monitoring. Any deviations from specified engineering and design criteria will be described in detail.

8.3.2 Status/Trend Monitoring

The status and trend of spring Chinook, steelhead, and bull trout and their habitats will be monitored throughout the Upper Columbia Basin following the guidelines in the Upper Columbia Monitoring Strategy (Hillman 2004).[145] Within each subbasin, status/trend sampling sites will be selected according to recovery plan priorities and the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) design, which is a spatially balanced, site-selection process developed for aquatic systems and recommended within the Upper Columbia Monitoring Strategy. This approach has been used successfully within the Wenatchee subbasin (under the Upper Columbia Monitoring Strategy) and in the Okanogan subbasin (under the Okanogan Basin Monitoring and Evaluation Program). The Upper Columbia Monitoring Strategy describes in detail the approach, indicators, and protocols needed to assess

[145] The Upper Columbia Monitoring Strategy was implemented within the Wenatchee subbasin as a pilot study in 2004. The strategy will be refined as new information becomes available through the pilot study and through other monitoring programs (e.g., Okanogan Basin Monitoring and Evaluation Program).

status and trends of listed fish species and their habitats in the Upper Columbia Basin. This strategy will be updated annually as new information becomes available. Further assessment is needed to evaluate if the Upper Columbia Monitoring Strategy is consistent with NOAA guidance and sufficient to measure the viability attributes and limiting factors for the listed ESU and DPS.

8.3.3 Effectiveness Monitoring

Not all recovery actions recommended in this plan need to be monitored for effectiveness. As noted in Section 5.5, only three replicates of each habitat restoration "class" implemented within each subbasin is needed to assess effectiveness. Habitat classes and their associated "specific" actions are listed in **Table 5.8**. To the extent possible, effectiveness of recovery actions will be monitored using the Before-After-Control-Impact (BACI) design with stratified random sampling, as described in the Upper Columbia Monitoring Strategy (Hillman 2004). The Upper Columbia Monitoring Strategy describes in detail the approach, indicators, and protocols needed to assess effectiveness of habitat restoration classes. Hatchery actions will be monitored according to the Draft Monitoring and Evaluation Plan for PUD Hatchery Programs (Murdoch and Peven 2005). It is also critically important to coordinate these effectiveness monitoring programs with status/trend monitoring and effectiveness monitoring within the Hydro sector.

8.3.4 Research

As noted earlier, unknown aspects of environmental conditions vital to salmonid survival are termed "critical uncertainties." In this plan, critical uncertainties are a major focus of research. Critical uncertainty research targets specific issues that constrain effective recovery plan implementation. This includes evaluations of cause-and-effect relationships between fish, limiting factors, and actions that address specific threats related to limiting factors. Listed below are research actions that are needed to assess the effects of the uncertainties on recovery of listed fish species in the Upper Columbia Basin. Research actions address both in-basin and out-of-basin factors and are not all-inclusive. As part of plan implementation, these research actions will be prioritized.

Harvest

- Evaluate innovative techniques (e.g., terminal fisheries and tangle nets) to improve access to harvestable stocks and reduce undesirable direct and indirect impacts to naturally produced Upper Columbia stocks.

- Evaluate appropriateness of stocks used in weak-stock management.

- Develop better methods to estimate harvest of naturally produced fish and indirect harvest mortalities in freshwater and ocean fisheries.

Hatchery

- Assess the interactions between hatchery and naturally produced fish.

- Determine relative performance (survival and productivity) and reproductive success of hatchery and naturally produced fish in the wild.

- Assess if hatchery programs increase the incidence of disease and predation on naturally produced fish.
- Examine the feasibility and need of steelhead kelt reconditioning.

Hydro Project

- Evaluate if passage through hydroelectric projects affects reproductive success of listed fish species.
- Assess baseline survival estimates for juvenile listed fish species as they pass hydroelectric projects.
- Assess the effects of hydroelectric operations on juvenile and subadult bull trout survival.
- Assess the effects of temporary powerhouse shutdowns on the incubation success of steelhead in spawning gravels in the Chelan tailrace.

Habitat

- Implement selected restoration projects as experiments.
- Increase understanding of estuarine ecology of Upper Columbia stocks.
- Increase genetic research to identify genotypic variations in habitat use.
- Increase understanding of linkages between physical and biological processes so managers can predict changes in survival and productivity in response to selected recovery actions.
- Examine relationships between habitat indicators and landscape variables.
- Examine fluvial geomorphic processes to better understand their effects on habitat creation and restoration.
- Examine water balance and surface/groundwater relations (in the sense of Konrad et al. 2003), especially the benefits of aquifer recharge during periods of high runoff in appropriate areas. Using the results inferred from these studies, evaluate the effects of aquifer recharge on late summer and winter instream flows and resultant habitat use. Implement and document an aquifer recharge demonstration project in the Methow Basin by diverting excess water during times of high spring runoff through selected unlined irrigation ditches. Evaluate the effect of this action (with selected irrigation ditches to be designated as control) to enhance stream flows at critical times on spring Chinook salmon and steelhead habitat use.
- Test assumptions and sensitivity of EDT model runs.
- Evaluate nutrient enrichment benefits and risks using fish from hatcheries or suitable analogs.
- Assess population structure and size of bull trout in the Upper Columbia Basin.
- Assess the presence of bull trout in the Lake Chelan and Okanogan subbasins and upstream of Entiat Falls in the Entiat subbasin.

- Assess the effectiveness and feasibility of using fish transfers, range expansion, and artificial propagation in bull trout recovery.
- Examine migratory characteristics and reproductive success of bull trout.
- Describe the genetic makeup of bull trout in the Upper Columbia Basin.

Ecological Interactions

- Determine the effects of exotic species on recovery of salmon and trout and of the feasibility to eradicate or control their numbers.
- Examine consumption rates of fish (especially exotics) that feed on listed fish species.
- Determine the interactions and effects of shad on Upper Columbia stocks in the lower Columbia River.
- Determine the significance of marine mammal predation on Upper Columbia stocks and alternatives for management in the Columbia River mainstem and estuary.
- Assess the occurrence of resident bull trout populations and their interactions with migrant (fluvial and adfluvial) populations.
- Determine the effects of brook trout and bull trout interactions (competition, predation, and hybridization).
- Evaluate the interactions of bull trout with spring Chinook and steelhead.

8.3.5 Data Management

Because the indicators and protocols recommended in this plan are from the Upper Columbia Monitoring Strategy, this plan will incorporate the data dictionary and infrastructure being developed for that program. The data management program is being developed by the Bureau of Reclamation, Spatial Dynamics, Inc., and Commonthread, Inc., with input from State, Federal, and Tribal agencies and consultants. The data dictionary is a data management tool that provides a comprehensive conceptual framework based on the monitoring indicators and data collection protocols. The data dictionary will also include a geo-database (incorporating an ArcHydro Geodatabase Model) that will host GIS work (landscape classification information). The data dictionary will be used to develop field forms that crews will fill out during data collection.

Data will be compiled, analyzed, and reported using protocols developed by the Implementation Team. The protocols will allow easy access by the public, but data entry will be limited to authorized individuals identified by the Implementation Team.

Before new data management systems and protocols are developed, efforts will be made to coordinate with state and other regional systems to limit costs and improve the ability to roll up information for evaluation across the region. Project data management will be informed by the PCSRF data system, guidance from PNAMP's effectiveness work group, and NOAA guidance.

8.3.6 Adaptive Management

Adaptive management has been defined in Washington State law as "reliance on scientific methods to test the results of actions taken so that the management and related policy can be changed promptly and appropriately" (RCW 79.09.020). It is described as a cycle occurring in four stages: identification of information needs; information acquisition and assessment (monitoring); evaluation and decision-making; and continued or revised implementation of management actions. Adaptive management is captured in the sequence: "hypothesis statement," "monitor," "evaluate," and "respond."

This plan has identified information needs and suitable monitoring programs. Evaluation will occur at three levels (**Figure 8.2**):

- **Scientific Evaluation**—An evaluation of available information by independent scientists to assess the strengths and weaknesses of the actions.
- **Public Evaluation—**An evaluation of available information by the public to assess and monitor socio-economic factors and impacts.
- **Decision-Making Evaluation—**An evaluation of available information by decision-makers, who determine what alternatives and management actions are needed when "triggers" are reached.[146]

The purpose for evaluation is to interpret information gathered from monitoring and research, assess deviations from targets or anticipated results (hypothesis), and recommend changes in policies or management actions where appropriate. Input from both independent scientists, stakeholders, and the general public are required. These groups will annually provide feedback to decision makers (UCSRB based on recommendations from the Implementation Team), who have the responsibility to change policies or management actions.

8.3.7 Check-In Schedule

The Upper Columbia Salmon Recovery Board with NOAA Fisheries and the USFWS will conduct mid-point evaluations, or "check-ins" in years 1, 3, 5, 8, 12, and every fourth year thereafter, following implementation. The first ***Check-In Report***, submitted one year after the plan begins to be implemented, will primarily address progress made towards obtaining funding, initiating studies, developing priorities, and other programmatic issues. To the extent possible, it will also provide updates to adult fish returns (spawners), abundance and abundance trends, and juvenile fish survival (including smolts/redd estimates). Later reports will detail research and monitoring results. If necessary, these results will be used to "adaptively" modify and prioritize the implementation schedule. The UCSRB acknowledges that rapid implementation of actions is key to the success of this plan.

It is important that the public and the agencies have confidence in the recommended recovery actions and in the science that supports the actions. Accordingly, the Upper Columbia Salmon Recovery Board, working through the Implementation Team and technical workgroups, will obtain independent scientific review of its 3-, 5-, 8-, and 12-year evaluation reports. Beyond the

[146] Triggers and thresholds will be developed by the Implementation Team with NMFS and USFWS.

12-year check-in, independent scientific review will be under the discretion of the Upper Columbia Salmon Recovery Board and the Implementation Team.

8.3.8 Consistency with Other Monitoring Programs

An important aspect of this recovery plan is that it will rely on existing monitoring programs to evaluate the status/trend and effectiveness of recovery actions within the Upper Columbia Basin, to the extent that existing programs are consistent with NOAA guidance and are sufficient for recovery needs. Specifically, this plan incorporates by reference the Upper Columbia Monitoring Strategy (Hillman 2004), the Okanogan Basin Monitoring and Evaluation Program, and the Draft Monitoring and Evaluation Plan for PUD Hatchery Programs (Murdoch and Peven 2005). The former two address status/trend and effectiveness monitoring of habitat actions, while the latter addresses status/trend and effectiveness of hatchery actions. The PUDs currently have monitoring programs identified in their HCPs and Biological Opinions to address hydroproject actions. Actions implemented in areas downstream from the ESU and DPS will be addressed within the Action Agencies/NOAA Fisheries RME Program for the FCRPS Biological Opinion. This plan encourages these programs to continue.

The development of other regional monitoring programs may result in modifications to the monitoring programs used in the Upper Columbia Basin. These other programs, in various states of development, include the Bull Trout Recovery Monitoring and Evaluation Program being developed by the Recovery Monitoring and Evaluation Technical Group (RMEG), the Collaborative, Systemwide Monitoring and Evaluation Project (CSMEP), and the Pacific Northwest Aquatic Monitoring Partnership (PNAMP). As these programs develop more fully, they will provide guidance on valid sampling and statistical designs, measuring protocols, and data management. This information may be used to refine and improve the existing monitoring and evaluation programs in the Upper Columbia Basin. The intent is to make monitoring and evaluation programs more consistent throughout the Columbia Basin and Pacific Northwest.

8.3.9 Coordination

Many entities have been or will be implementing recovery and other actions within the Upper Columbia Basin. It is critical that these programs be coordinated to reduce redundancy, increase efficiency, and minimize costs. Monitoring programs implemented within the Upper Columbia region include:

- Upper Columbia Monitoring Strategy,
- Okanogan Basin Monitoring and Evaluation Program,
- Action Agencies/NOAA Fisheries RME Program,
- Draft Monitoring and Evaluation Plan for PUD Hatchery Programs,
- Washington Salmon Recovery Funding Board Program,
- HCPs Monitoring Programs,
- Coho Reintroduction Monitoring Program,
- PACFISH/INFISH Monitoring Program,

- Pacific Northwest Interagency Regional Monitoring Program,
- USFWS, USGS, and BOR monitoring programs, and
- WDFW and Department of Ecology monitoring programs.

In 2004, the Upper Columbia Regional Technical Team (UCRTT) and its monitoring subcommittee began the process of coordinating monitoring activities in the Upper Columbia Basin. The UCRTT holds annual meetings with entities conducting monitoring activities within the Upper Columbia Basin with the purpose of coordinating activities and sharing information. The UCRTT is working to enhance coordination between the Upper Columbia Monitoring Strategy, the Okanogan Basin Monitoring and Evaluation Program, and other monitoring programs in the Upper Columbia Basin. These efforts have been beneficial and this plan encourages the process established by the UCRTT to continue. The UCRTT will also coordinate an assessment of the programs incorporated by reference into this plan to evaluate their consistency with NOAA guidance and their sufficiency for recovery.

8.4 Implementation Schedule

Recovery of listed species is a long process that requires sacrifice, patience, and courage. Because limited resources do not allow all actions to be implemented immediately, it is important to sequence actions according to their importance to recovery. This section of the plan describes a method for sequencing actions. Because of a lack of information, many details of the schedule remain undefined. For example, information is lacking on identification of response triggers, identification of milestones, and designation of management responses to triggering events. Nonetheless, general features of the implementation schedule can be described including the approach to prioritization of actions.

8.4.1 Sequence of Actions

This plan has identified a large number of recovery actions that need to be implemented within the Upper Columbia Basin. As noted earlier, resources are not currently available to implement all the recovery actions in the near term. Therefore, it is important to sequence or prioritize actions within and between all sectors. In this section, the plan identifies a general framework for sequencing recovery actions within the Upper Columbia Basin.

The framework categorizes projects or actions based on multiple objectives and characteristics. It also establishes a general model for selecting and implementing actions that will lead to recovery of Upper Columbia spring Chinook, steelhead, and bull trout. The approach is based on biological effectiveness and socio-economic feasibility. Actions listed in Appendix G will serve as the basis for project prioritization. ***This framework is intended as a guide. It is not intended to exclude any projects listed in Appendix G from implementation.*** This framework has been used successfully in the Entiat subbasin. The framework may evolve as new information from RME becomes available.

Project sequencing is organized into four general “tiers” of priority (Figure 8.3):

Tier I: Higher biological benefit; lower cost; higher feasibility

Tier II: Higher biological benefit; higher cost; lower feasibility

Tier III: Lower biological benefit; lower cost; higher feasibility

Tier IV: Lower biological benefit; higher cost; lower feasibility

The process of sequencing actions includes:

- Assigning a qualitative ranking of the biological benefits to each strategy. This ranking is based on how well each project addresses the VSP parameters.
- Rate the feasibility of each project. Criteria used to rate feasibility could range from professional and stakeholder input to an in-depth feasibility study. Criteria needed to describe feasibility should include at least: time to implement; constructability; acceptance by local governments; and acceptance by local stakeholders.
- Rate projects based on cost. Various methods can be used to estimate cost, but initially it can be quantitative.

After projects are rated on feasibility and cost, they are then compared to biological benefit. Those projects that are relatively inexpensive and ordered relatively high on feasibility and biological benefit will appear as Tier I projects. Tier IV projects have the lowest biological benefits and feasibility and relatively high costs. Projects in this tier should be implemented only if there are no projects within other tiers. Appendix L provides an example of the use of the prioritization framework.

Using this method, an implementation schedule for the Upper Columbia Basin was prepared (Appendix M). The implementation schedule is a living document that will be revised annually by the local habitat groups and the UCSRB and RTT.

8.4.2 Assurances of Implementation

The various levels of governments, tribes, non-governmental entities, and citizens have made commitments through participation in on-going and developing processes and participating in actions (projects) throughout the Upper Columbia Basin. In particular, the Upper Columbia Salmon Recovery Board has expended considerable political capital in developing this recovery plan by addressing difficult and sensitive issues. The success of this plan is dependent on the cooperation among agencies, entities, and citizens within and outside the region. The region has recognized that recovering spring Chinook, steelhead, and bull trout populations has positive effects to many aspects of the local quality of life.

8.5 Public Education and Outreach

The recovery of spring Chinook, steelhead, and bull trout in the Upper Columbia Basin is dependent on the collective actions of the people in the region. Recovery cannot be accomplished through legislation, rules, or money. These are only tools for recovery. It depends on the cumulative effort of people working as individuals and collectively through and with organizations and governmental entities to achieve a common goal. In this case, the goal is the recovery of spring Chinook, steelhead, and bull trout to viable and sustainable levels. It must provide for the equitable sharing of burdens and benefits across affected interests and regions. Recovery will require fundamental changes in how we view, care for, and manage our fish, streams, and watersheds. A successful recovery program must work for people and fish. It must be sound biologically and technically and also be sensitive and responsive to regional and local cultural, social, and economic values. Documentation of public outreach efforts during the development of this plan is included in Appendix N.

8.5.1 Goal

It is a goal of public education and outreach to engage the public as an active partner in ***implementing and sustaining*** recovery efforts. This goal will be achieved by building public awareness, understanding, and support; and by providing opportunities for participation in all aspects of recovery implementation. The term "public" is intended to be inclusive of individuals, community groups, environmental and conservation organizations, businesses, agricultural interests, recreational interests, and others with a stake or role in achieving recovery.

Through a collaborative process, members of the public and scientists will exchange information and tools needed to effectively support and participate in recovery. This effort must continue so that support for recovery increases over time and integrates the continual changes in the local and regional environments. Recovery is sharing responsibility and requiring coordinated and complementary participation at the federal, tribal, state, local, and citizen levels.

8.5.2 Principles

Planning and implementation must be done in a collaborative and transparent manner with opportunities for the public to be fully engaged and involved at each step. Decisions for recovery of salmon and trout affect the future of all those who live and work in this region, so the counties are committed to understanding the diverse needs and concerns of the public, and to learning from experiences.

The dissemination of information should be thorough and a shared responsibility to enhance public education and to promote the broadest understanding of the region's needs. Additionally, existing information will be used to characterize community goals related to regional recovery planning and adaptive management including such aspects as economic development, land use, environmental perspectives, and social issues.

Public participation is a dynamic activity that requires teamwork and commitment. In developing this plan, it has become clear that engaging the interested citizen is challenging. Effective public participation and involvement requires building relationships. Local citizens have more confidence and ownership of local processes than regional processes.

8.5.3 Implementation

As noted above, public education and outreach is a responsibility shared by all implementation partners. Each implementing partner must have an effective public education and outreach effort tailored to its recovery responsibilities and the needs of its constituency. Each implementing partner must also be able to represent the regional recovery effort accurately and consistently and to put its actions in the broader context of the regional effort. While the purpose of these programs is to build awareness, understanding, support, and participation, multiple public education and outreach efforts also have the potential to overwhelm and confuse the public and to be repetitive and wasteful. Therefore, existing functional watershed groups/venues should be used as often as possible for information sharing.

The implementation approach relies largely on the individual implementing partners. It also identifies measures and actions to coordinate and integrate these individual efforts into an effective regional public education and outreach effort that will enhance consistency, avoid redundancy, and leverage efforts and resources.

A regional education and outreach program will be established to support, assist, and coordinate local efforts by implementation partners. The UCSRB in consultation with the implementing partners will develop the regional program. The program will be consistent with the principles discussed above and will:

- Develop and distribute informational and educational materials explaining the reasons for the recovery effort and the goals, strategies, measures, actions, and priorities of the recovery plan.
- Coordinate and facilitate communication and information sharing among agencies, governments, organizations, and the public. This will include a regional communications network, information clearinghouse, and identification of informational contacts for implementing partners.
- Identify opportunities for and assist implementing partners in integrating or consolidating similar, duplicative, or complementary education and outreach efforts. Provide the public with information on implementation actions throughout the region, including notice of opportunities to participate and information sources.
- Provide the public with information on the progress, status, and achievements of recovery actions throughout the region.
- Encourage and assist schools and educational organizations, such as conservation districts and WSU cooperative extension, to integrate salmon recovery into their environmental, agricultural, watershed, water quality curriculum, and classes. Also support agency, local government, and utility educational programs promoting actions by individuals to protect and conserve water resources.
- Coordinate briefings and presentations to civic, business, trade, environmental, conservation, and fishing organizations on the regional recovery program, actions, and progress.
- Establish regional measures to acknowledge and celebrate the contributions of organizations, businesses, and individuals. Publicize incentive programs for the protection and restoration of water resources and habitat and encourage landowner participation.
- Encourage business and professional organizations to adopt and promote implementation of best management practices for the protection and restoration of fish and habitat.
- Encourage and assist local or community organizations interested or involved in watershed and habitat protection and restoration.
- Develop a resource publication to assist implementing partners and the public with funding education and recovery programs and projects.

In concert with the development of the public education and outreach plan, the implementing partners will be requested to prepare an education and outreach plan for their implementing activities. While public entities are already required by law or rule to have some form of public education and outreach, these plans would help to strengthen efforts by the implementing partners are consistent with the principles and regional program discussed above and coordinated with the efforts of other implementing partners.

8.6 Funding Strategy

As indicated in Section 6, recovery of listed fish species in the Upper Columbia Basin may cost at least 125 million dollars. A major uncertainty is exactly how recovery will be funded. HCPs and binding mitigation agreements help guarantee that some programs (e.g., state-run mitigation hatchery programs, tributary habitat fund, etc.) have secure funding and will continue operating into the future. However, these programs fall well short of funding the total needs of this plan. Additional funding will be required to implement this recovery plan.

8.6.1 Funding Sources

This plan will rely on the following funding sources to aid in implementing the Upper Columbia Salmon Recovery Plan.

- The Washington Salmon Recovery Funding Board.
- Public Utility District funds.
- The Bonneville Power Administration (BPA) Fish and Wildlife Program.
- The Federal Columbia River Power System Biological Opinion.
- Appropriations from the Washington State Legislature for state agency budgets (WDFW, WDOE, Conservation Districts).
- Pacific Coast Salmon Recovery Fund (NMFS).
- Appropriations from the U.S. Congress for federal agency (USACE, USFWS, USGS, USFS, NRCS, BOR, and BLM).
- Local government mechanisms funded through state legislative appropriations.
- Other nongovernmental organizations such as the National Fish and Wildlife Foundation, Regional Fishery Enhancement Groups, the Bonneville Environmental Foundation, and the Bullitt Foundation.
- NOAA Community-Based Restoration Program.
- Voluntary projects funded through public and private partnerships.

The UCSRB recommends that in addition to funding recovery actions, funding sources shall also pay for all monitoring and evaluation activities associated with recovery actions.

8.6.2 Order In Which Projects Will Be Funded

Projects will be funding according to the prioritization framework described in Section 8.3.1. In short, the prioritization of projects for funding will be based on a balance between the biological benefit of the project and the cost and feasibility of implementing the project (see Figure 8.3).

Projects that address primary limiting factors, have high biological benefit, are relatively inexpensive, and are feasible to implement will receive highest funding priority. Projects that are expensive, have low biological benefit to listed fish species, and have relatively low feasibility will receive lowest funding priority.

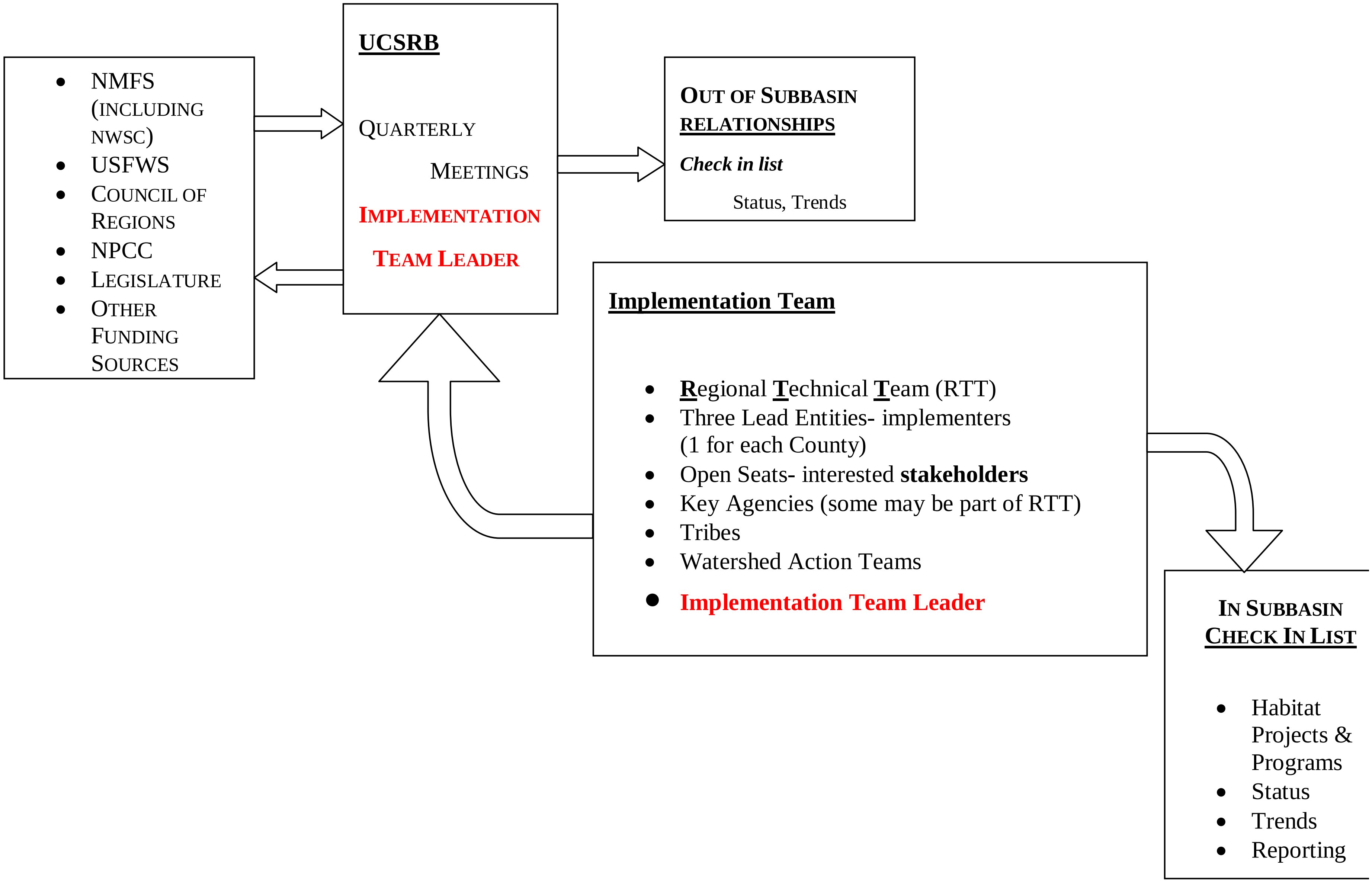

Figure 8.1 Diagram showing implementation structure

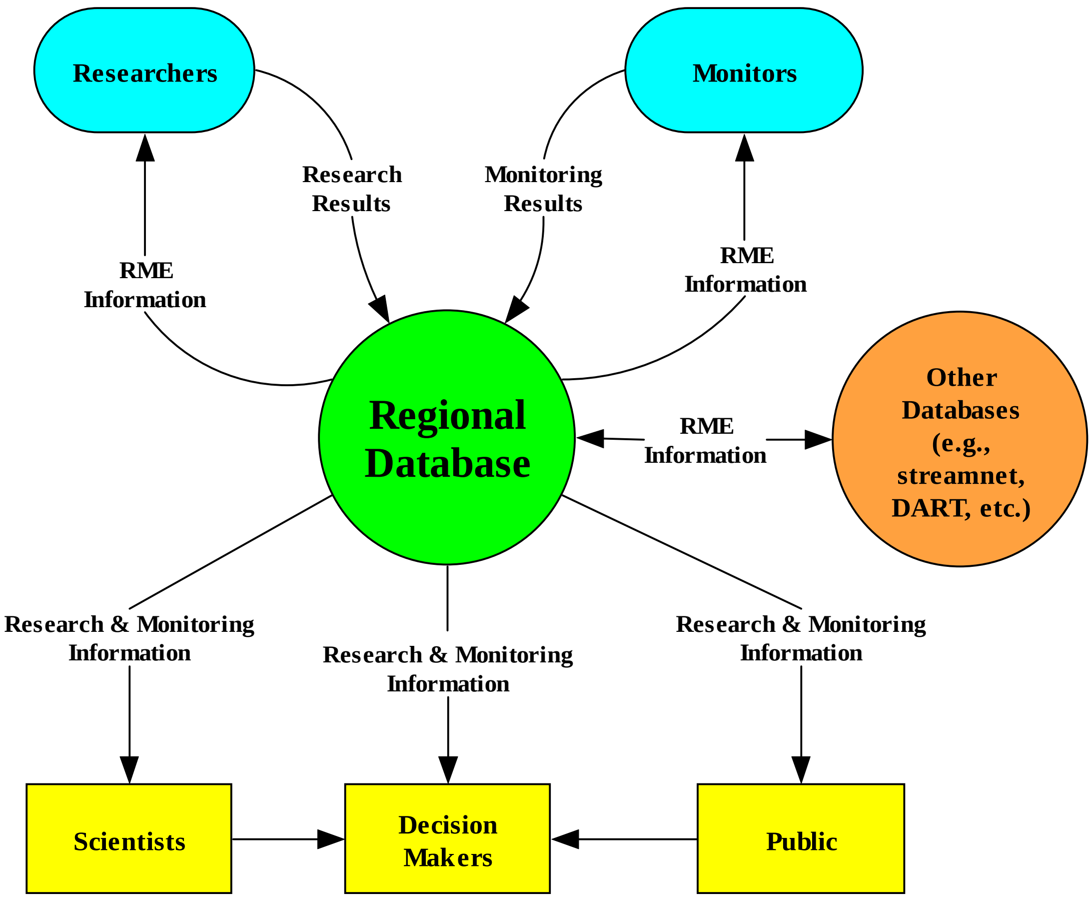

Figure 8.2 Diagram showing the flow of information from researchers and monitors in the Upper Columbia Basin to scientific reviewers, public, and decision makers.

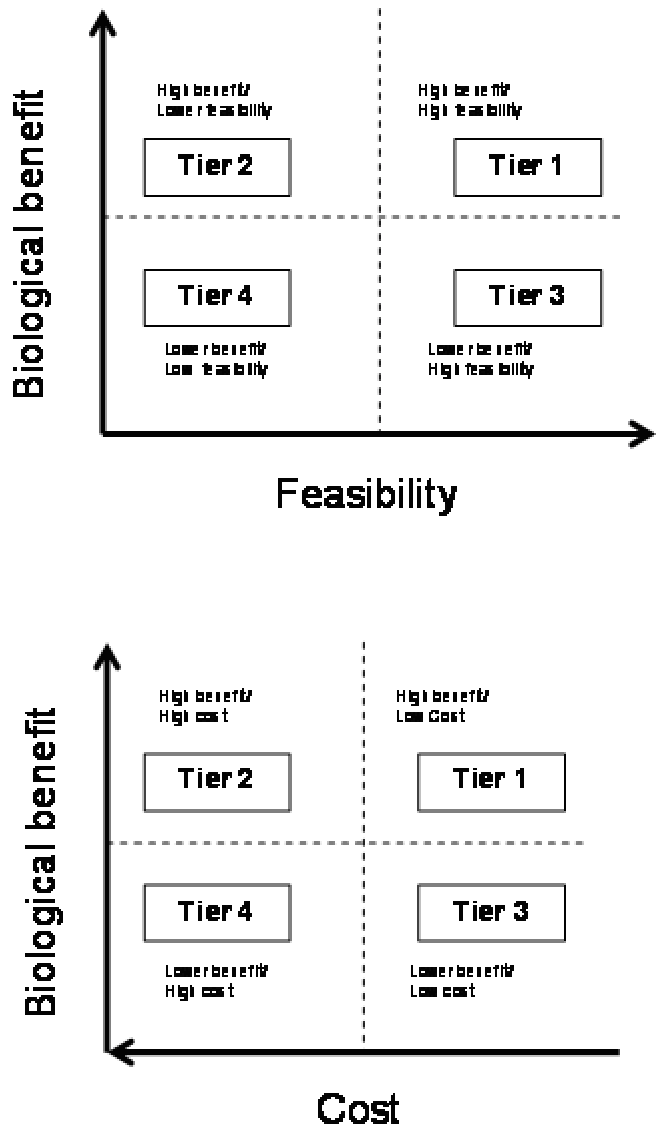

Figure 8.3 Relationships between biological benefits, costs, and feasibility for prioritizing (sequencing) recovery actions. Tier 1 actions receive the highest priority, while Tier 4 actions receive the lowest.

9 Acronyms

ACOE	Army Corps of Engineers
ADA	Americans with Disabilities Act
AHA	All H Analyzer
APRE	Artificial Production Review and Evaluation
BAMP	Biological Assessment and Management Plan
BKD	bacterial kidney disease
BLM	Bureau of Land Management
BMPs	Best Management Practices
BO	Biological Opinion
BOD	Biological Oxygen Demand
BOR	U.S. Bureau of Reclamation
BPA	Bonneville Power Administration
C&S	ceremonial and subsistence
CAO	Critical Area Ordinances
Colville Tribes	Confederated Tribes of the Colville Nation
CPUD	Chelan County Public Utility District
CREP	Conservation Reserve Enhancement Program
CRFMP	Columbia River Fish Management Plan
CSMEP	Collaborative, Systemwide Monitoring and Evaluation Project
CTH	Colville Trout Hatchery
CWT	coded wire tag
DNA	deoxyribonucleic acid, genetic information
DPS	distinct population segment
DPUD	Douglas County Public Utility District
EDT	ecosystem diagnosis and treatment
EFC	Evergreen Funding Consultants
EIBS	erythrocytic inclusion body syndrome
EMAP	Environmental Monitoring and Assessment Program

ENFH	Entiat National Fish Hatchery
ESA	Endangered Species Act
ESU	evolutionarily significant unit
EWU	Eastern Washington University
FCRPS	Federal Columbia River Power System
FERC	Federal Energy Regulatory Commission
FR	Federal Register
FRD	Fruit Reporting Districts
FRN	Federal Register Notice
FWEE	Foundation for Water and Energy Education
GCFMP	Grand Coulee Fish Maintenance Project
GM	geometric mean, sometimes specific to 12-year span
GMA	Growth Management Act
GPUD	Grant County Public Utility District
HB	House Bill
HCP	Habitat Conservation Plan
HE	hatchery effectiveness
HGMP	Hatchery and Genetic Management Plan
HSRG	Hatchery Scientific Review Group
IAC	Interagency Committee for Outdoor Recreation
ICBTRT	Interior Columbia Basin Technical Recovery Team
ISAB	Independent Scientific Advisory Board
ISRP	Independent Scientific Review Panel
IHN	infectious hepatopoietic necrosis
IPNV	infectious pancreatic necrosis virus
LNFH	Leavenworth National Fish Hatchery
LWD	Large Woody Debris
MFHC	Methow Fish Hatchery Complex
NCW	North Central Washington

NFH	National Fish Hatchery
NIIP	National Income Indicators Project
NMFS	National Marine Fisheries Service
NNI	no net impact
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
NPPC	Northwest Power Planning Council
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NWFSC	Northwest Fisheries Science Center
PATH	Plan for Analyzing and Testing Hypotheses
PCSRF	Pacific Coastal Salmon Recovery Fund
PFMC	Pacific Fishery Management Council
PIT	passive integrated transponder
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
PSC	Pacific Salmon Commission
PUD	Public Utility District
QAR	Quantitative Analysis Report
QHA	quantitative habitat analysis
RCW	Revised Code of Washington
RIFHC	Rock Island Fish Hatchery Complex
RME	research, monitoring, and evaluation
RMEG	Recovery Monitoring and Evaluation Technical Group
RTT	Regional Technical Team
SAR	smolt-to-adult return rate
SEPA	State Environmental Policy Act
SMA	Shoreline Management Act
TAC	***U.S. v Oregon*** Technical Advisory Committee
TMDL	Total Maximum Daily Load

TRT	Technical Recovery Team (see ICBTRT)
UCB	Upper Columbia Basin
UCHCC	Upper Columbia Habitat Coordination Committee
UCR	Upper Columbia Region
UCRTT	Upper Columbia Regional Technical Team
UCSRB	Upper Columbia Salmon Recovery Board
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
VSP	viable salmonid population
WAESD	Washington State Employment Security Department
WASS	Washington Agricultural Statistics Service
WAT	Watershed Action Teams
WDFW	Washington Department of Fish and Wildlife
WDOE	Washington Department of Ecology
WFH	Wells Fish Hatchery
WMA	Watershed Management Act
WNFH	Winthrop National Fish Hatchery
WRIA	watershed resource inventory area
WSU	Washington State University
YN	Yakama Nation

10 Glossary

abundance. Refers to the total number of individual organisms in a population or subpopulation. In this plan, abundance refers to the total number of spawning adults within a population.

adaptive management. A management process that applies the concept of experimentation to design and implementation of natural resource plans and policies.

adaptive trait. Characteristics that improve an individual's survival and fitness.

adfluvial bull trout. Bull trout that migrate from tributary streams to a lake or reservoir to mature (one of three bull trout life's histories). Adfluvial bull trout return to a tributary to spawn.

age class. A group of individuals of a species that have the same age (e.g., 1 year old, 2 year old, etc).

aggrading stream. A stream that is actively building up its channel or floodplain by being supplied with more bedload than it is capable of transporting.

allochthonous. Includes all organic matter that a stream receives from production that occurred outside the stream channel. It often constitutes a larger fraction of a stream's total inputs of organic matter. (See autochthonous.)

alluvial. Pertaining to or composed of slits and clays (usually) deposited by a stream of flowing water. Alluvial deposits may occur after a flood event.

alluvial fan. A sedimentary deposit located at a topographic break such as the base of a mountain front, escarpment, or valley side, that is composed of streamflow and/or debris flow sediments and that has the shape of a fan, either fully or partially extended.

anadromous (fish). A fish that is hatched in fresh water, migrates to the ocean to grow and live as an adult, and then returns to freshwater to spawn (reproduce).

artificial propagation. The use of artificial procedures to spawn adult fish and raise the resulting progeny in fresh water for release into the natural environment, either directly from the hatchery or by transfer into another area.

autochthonous. Includes organic matter that is produced within the stream. Primary production by periphyton, macrophytes, and phytoplankton constitutes important autochthonous sources. (See allochthonous.**)**

bedload. Sediment particles that are moved on or immediately above the streambed, such as the larger heavier particles (gravel, boulders) rolled along the bottom; the part of the load that is not continuously in suspension.

braided stream. A stream that forms an interlacing network of branching and recombining channels separated by islands and channel bars. Generally a sign of stream disequilibrium resulting from transportation of excessive rock and sediment from upstream areas and characteristic of an aggrading stream in a wide channel on a floodplain.

bypass system (fish). Structure in a dam that provides a route for fish to move through or around a dam without going through the turbines.

canopy cover (of a stream). Vegetation projecting over a stream, including crown cover (generally more than 1 meter (3.3 feet) above the water surface) and overhang cover (less that 1 meter (.3 feet) above the water).

carrying capacity (fish). Refers to the predicted average maximum number of fish that can be sustained in a habitat over the long term.

channel morphology. The physical dimension, shape, form, pattern, profile, and structure of a stream channel.

channel stability. The ability of a stream, over time and in the present climate, to transport the sediment and flows produced by its watershed in such a manner that the stream maintains its dimension, pattern, and profile without either aggrading or degrading.

channelization. The straightening and deepening of a stream channel to permit the water to move faster, to reduce flooding, or to drain wetlands.

char. A fish belonging to the genus Salvelinus and related to both the trout and salmon. The bull trout, Dolly Varden trout, brook trout, and the Mackinaw trout (or lake trout) are all members of the char family. Char live in the icy waters (both fresh and marine) of North America and Europe.

community. Any group of organisms belonging to a number of different species that co-occur in the same habitat or area and interact through trophic and spatial relationships.

community structure. Number of species and their abundance within a community.

complex interacting groups. Multiple local populations that may have overlapping spawning and rearing areas within a geographic area.

core area. The combination of core habitat (i.e., habitat that could supply all elements for the long-term security of bull trout) and a core population (a group of one or more local bull trout populations that exist within core habitat) constitutes the basic unit on which to gauge recovery within a recovery unit. Core areas require both habitat and bull trout to function, and the number (replication) and characteristics for local populations inhabiting a core area provide a relative indication of the core area's likelihood to persist. A core area represents the closest approximation of a biologically functioning unit for bull trout.

core habitat. Habitat that encompasses spawning and rearing habitat (resident populations), with the addition of foraging, migrating, and overwintering habitat if the population includes migratory fish. Core habitat is defined as habitat that contains, or if restored would contain, all of the essential physical elements to provide for the security of allow for the full expression of life history forms of one or more local populations of bull trout. Core habitat may include currently unoccupied habitat if that habitat contains essential elements for bull trout to persist or is deemed critical to recovery.

core population. A group of one or more bull trout local populations that exist within core habitat.

coterminous. Used of organisms having similar distributions.

Council of Regions. An ***ad hoc*** consortium of regional salmon recovery organizations in Washington State that improves coordination on salmon recovery issues.

Distinct Population Segment (DPS). A listable entity under the Endangered Species Act that meets tests of discreteness and significant according to U.S. Fish and Wildlife Service and NOAA Fisheries policy.

deposition (stream). The settlement of accumulation of material out of the water column and onto the streambed. Occurs when the energy of flowing water is unable to support the load of suspended sediment.

depositional areas (stream). Local zones within a stream where the energy of flowing water is reduced and suspended material settles out, accumulating on the streambed.

discharge (stream). With reference to stream flow, the quantity of water that passes a given point in a measured unit of time, such as cubic meters per second or, often, cubic feet per second.

diversity. All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population.

domestication. The process of fish becoming genetically adapted to conditions of artificial propagation. Because fish are adapted to conditions of artificial propagation, their survival and the survival of their offspring is less than that for naturally produced fish that are genetically adapted to natural conditions.

ecoregion. A relatively uniform area defined holistically based on geology, climate, landform, soil, vegetation, and water.

ecosystem. A community of organisms and their physical environment interacting as an ecological unit.

effective population size. The number of breeding individuals that would give rise to the same amount of random genetic drift as the actual population, if ideal conditions held.

embeddedness. The degree to which large particles (boulders, gravel) are surrounded or covered by fine sediment, usually measured in classes according to percentage covered.

entrainment. Process by which aquatic organisms are pulled through a diversion, turbine, spillway, or other device.

Evolutionarily Significant Unit (ESU). A population or group of populations that is reproductively isolated from other population units and represents an important component in the evolutionary legacy of the species.

exotic. A non-native or foreign organism or species that has been introduced into an area.

extant. Existing or living at the present time.

extirpation. The total elimination of a species from a particular local area.

fecundity. The number of eggs readied for spawning by a female. It is usually expressed as the number of eggs per size (length or weight) of female.

fine sediment (fines). Sediment with particle sizes of 2.0 mm (.08 inch) or less, including sand, silt, and clay.

fish ladder. A device to help fish swim around a dam.

floodplain. Adjacent to stream channels, area that are typified by flat ground and are periodically submerged by floodwater.

flow regime. The quantity, frequency, and seasonal nature of water flow.

fluvial bull trout. Bull trout that migrate from tributary streams to larger rivers to mature (one of three bull trout life histories). Fluvial bull trout migrate to tributaries to spawn.

functionally extirpated. Describes a species that has been extirpated from an area; though a few individuals may occasionally be found, they are not thought to constitute a viable population.

genotype. The set of alleles (variants of a gene) possessed by an individual at a particular locus or set of loci.

geometric mean. A measure of central tendency that is applied to multiplicative processes (e.g., population growth). It is calculated as the antilogarithm of the arithmetic mean of the logarithms of the data.

habitat connectivity (stream). Suitable stream conditions that allow fish and other aquatic organisms to move freely upstream and downstream. Habitat linkages that connect to other habitat areas.

hatchery produced fish. Fish produced from parents that were selected and spawned artificially.

headwaters. The source of a stream. Headwater streams are the small swales, creeks, and streams that are the origin of most rivers. These small streams join together to form larger streams and rivers or run directly into larger streams and lakes.

hooking mortality. Death of a fish from stress or injury after it is hooked and reeled in, then released back to the water.

hybridization. Any crossing of individuals of different genetic composition, typically different species, that result in hybrid offspring.

hydrologic response. The response of a watershed to precipitation; usually refers to streamflow resulting from precipitation.

hydrologic unit (code). Watersheds that are classified into four types of units: regions, subregions, accounting units, and cataloging. The units from the smallest (cataloging units) to the largest (regions). Each unit is identified by a unique hydrologic unit code consisting of two to eight digits based on the four levels of classification in the hydrologic unit system.

hyporheic zone. Area of saturated sediment and gravel beneath and beside streams and rivers where groundwater and surface water mix. Water movement is mainly in a downstream direction.

independent population. A group of fish of the same species that spawns in a particular lake or stream at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season.

Interior Columbia Basin Technical Recovery Team (ICBTRT). Expert panel formed by NOAA Fisheries to work with local interests and experts and ensure that ICBTRT recommendations for delisting criteria are based on the most current and accurate technical information available.

intermittent stream. A stream that flows only at certain times of the year as when it receives water from springs (or by surface water) or when water losses from evaporation or seepage exceed the available streamflow.

interspecific competition. Competition for resources between two or more different species.

intrinsic potential. The potential of the landscape to support a fish population. It is used when historic population characteristics are unknown.

introgression (genetic). The spread of genes of one species into the gene pool of another by hybridization or by backcrossing (interbreeding between hybrid and parental species).

legacy effects. Impacts from past activities (usually a land use) that continue to affect a stream of watershed in the present day.

limiting factor. A factor that limits a population from achieving complete viability with respect to any Viable Salmonid Population (VSP) parameter.

local population. A group of fish of the same species that spawn within a particular stream or portion of a stream system. Multiple local populations may exist within a core area. A local population is considered to be the smallest group of fish that is known to represent an interacting reproductive unit. For most waters where specific information is lacking, a local population may be represented by a single headwater tributary or complex of headwater tributaries. Gene flow may occur between local populations (e.g., those within a core population), but is assumed to be infrequent compared with that among individuals within a local population.

mass wasting. Loss of large amounts of material in a short period of time, i.e., downward movement of land mass material or landslide.

metapopulation. A group of semi-isolated subpopulations of a species that are interconnected and that probably share genetic material.

metrics. A measurement that identifies or describes a subject or object. For example, the number of major spawning areas within an area is a metric.

migratory corridor. Stream reaches used by fish to move between habitats. A section of river or stream used by fish to access upstream spawning areas or downstream lake or ocean environments.

migratory life-history form (bull trout). Bull trout that migrate from spawning and rearing habitat to lakes, reservoirs, or larger rivers to grow and mature.

morphology. Refers to the form and structure of an organism, with special emphasis on external features.

naturally produced. Fish produced from naturally spawning parents.

niche. The ecological role of a species in a community. It is conceptualized as the multidimensional space of which the coordinates are the various parameters representing the condition of existence of the species.

nonnative species. Species not indigenous to and area, such as brook trout in the western United States.

occupancy unknown. Refers to areas in which fish (e.g., bull trout) occurred historically, but their current status (presence) is unknown.

peak flow. Greatest stream discharge recorded over a specified period of time, usually a year, but often a season.

phenotype. Expressed physical, physiological, and behavioral characteristics of an organism that may be due to genetics, the environment, or an interaction of both.

piscivorous. Describes fish that prey on other fish for food.

potential local population. A local population that does not currently exist, but that could exist, if spawning and rearing habitat or connectivity were restored in the area, and contribute to recovery in a known or suspected unoccupied area.

precocious. Maturing particularly early in development.

probability of persistence. The probability (usually expressed as a percentage) that a population or subpopulation of fish will survive and be present in a specific geographic location through some future time period, usually 100 years.

productivity. A measure of a population's ability to sustain itself or its ability to rebound from low numbers. The terms "population growth rate" and "population productivity" are interchangeable when referring to measures of population production over a entire life cycle. In this plan, productivity is measured as recruits per spawner (spring Chinook and steelhead) or the long-term trend in numbers of adults (bull trout).

recovery subunit (bull trout). Portions of larger recovery units treated separately to improve management efficiency.

recovery unit (bull trout). Recovery units are the major units for managing recovery efforts; each recovery unit is described in a separate chapter in the recovery plan. A distinct population segment may include one or several recovery units. Most recovery units consist of one or more major river basins. Several factors were considered in our identifying recovery units, for example, biological and genetic factors, political boundaries, and ongoing conservation efforts. In some instances, recovery unit boundaries were modified to maximize efficiency of established watershed groups, encompass areas of common threats, or accommodate other logistic concerns. Recovery units may include portions of mainstem rivers (e.g., Columbia and Snake rivers) when biological evidence warrants inclusion. Biologically, recovery units are considered groupings of bull trout for which gene flow was historically or is currently possible.

recruitment. The successful addition through birth and death of new individuals (fish) to a specific population.

redd. A nest constructed by female fish of salmonid species in streambed gravels where eggs are deposited and fertilization occurs. Redds can usually be distinguished in the streambed gravel by the cleared depression, and an associated mound of gravel directly downstream.

resident life history form (bull trout). Bull trout that do not migrate, but that reside in tributary streams their entire lives (one of three bull trout life cycles).

riparian area. Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.

salmonid. Fish of the family salmonidae, including trout, salmon, chars, grayling, and whitefish. In general usage, the term most often refers to salmon, trout, and chars.

scour. Concentrated erosive action by stream water, as on the outside curve of a bend; also, a place in a streambed swept clear by a swift current.

smolt. A juvenile salmon or steelhead migrating to the ocean and undergoing physiological and behavioral changes to adapt its body from a freshwater environment to a saltwater environment.

source population. Strong subpopulation that are within a metapopulation and that contribute to other subpopulations and reduce the risk of local extinctions.

spatial structure. The geographic distribution of a population and all the processes that affect the distribution.

spawning and rearing habitat. Stream reaches and the associated watershed areas that provide all habitat components necessary for spawning and juvenile rearing for a local fish population. Spawning and rearing habitat generally supports multiple year classes of juveniles of resident of migratory fish and may also support subadults and adults from local populations of resident fish.

spawning escapement. The number of adult fish from a specific population that survive spawning migrations and enter spawning grounds.

spillway. The part of the dam that allows high water to flow (spill) over the dam.

stochastic. The term is used to describe natural events or processed that are random. Examples include environmental conditions such as rainfall, runoff, and storms, or life-cycle events, such as survival or fecundity rates.

stock. The fish spawning in a particular lake or stream(s) at a particular season, which to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season. A group of fish belonging to the same population, spawning in a particular stream in a particular season.

storage reservoir. An artificial storage place for water, from which the water may be withdrawn for irrigation, municipal water supply, or flood control.

subwatershed. Topographic perimeter of the catchment area of a stream tributary.

suspended load (washload). The part of the total stream load that is carried for a considerable period of time in suspension, free from contract with the stream bed, it consists mainly of silt, clay, and sand.

suspended sediment. Solids, either organic or inorganic, found in the water column of a stream or lake. Sources of suspended sediment may be either human induced, natural, or both.

take. Activities that harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or attempt to engage in any such conduct to a listed (Endangered Species Act) species.

tolerance. Represents the range of an environmental factor (e.g., temperature, fine sediment, water velocity, etc.) within which an organism or population can survive.

transplantation. Moving naturally produced fish from one stream system to another without the use of artificial propagation.

trophic status. Referring to the nourishment status or biological productivity of a water body; determined largely by nutrient concentrations (i.e., phosphorous and nitrogen) and the resultant synthesis of organic compounds by green plants in the presence of these nutrients and light energy.

uncertainty. A lack of knowledge about stochastic events and the ecological and social processes that affect fish.

viable population. An independent population that has negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100-year timeframe.

viability curve. A curve showing the relationship between population abundance and productivity. Populations that fall above the curve are at a lower risk of extinction than populations that fall below the curve.

water right. Any vested or appropriation right under which a person may lawfully divert and use water. It is a real property right appurtenant to and severable from the land on or in connection with which the water is used; such water right passed as an appurtenance with a conveyance of the land by deed, lease, mortgage, will, or inheritance.

watershed. The area of land from which rainfall (and/or snow melt) drains into a stream or other water body. Watersheds are also sometimes referred to as drainage basins or drainage areas. Ridged of higher ground generally form the boundaries between watersheds. At these boundaries, rain falling on one side flows toward the low point of one watershed, while rain falling on the other side of the boundary flows toward the low point of a different watershed.

woody debris. Woody material such as trees and shrubs; includes all parts of a tree such as root system, bowl, and limbs. Large woody debris generally refers to the woody material whose smallest diameter is greater than 10 centimeters, and whose length is greater than 1 meter.

year class (cohort). Fish in a stock spawned in the same year. For example, the 1997 year class of steelhead includes all steelhead spawned in 1997, which would be 1 in 1998. Occasionally, a stock produces a very small or very large year class that can be pivotal in determining stock abundance in later years.

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Appendix A

Upper Columbia Basin Fish Species

Table 1 List of fishes that occur in the Upper Columbia Basin (between the mouth of the Yakima River and Chief Joseph Dam). Temperature classification follows Zaroban et al. (1999) and trophic guilds follow Li et al. (1987). Table is from Hillman (2000).

Common name	Scientific Name	Native (N) or Exotic (E)	Feeding location in water column			Primary prey				
			Surf	Mid	Bot	Plant	Detrit	Mic	Mac	Fish
Cold-water species:										
White sturgeon	*Acipenser transmontanus*	N			x	x	x	x	X	x
Chinook salmon (juv)	*Oncorhynchus tshawytscha*	N	X	x	x				X	
Coho salmon (juv)	*Oncorhynchus kisutch*	N	X	x	x				X	
Sockeye/kokanee (juv)	*Oncorhynchus nerka*	N	x	X	x			x	X	
Steelhead/rainbow	*Oncorhynchus mykiss*	N	x	X	x				X	x
Cutthroat trout	*Oncorhynchus clarki*	N	X	x	x				X	x
Brown trout	*Salmo trutta*	E	x	X	x				X	x
Atlantic salmon	*Salmo salar*	E	x	X	x				X	x
Bull trout	*Salvelinus confluentus*	N	x	x	X				X	x
Brook trout	*Salvelinus fontinalis*	E	x	X	x				X	x
Mountain whitefish	*Prosopium williamsoni*	N	x	x	X				X	
Lake whitefish	*Coregonus clupeaformis*	E		x	X				X	x
Burbot	*Lota lota*	N		x	X				X	x
Longnose sucker	*Catostomus catostomus*	N			X	x	x	x	x	
Sculpins	*Cottus spp.*	N			X				X	x

Common name	Scientific Name	Native (N) or Exotic (E)	Feeding location in water column			Primary prey				
			Surf	Mid	Bot	Plant	Detrit	Mic	Mac	Fish
Cool-water species:										
Longnose dace	*Rhinichtys cataractae*	N			X				X	
Peamouth	*Mylocheilus caurinus*	N			X				X	x
Chiselmouth	*Acrocheilus alutaceus*	N			X	X			x	
Northern pikeminnow	*Ptychocheilus oregonensis*	N	x	x	X				X	x
Redside shiner	*Richardsonius balteatus*	N	x	X	x				X	
Sand roller	*Percopsis transmontana*	N			X				X	
Bridgelip sucker	*Catostomus columbianus*	N			X	X			x	
Mountain sucker	*Catostomus platyrhynchus*	N			X	X	x	x	x	
Largescale sucker	*Catostomus macrocheilus*	N			X	X	x	x	x	
Pacific lamprey (juv)	*Lampetra tridentata*	N			X	x		X	x	
Pacific lamprey (adult)	*Lampetra tridentata*	N		X						X
River lamprey (juv)	*Lampetra ayresi*	N			X	x	X	x		
River lamprey (adult)	*Lampetra ayresi*	N		X						X
Western brook lamprey (juv)	*Lampetra richardsoni*	N			X	x	X	x		
Western brook lamprey (adult)	*Lampetra richardsoni*	N		X						X
Threespine stickleback	*Gasterosteus aculeatus*	N	x	X	x				X	
Pumpkinseed	*Lepomis gibbosus*	E		X	x				X	x
Walleye	*Stizostedion vitreum*	E		x	X				x	X
Yellow perch	*Perca flavescens*	E	x	X	x				X	x

Common name	Scientific Name	Native (N) or Exotic (E)	Feeding location in water column			Primary prey				
			Surf	Mid	Bot	Plant	Detrit	Mic	Mac	Fish
Smallmouth bass	*Micropterus dolomieu*	E	x	x	X				X	x
Sculpin	*Cottus spp.*	N			X				X	x
Warm-water species:										
Channel catfish	*Ictalurus punctatus*	E			X				X	x
Black bullhead	*Ameiurus melas*	E			X	x			X	
Brown bullhead	*Ameiurus nebulosus*	E			X	x	x	x	X	x
Tench	*Tinca tinca*	E			X	x			X	
Common carp	*Cyprinus carpio*	E			X	x	x	x	X	
Bluegill	*Lepomis macrochirus*	E	x	X	x				X	x
Black crappie	*Pomoxis nigromaculatus*	E	x	X	x				X	x
Largemouth bass	*Micropterus salmoides*	E	x	X	x				x	X

Surf = surface feeder; Mid = midwater feeder; Bot = bottom feeder; Detrit = detritus; Mic = microinvertebrate; Mac = macroinvertebrate. Capital letters denote dominant mode

Appendix B

Description of spatial structure and diversity of spring Chinook and steelhead populations within the Upper Columbia Basin

In December 2005, the ICBTRT produced draft status reports for populations of spring Chinook and steelhead within the Upper Columbia ESUs. In this appendix we reproduce portions of those draft status reports with little editing. The information contained in this appendix only includes information on the spatial structure and diversity of the populations. Information on abundance and productivity is found in Section 2 of the Plan.

The following information was used as a guide to assess the spatial structure and diversity of spring Chinook and steelhead populations in the Upper Columbia Basin (from ICBTRT 2005).

Goal	Mechanism	Factor	Metrics
A. Allow natural rates and levels of spatially-mediated processes.	1. Maintain natural distribution of spawning aggregates.	a. Number and spatial arrangement of spawning areas.	Number of MSAs, distribution of MSAs, and quantity of habitat outside MSAs.
		b. Spatial extent or range of population	Proportion of historical range occupied and presence/absence of spawners in MSAs.
		c. Increase or decrease gaps or continuities between spawning aggregates.	Change in occupancy of MSAs that affects connectivity within the population.
B. Maintain natural levels of variation.	1. Maintain natural patterns of phenotypic and genotypic expression.	a. Major life history strategies.	Distribution of major life history expression within a population.
		b. Phenotypic variation.	Reduction in variability of traits, shift in mean value of trait, loss of traits.
		c. Genetic variation.	Analysis addressing within and between population genetic variation.
	2. Maintain natural patterns of gene flow.	a. Spawner composition	(1) Proportion of hatchery origin natural spawners derived from a local (within population) brood stock program using best practices.
			(2) Proportion of hatchery origin natural spawners derived from a within MPG brood stock program, or within population (not best practices) program.
			(3) Proportion of natural spawners that are unnatural out-of-MPG strays.
			(4) Proportion of natural spawners that are unnatural out-of-ESU strays.
	3. Maintain occupancy in a natural variety of available habitat types.	a. Distribution of population across habitat types.	Change in occupancy across ecoregion types.
	4. Maintain integrity of natural systems.	a. Selective change in natural processes or impacts.	Ongoing anthropogenic activities inducing selective mortality or habitat change within or out of population boundary

Wenatchee Spring Chinook Population

The Wenatchee spring Chinook population is part of the Upper Columbia ESU that only has one extant *MPG* including 3 current populations—Wenatchee, Entiat, and Methow Rivers (Figure 1) (ICTRT 2004). The ICTRT classified the Wenatchee River spring Chinook population as “very large” in size based on historical habitat potential (ICTRT 2005). This classification requires a minimum abundance threshold of 2000 wild spawners with sufficient intrinsic productivity (>1.0 r/s) to exceed a 5 % extinction risk on the viability curve (ICTRT 2005). Additionally, the Wenatchee spring Chinook population was classified as a “type B” population (based on historic intrinsic potential) because it has dendritic tributary structure with multiple major spawning areas (Table 1) (ICTRT 2005).

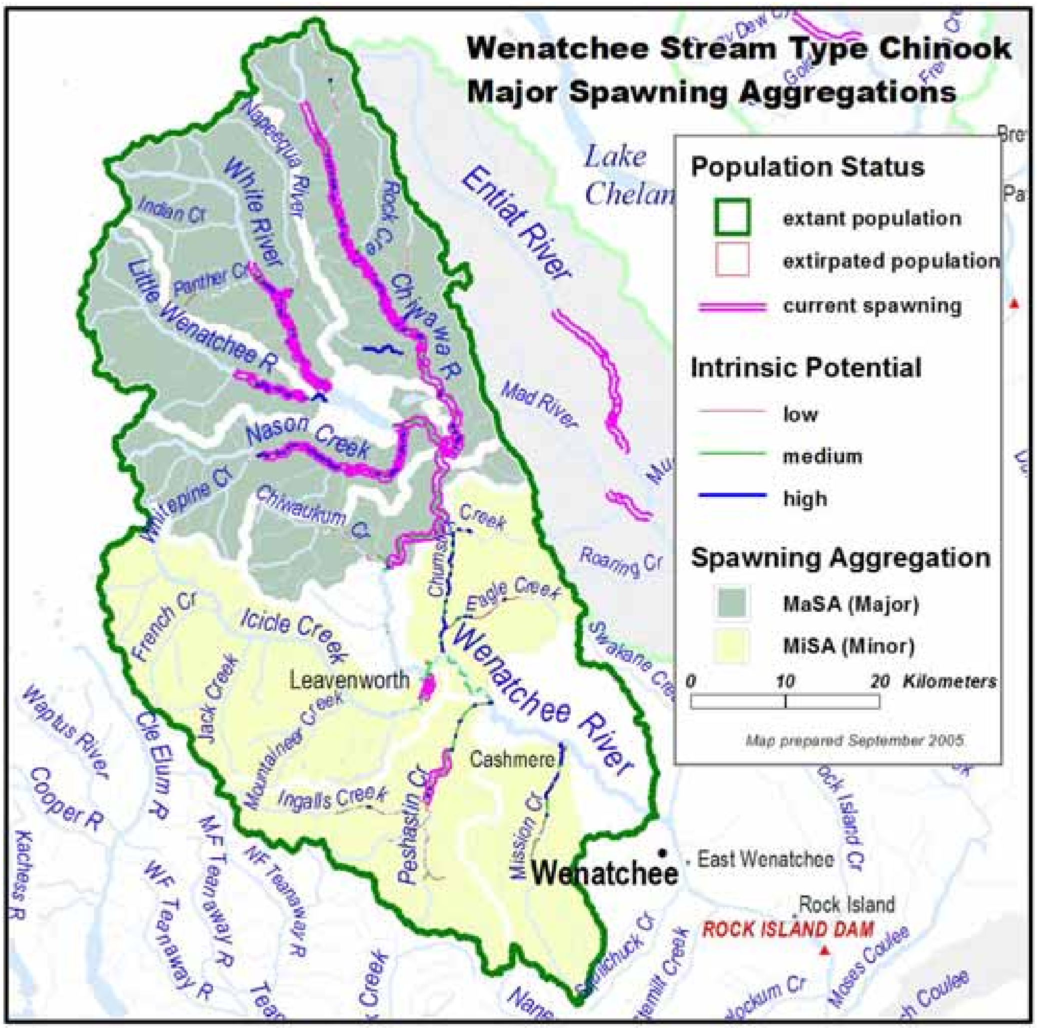

Figure 1. Wenatchee spring Chinook major and minor spawning aggregations.

Table 1. Wenatchee spring Chinook basin statistics

Drainage Area (km2)	3,440
Stream lengths km* (total)	1,733.2
Stream lengths km* (below natural barriers)	1,082.1
Branched stream area weighted by intrinsic potential (km2)	1.573
Branched stream area km2 (weighted and temp. limited)	1.527
Total stream area weighted by intrinsic potential (km2)	1.883
Total stream area weighted by intrinsic potential (km2) temp limited	1.798
Size / Complexity category	Very Large / B (dendritic structure)
Number of MaSAs	5
Number of MiSAs	4

*All stream segments greater than or equal to 3.8m bankfull width were included

**Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22^{o}C.

The ICTRT has identified five historical Major Spawning Areas (MaSAs) and four minor spawning areas (MiSAs) within the Wenatchee population (Figure 2). The five MaSAs are: Chiwawa, Nason Cr., Little Wenatchee R., White River and the upper Wenatchee mainstem (Tumwater Canyon to Lake Wenatchee). The minor spawning areas (MiSAs) estimated from the intrinsic potential analysis include Icicle, Chumstick, Peshastin, and Mission Creeks.

Currently, the primary spawning areas used by spring Chinook in the Wenatchee are the Chiwawa River, Nason Creek, White River, the Little Wenatchee River and the mainstem Wenatchee between Tumwater Canyon and Lake Wenatchee. Icicle Creek consistently has unlisted Carson stock spring Chinook spawning below the Leavenworth National Fish Hatchery and, between 2001 and 2004, Carson stock hatchery spring Chinook were planted in Peshastin Creek. Redds in these drainages would not contribute to VSP parameters because almost no wild Wenatchee origin fish are known to spawn in these MiSAs. During high abundance years, such as 2001, spring Chinook also spawn in Chiwaukum Creek.

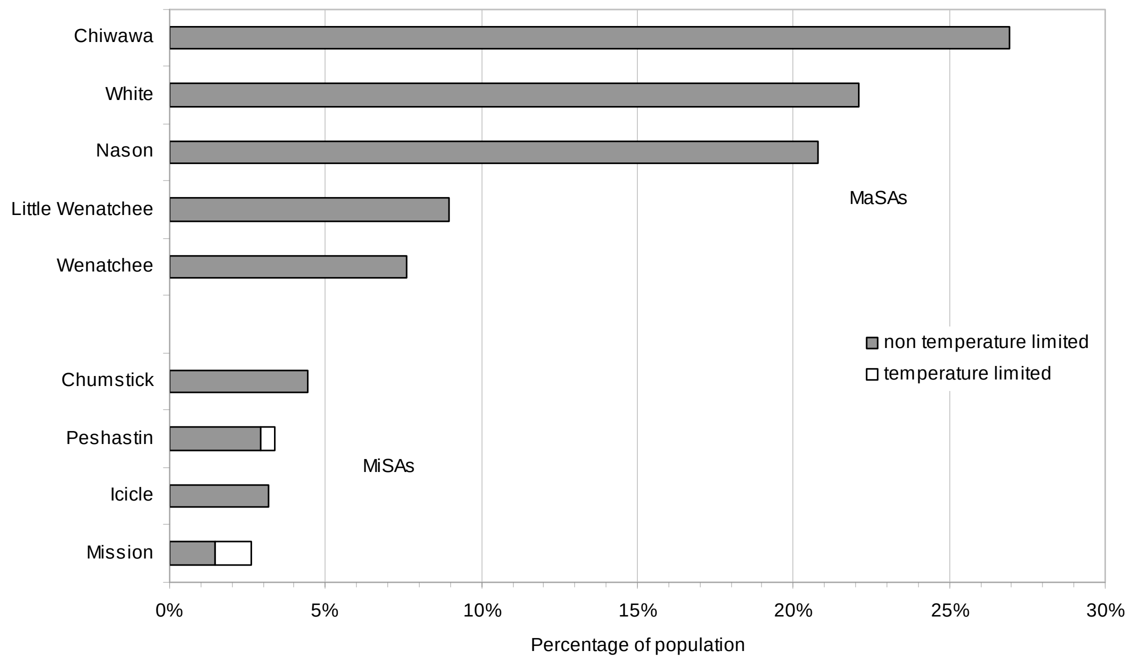

Figure 2. Percentage of historical spawning habitat (of the population) by major/minor spawning area. White portions are subject to temperature limitations.

Factors and Metrics

A.1.a Number and spatial arrangement of spawning areas. The Wenatchee spring Chinook population has five MaSAs (Chiwawa, Nason, White, and Little Wenatchee, and Upper Wenatchee mainstem) and they are all currently occupied (based on agency defined distribution) so it is at *very low risk*.

A.l.b. Spatial extent or range of population. The Wenatchee spring Chinook population has five MaSAs (Chiwawa, Nason, White, and Little Wenatchee, and Upper Wenatchee mainstem) and they are all occupied (based on agency defined distribution) so it is at *very low risk* (Figure 3). Additionally, based on redd counts in index areas from the most recent brood cycle (2000-2004) and during the last 3 brood cycles, the Wenatchee population would also be at very low risk. However, there were some years during the last 3 brood cycles that did not meet minimum occupancy requirements in the White, Little Wenatchee, and Upper Wenatchee mainstem MaSAs.

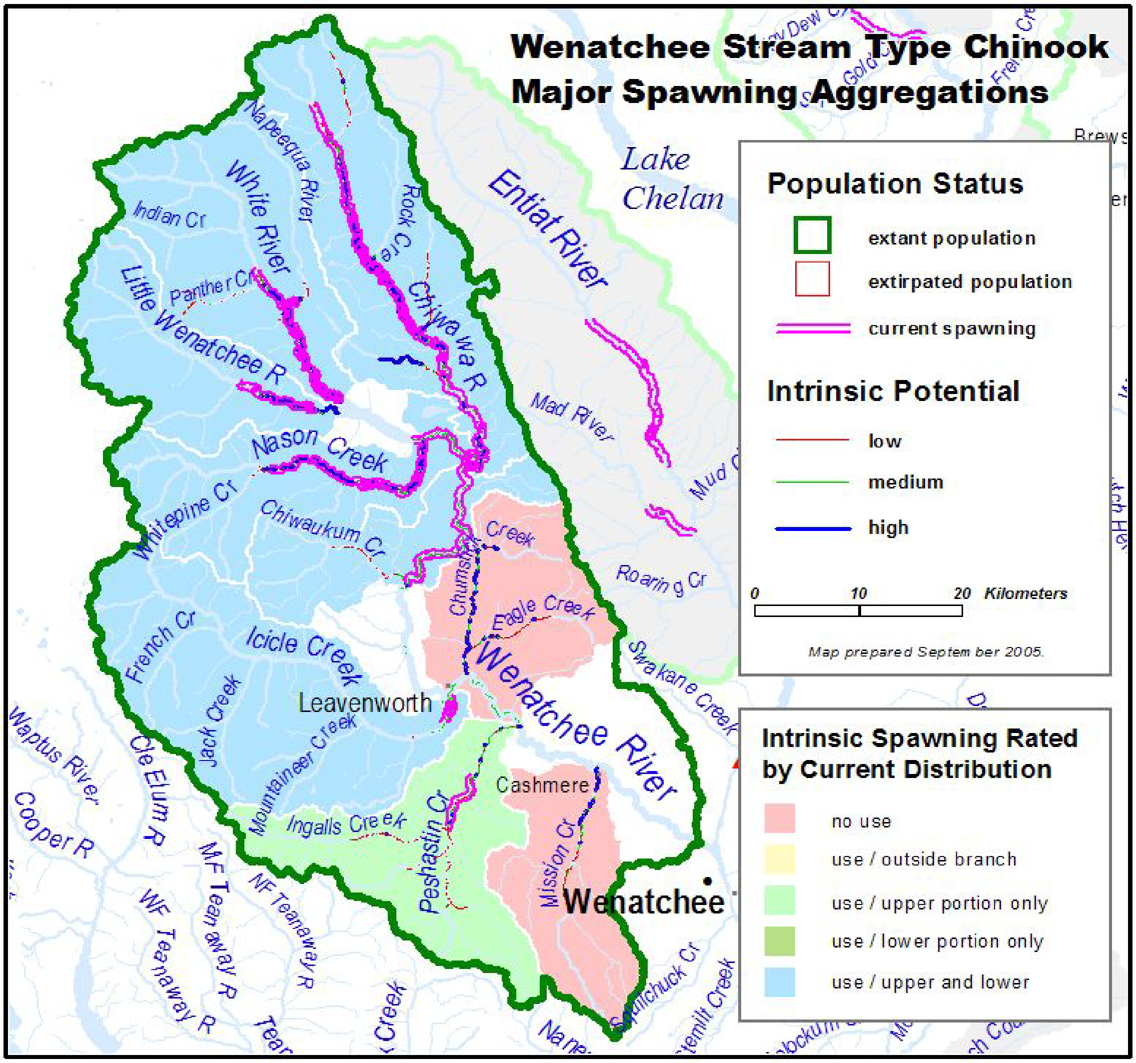

Figure 3. Wenatchee Spring Chinook current distribution.

<u>A.1.c. Increase or decrease in gaps or continuities between spawning aggregates.</u> There has been no increase or decrease in gaps between MaSAs for the Wenatchee spring Chinook population; however, the loss of multiple MiSAs at the lower end of the population boundary (below Tumwater Canyon) puts the population at *moderate risk*. It is assumed that habitat conditions, primarily flow and barriers prohibit the use of Mission and Chumstick Creeks as minor spawning areas. There is considerable uncertainty regarding the ability of these watersheds (Mission and Chumstick) to produce spring Chinook, even under pristine historical conditions. Additionally, there is uncertainty regarding passage of spring Chinook at the Boulder field in Icicle Creek. The opinion of local biologists is that the boulder field always was a barrier (even though road debris has made it artificially enhanced) and recent studies using marked hatchery fish from the LNFH, and historical information from the Wenatchi Tribe support that assumption (Cappellini 2001).

B.1.a. Major life history strategies. The Wenatchee spring Chinook population is *very low risk*, because no major life history strategies have been lost.

Studies of juvenile rearing and migration have identified three major juvenile life history patterns within the Wenatchee spring Chinook population: summer and overwinter rearing within natal spawning areas, fall presmolt migration and overwintering in the mainstem Wenatchee downstream of natal tributaries, and early summer emigration to downstream areas for summer rearing and overwintering. Limited PIT tagging information indicates that emigrating parr and presmolts use the mainstem reaches above and below Tumwater Dam for subsequent rearing.

B.1.b. Phenotypic variation. We do not have data available for this metric. Even if we determined that there was a change to one or more traits we do not know what the exact baseline is because changes likely occurred before there was biological monitoring. Therefore, we will assume that there has been some change and increase in variance for 2 or more traits placing the population at *moderate risk*.

B.1.c. Genetic variation. The Wenatchee spring Chinook population was determined to be at *high risk* for genetic variation due to a persistent homogenization from previous fish management efforts. Analyses based on allozymes collected in the 1980s suggest that there was some differentiation between subpopulations consistent with the level of differentiation expected in that time frame, particularly in the White River drainages. However, microsatellite samples collected in the late 1990s and early 2000s do not show this same differentiation, suggesting that recent management practices may have disrupted natural gene flow (ICTRT pop id draft, in prep).

The ICTRT genetic subgroup has reviewed the current status of all populations in the Interior basin. The subgroup concluded that the Wenatchee population has been homogenized with other UC populations due to past practices. Their conclusion was based on high similarity to all UC hatchery samples and ANOVA analysis indicating no apparent structure between populations, or with minor exceptions, within populations. Data examined include both allozyme and microsatellite data collected by WDFW and analyzed in Ford et al. (2000), and by the ICTRT genetics subgroup. It is possible that the true genetic risk metric for this population is lower. If additional data becomes available indicating differentiation between and within populations (either genetic data indicating levels of divergence consistent with the time since separation; or genetic information showing strong spatial structure), the risk level for this metric could improve to moderate or low risk.

B.2.a. Spawner composition.

(1) *Out-of-ESU strays*. The Wenatchee spring Chinook population is at *high risk* with respect to this metric due to the presence of non-local (outside the ESU origin) stocks on the spawning grounds, which include both LNFH and other stocks from hatcheries outside the Upper Columbia ESU. Tagging studies indicate that LNFH stray rates are generally low (<1%) (Pastor 2004). However, based on expanded carcass recoveries from spawning ground surveys (2001-2004), LNFH and other out-of-basin strays have comprised from 3-27% of the spawner composition above Tumwater Canyon (WDFW unpublished data). Its possible that 4 years of data is not sufficient to evaluate this metric and our risk assessment could change with the inclusion of a longer time series of data. It has been suggested that the mark rate and recovery rate for hatchery fish was insufficient to determine spawner composition prior to 2000 (Andrew

Murdoch, personal communication). Therefore, continuing a 100% external mark rate of hatchery fish and recovering high proportions of carcasses should be a priority.

(2) *Out of MPG strays*. The Upper Columbia ESU only has one extant MPG, so this metric is *not applicable* and no score will be given.

(3) *Out of population strays*. Out of population (but within MPG) origin strays comprised 0% and 1.8% of the naturally spawning population in 2001 and 2002, respectively (Tonseth 2003, 2004). Based on this short-term data set, the population was at *low risk* with respect to this metric. However, we recognize that two years is likely not sufficient to assess long-term risk and conclude that more years need to be added to the time series. Additionally, if the rearing and release practices discussed in the next metric are not addressed then all the hatchery fish on the spawning grounds will fall into this category and the population will be at high risk for this metric.

(4) *Within-population strays*. Since 1993, a total of 56% of the spawners in tributaries above Tumwater Canyon have been of local hatchery origin, specifically the Chiwawa supplementation program (WDFW unpublished data). Regardless of the duration (# of generations), this high proportion of hatchery fish on the spawning grounds places the population at *high risk* for this metric. Additionally, the Chiwawa River integrated hatchery program strays to other non-target MaSAs and commonly makes up greater than 10 % of the spawner composition in Nason Creek and the White and Little Wenatchee Rivers, based on comprehensive data collected in 2001 and 2002 (Tonseth 2003; Tonseth 2004).

B.3.a. Distribution of population across habitat types. The intrinsic potential distribution for Wenatchee spring Chinook covered four ecoregions; however, over 90% of the high to medium rated habitat was in two ecoregion types, Chiwaukum Hills and Lowlands and Wenatchee Chelan Highlands (Figure 4; Table 2). The loss of occupancy in all four MiSAs below Tumwater Canyon did not eliminate an ecoregion type or shift the distribution of ecoregion types by more than 1/3. Therefore, the population was at low risk for this metric.

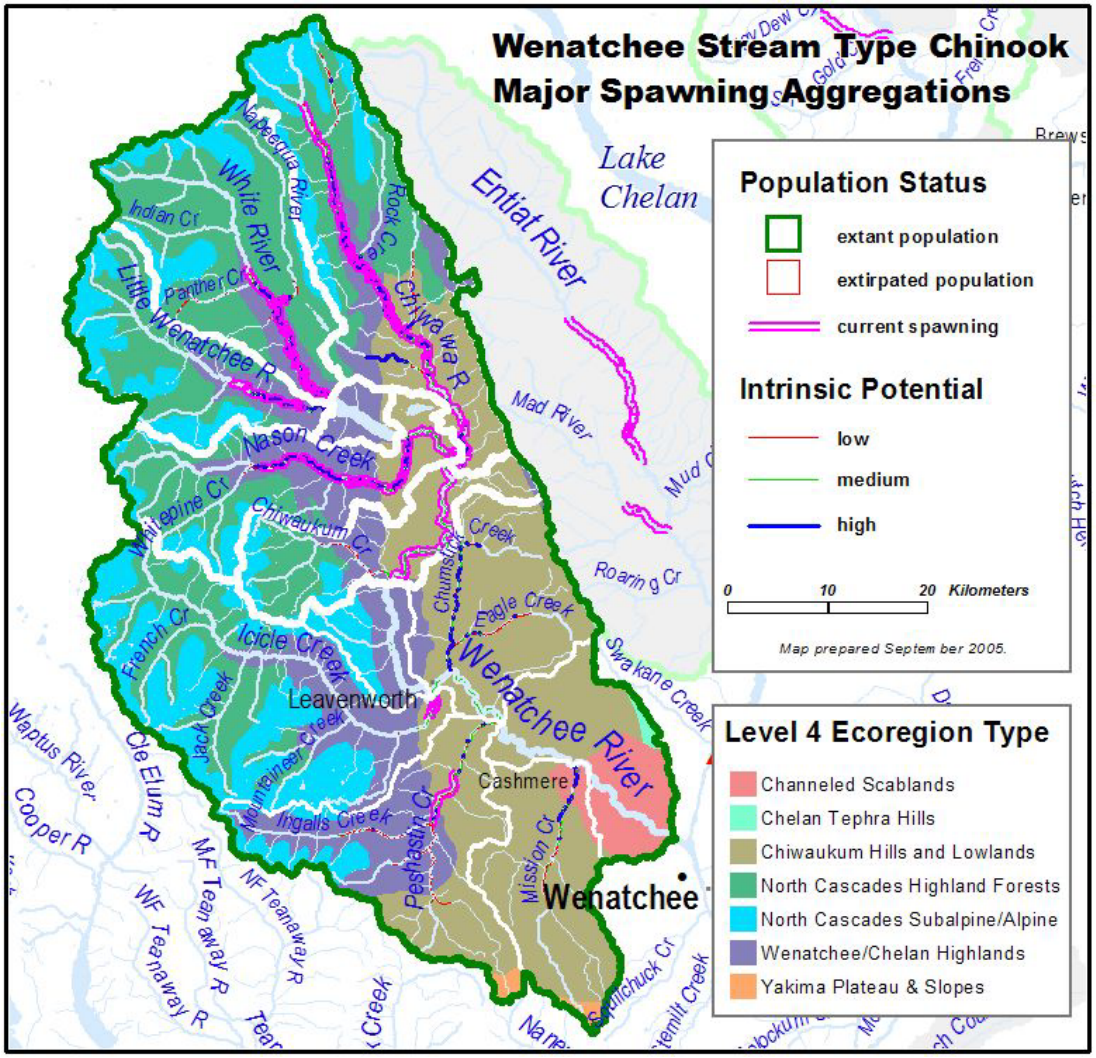

Figure 4. Wenatchee Spring Chinook population across various ecoregions.

Table 2. Wenatchee Spring Chinook – proportion of spawning area across various ecoregions

Ecoregion	% of historical spawning area in this ecoregion (non-temperature limited)	% of currently occupied spawning area in this ecoregion (non-temperature limited)	% of historical spawning area in this ecoregion (temp. limited)
Channeled Scablands	1.3%	0%	0.2%
Chiwaukum hills and lowlands	44.1%	44.8%	44.3%
North Cascades and Highland Forests	2.5%	3.1%	2.5%
Wenatchee / Chelan Highlands	52.1%	52.2%	53.0%

*Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22^{o}C.

B.4.a. Selective change in natural processes or selective impacts.

Hydropower system: Low risk, although it has slowed out migration for early and late out migrants, but in recent years flow augmentation has reduced the impact to the middle 95% of the run.

Harvest: Low risk in recent generations. Harvest rates affect <20% of the adults and selective gear reduces the impact of selectivity.

Hatcheries: Low risk, broodstock management of the Chiwawa supplementation program has been designed to be non-selective.

Habitat: Low risk, although low flow in Peshastin Creek from water withdrawals could prohibit run timing for late arriving adults, it’s a minor proportion of the population.

Based on low risk estimates across the four sectors, we conclude that the population is at *low risk* for this metric.

Spatial Structure and Diversity Summary

The Wenatchee spring Chinook population was determined to be at low risk for goal A (allowing natural rates and levels of spatially mediated processes) but at high risk for goal B (Maintaining natural levels of variation) resulting in an overall HIGH risk rating (Table 3). The metrics for genotypic and phenotypic variation were the determining factors for the high risk rating of Wenatchee spring Chinook. We concluded that there was evidence for a high degree of homogenization within the Wenatchee population as well as among the three extant Upper Columbia Spring Chinook populations. However, there was considerable uncertainty regarding whether or not the level of divergence in the Wenatchee was sufficient for a moderate risk rating. Therefore continued efforts to maintain natural levels of exchange within and among populations and further evaluation could lead to an improved risk rating. For B.1.b. (phenotypic variation), an analysis needs to be conducted that shows that the phenotypic traits of the current population are consistent with the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting. Based on the scoring system, this metric must be addressed in order for the status of goal B to improve to low risk.

There were two metrics that were rated at high risk related to spawner composition that did not directly reduce the overall risk conclusion, but should be considered potential threats to both genotypic (B.1.3) and phenotypic variation (B.1.b). First, Chiwawa River hatchery fish (local origin stock; B.2.a.2) comprise a large portion of the fish on the spawning grounds over multiple generations. Additionally, this hatchery has not been operated to meet “best management practices,” because the rearing and release strategies (acclimation of Chiwawa fish on Wenatchee River water over the winter) have likely increased the probability of straying to non-target MaSAs. Second, the high proportion (3-27%) of LNFH fish (out-of-ESU stock) on the spawning grounds poses an additional risk to genotypic and phenotypic variation. However, due to the scoring system these high-risk ratings were averaged with other metrics and did not directly cause an increased risk rating.

Table 3. Spatial structure and diversity scoring table

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a	VL (2)	VL (2)	Mean = 1.33 Low Risk	Low Risk	**High Risk**
A.1.b	VL (2)	VL (2)			
A.1.c	M (0)	M (0)			
B.1.a	VL (2)	VL (2)	High Risk	High Risk	
B.1.b	M (0)	M (0)			
B.1.c	H (1)	H (1)			
B.2.a(1)	H (-1)	High Risk (-1)	High Risk (-1)		
B.2.a(2)	NA				
B.2.a(3)	L (1)				
B.2.a(4)	H (-1)				
B.3.a	L (1)	L (1)	L (1)		
B.4.a	L (1)	L (1)	L (1)		

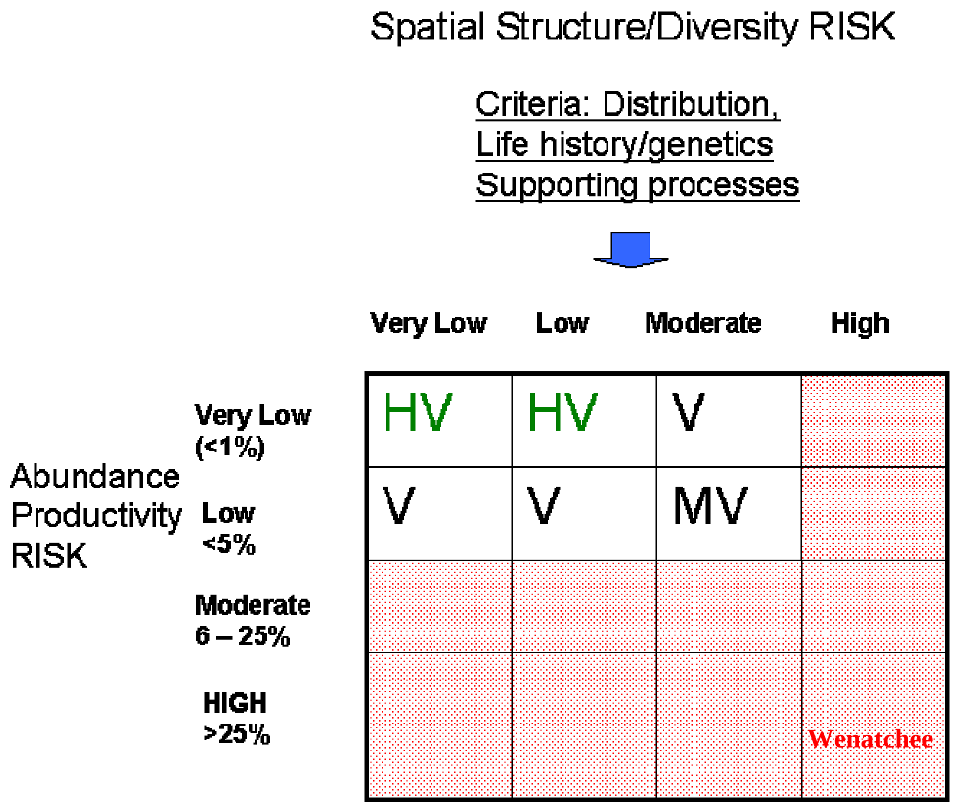

Figure 5. Abundance & productivity and spatial structure & diversity integration

Overall Risk Rating:

Spatial structure and diversity of Wenatchee spring Chinook was rated at high risk, primarily because of a high level of genetic homogenization within and among populations. Improvement of the spatial structure and diversity status to low risk would be required to allow the Wenatchee population to achieve a "highly viable" status (in addition to the improvements needed for abundance and productivity) (Figure 5). Based on the MPG guidelines, the Wenatchee population will need to achieve a highly viable status for recovery of the ESU (ICTRT 2005).

Wenatchee Summer Steelhead Population

The Wenatchee summer steelhead population is part of the Upper Columbia ESU that only has one extant *MPG* that includes 4 current populations: Wenatchee, Entiat, Methow, and Okanogan Rivers) plus Crab Creek (Figure 6) (ICTRT 2004). The ICTRT classified the Wenatchee River summer steelhead population as "Large" in size based on historical habitat potential (ICTRT 2005). This classification requires a minimum abundance threshold of 1500 wild spawners with sufficient intrinsic productivity (>1.0 r/s) to exceed a 5% extinction risk on the viability curve (ICTRT 2005). Additionally, the Wenatchee steelhead population was classified as a "type B" population (based on historic intrinsic potential) because of its dendritic structure tributary structure with multiple major spawning areas (Table 4) (ICTRT 2005).

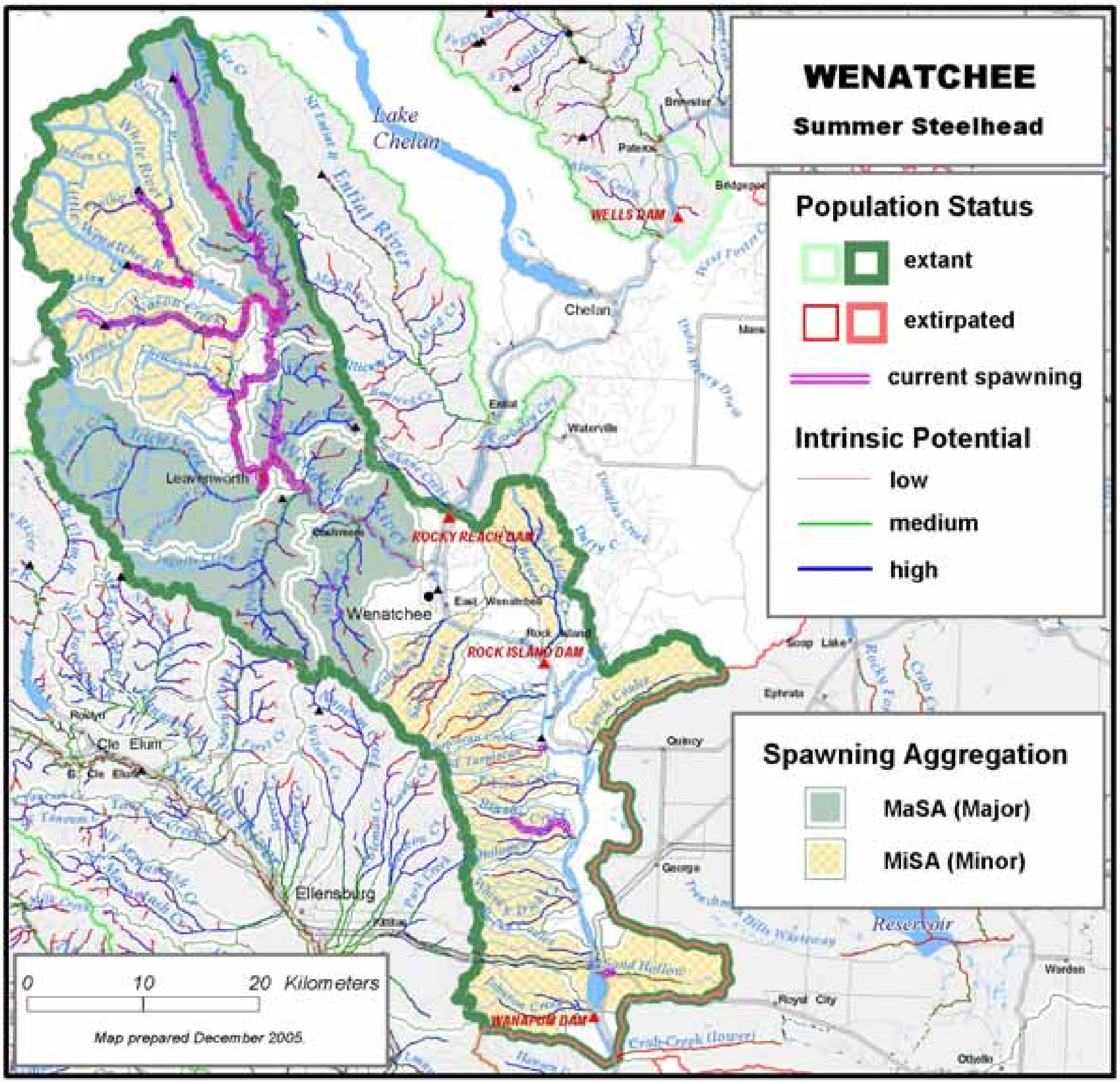

Figure 6. Wenatchee summer steelhead major and minor spawning aggregations

Table 4. Wenatchee summer steelhead basin statistics

Drainage Area (km2)	5,744
Stream lengths km* (total)	2,173
Stream lengths km* (below natural barriers)	1,497
Branched stream area weighted by intrinsic potential (km2)	4.209
Branched stream area km2 (weighted and temp. limited)	3.301
Total stream area weighted by intrinsic potential (km2)	6.396
Total stream area weighted by intrinsic potential (km2) temp limited	4.996
Size / Complexity category	Large / B (dendritic structure)
Number of MaSAs	5
Number of MiSAs	13

*All stream segments greater than or equal to 3.8m bankfull width were included

**Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22^{o}C.

Summer steelhead in the Wenatchee population formerly had a wide distribution, utilizing all major tributaries. Currently, the ICTRT defines the population to encompass mainstem Columbia River tributaries above Crab Creek, up to and including the Wenatchee River subbasin.

In the Columbia mainstem tributaries, USBR and WDFW has identified spawning in Sand Hollow, Quilomene, Brushy, and Trinidad Creeks (Lynch Coulee) (USBR, WDFW unpubished data). Additionally, during the extreme low flow year of 2005, spawners and/or carcasses were observed near or at the mouths of Tarpiscan, Johnson, and Squilchuck Creeks (WDFW unpublished data). Lynch Coulee does not receive flows from the irrigation system, but the springs are likely enhanced from the Columbia Basin Reclamation Project.

The major component of productivity is within the Wenatchee subbasin itself. Most current spawning identified by WDFW occurs in the Chiwawa River and its tributaries, Wenatchee mainstem above Tumwater Canyon, Nason Creek, and Peshastin Creek. Spawning has also been observed within the White and Little Wenatchee Rivers, as well as Icicle, Chiwaukum, Chumstick, and Mission Creeks.

The ICTRT has identified five intrinsic Major Spawning Areas (MaSAs) and 13 Minor Spawning Areas (MiSAs), within the Wenatchee population (Figure 7).

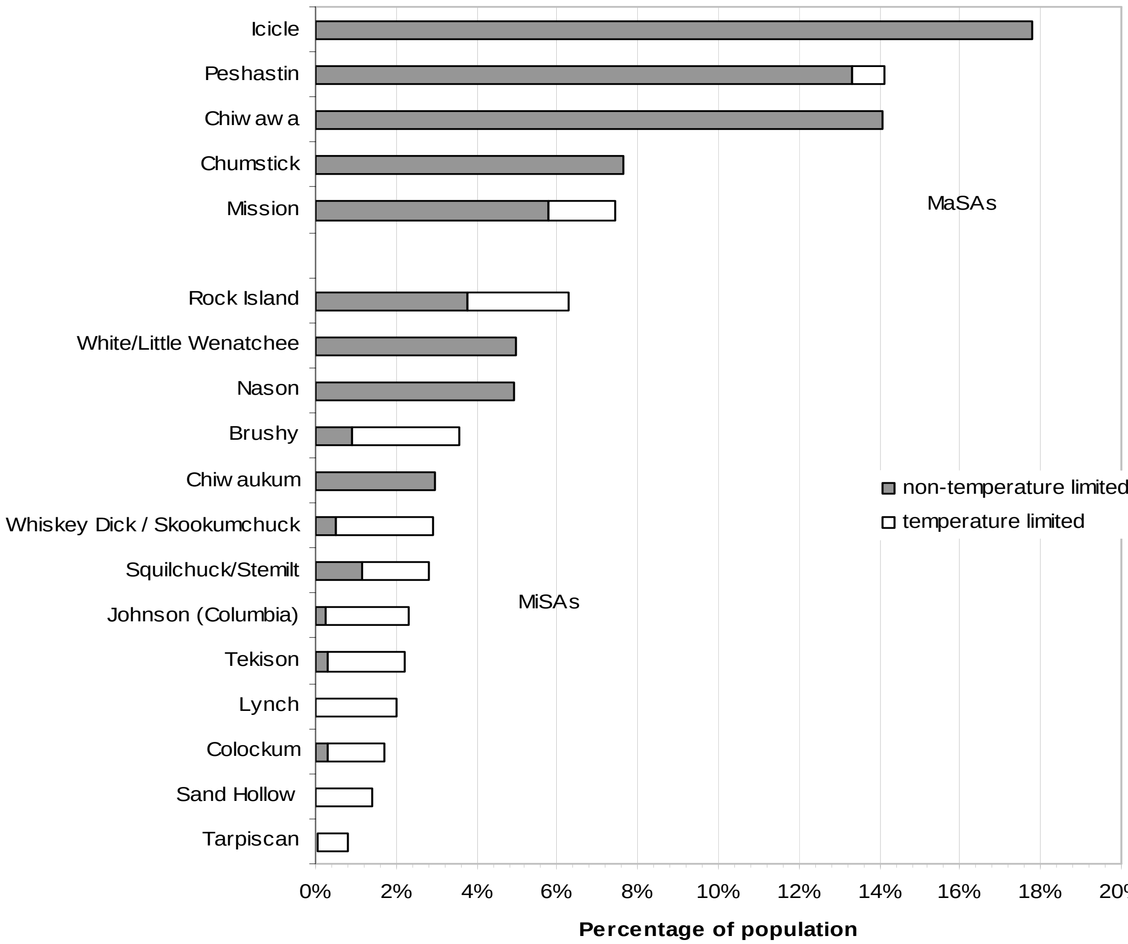

Figure 7. Percentage of historical spawning habitat (of the population) by major/minor spawning area. White portions are subject to temperature limitations.

Factors and Metrics

A.1.a Number and spatial arrangement of spawning areas. The Wenatchee Summer Steelhead population contains 5 MaSAs and 13 MiSAs. All of the MaSAs and many of the MiSAs are occupied based on agency distribution so the population is at *very low risk* for this metric (WDFW salmonscape). Additionally, more detailed recent (2001-2005) surveys have revealed the presence of multiple redds in the upper and lower halves of three of the MaSAs (Chiwawa, Peshastin, Mission) and several of the MiSAs including the Wenatchee mainstem, Quilomene Creek, Brushy Creek, Nason Creek and Trinidad Creek (Tonseth and Viola 2003; Murdoch et al. 2004; Tonseth 2004; WDFW unpublished data).

A.l.b. Spatial extent or range of population. Efforts to monitor the distribution and abundance of spawning steelhead have been expanded in recent years (2001-2004), but we still do not have comprehensive, long-term data sets to rate this metric for the entire Wenatchee watershed. Based on these recent data sets, four of the five MaSAs in the Wenatchee summer steelhead population are currently occupied, which puts the population at *moderate risk* for this metric (Figure 8). The Icicle Creek MaSA has consistently had redds in the lower 2 miles, but not within core branch spawning reaches identified by the intrinsic analysis. Most of these core reaches are located above the Leavenworth NFH, where Steelhead passage is currently blocked. However, the USFWS intends to provide passage (in the near future) during portions of the year that may allow for re-occupation of this MaSA (Jim Craig, personal communication). The presence of redds in the White/Little Wenatchee MaSA has been inconsistent in recent years, though this habitat is considered functional with few, if any, primary limiting factors. The Chumstick MaSA has been blocked by a culvert near the mouth during most years, although a few redds have been observed under certain flow conditions.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates. Unoccupied MaSAs have not increased the gaps between MaSAs by more than 10 km so the population is at *low risk* for this metric.

B.1.a. Major life history strategies. The Wenatchee summer steelhead population is *very low risk*, because no major life history strategies have been lost. There never was a winter run component and resident *O. mykiss* are known to occur at various locations in the subbasin (NPPC 2004).

B.1.b. Phenotypic variation. There are no data available for this metric. Even if we determined that there was a change to one or more traits we do not know what the exact baseline is because changes likely occurred before there was biological monitoring. Therefore, we will assume that there has been some change and increase in variance for 2 or more traits placing the population at *moderate risk*.

B.1.c. Genetic variation. The Wenatchee summer steelhead population was determined to be at *high risk* for genetic variation due to a persistent homogenization from previous and ongoing fish management efforts. The genetic signal shows little differentiation between populations with strong similarity to Wells Hatchery; however, all available data at least 20 years old. There is a possibility that the true genetic risk metric for this population should be lower. If additional data becomes available indicating differentiation between and within populations (either genetic data indicating levels of divergence consistent with the time since separation; robust straying data or genetic information showing strong spatial structure), this metric can be downgraded.

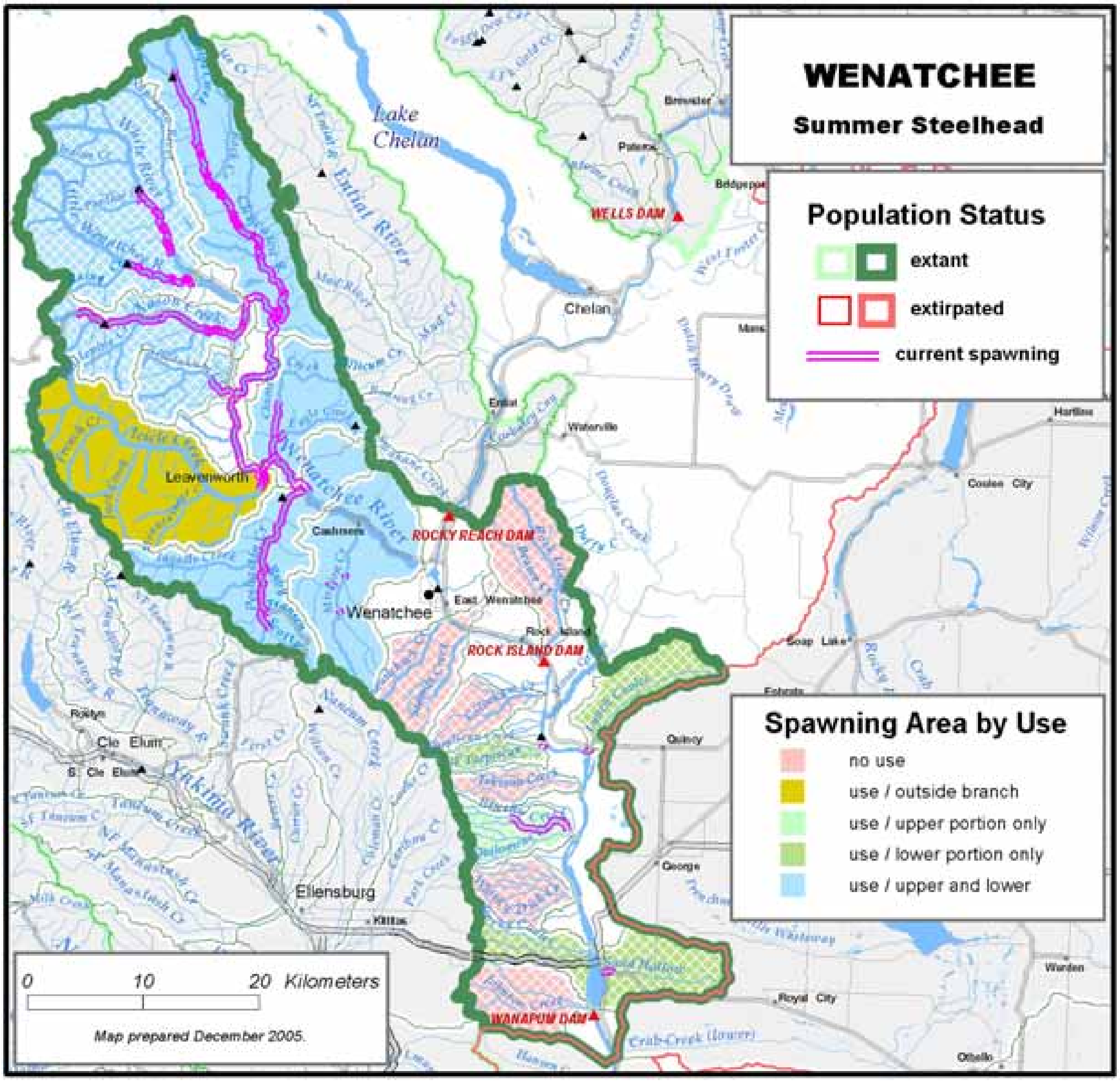

Figure 8. Wenatchee summer steelhead current distribution.

<u>B.2.a. Spawner composition.</u> We do not have estimates of spawner composition for the various MaSAs and MiSAs of the Wenatchee steelhead population because carcasses cannot be obtained in sufficient numbers from the spawning ground surveys. However, between 2001 and 2004 an average of 47% (range 30-69%) of the females passing Tumwater Dam were of wild origin (Tonseth 2004). This level of hatchery fish on the spawning grounds puts the population at *high risk* for this metric, regardless of the origin of the hatchery fish.

(1) Out-of-ESU strays. We have no data to evaluate the proportion of out of ESU hatchery strays on the spawning grounds of the Wenatchee population; therefore the default rating is *moderate risk*. However, there are no hatchery programs propagating non-local anadromous stock in the ESU and we have no reason to believe that the Wenatchee steelhead population is at an elevated risk level for this metric. Therefore, when considering future status reviews we may want to

consider an alternative measurement location, such as Priest Rapids Dam, to determine risk to the ESU, instead of to individual populations.

(2) *Out of MPG strays*. The Upper Columbia ESU only has one extant MPG, so this metric is not applicable and no score will be given.

(3) Out of population strays. We do not have estimates of spawner composition for the various MaSAs and MiSAs of the Wenatchee steelhead population because carcasses cannot be obtained in sufficient numbers from the spawning ground surveys. However, between 2001 and 2004 an average of 47% (range 30-69%) of the females passing Tumwater Dam were of wild origin (Tonseth 2004). The long term integrated program in the Wenatchee Basin collects fish at Dryden Dam (lower mainstem) and releases them at various locations throughout the upper basin, thereby mixing the progeny from various MaSAs and not encouraging local adaptation within the population. Additionally, because fish are not reared and acclimated in the Wenatchee basin, this program is not meeting best management strategies. Therefore, the population is at *high risk* for this metric.

(4) *Within-population strays*. This metric is *not applicable* for the Wenatchee because the local origin hatchery fish were considered not best management strategies for reasons identified earlier.

B.3.a. Distribution of population across habitat types. The distribution of intrinsic branches for Wenatchee summer steelhead covers 9 ecoregions, 5 of which were considered significant (> 10%) (Figure 9; Table 5). Currently occupied spawning areas for this population exist primarily within 2 ecoregions—Chiwaukum Hills & Lowlands and Wenatchee/Chelan Highlands and substantial shifts (> 67 %) have occurred in 2 of the 5 significant ecoregions putting the population at *moderate risk* for this metric.

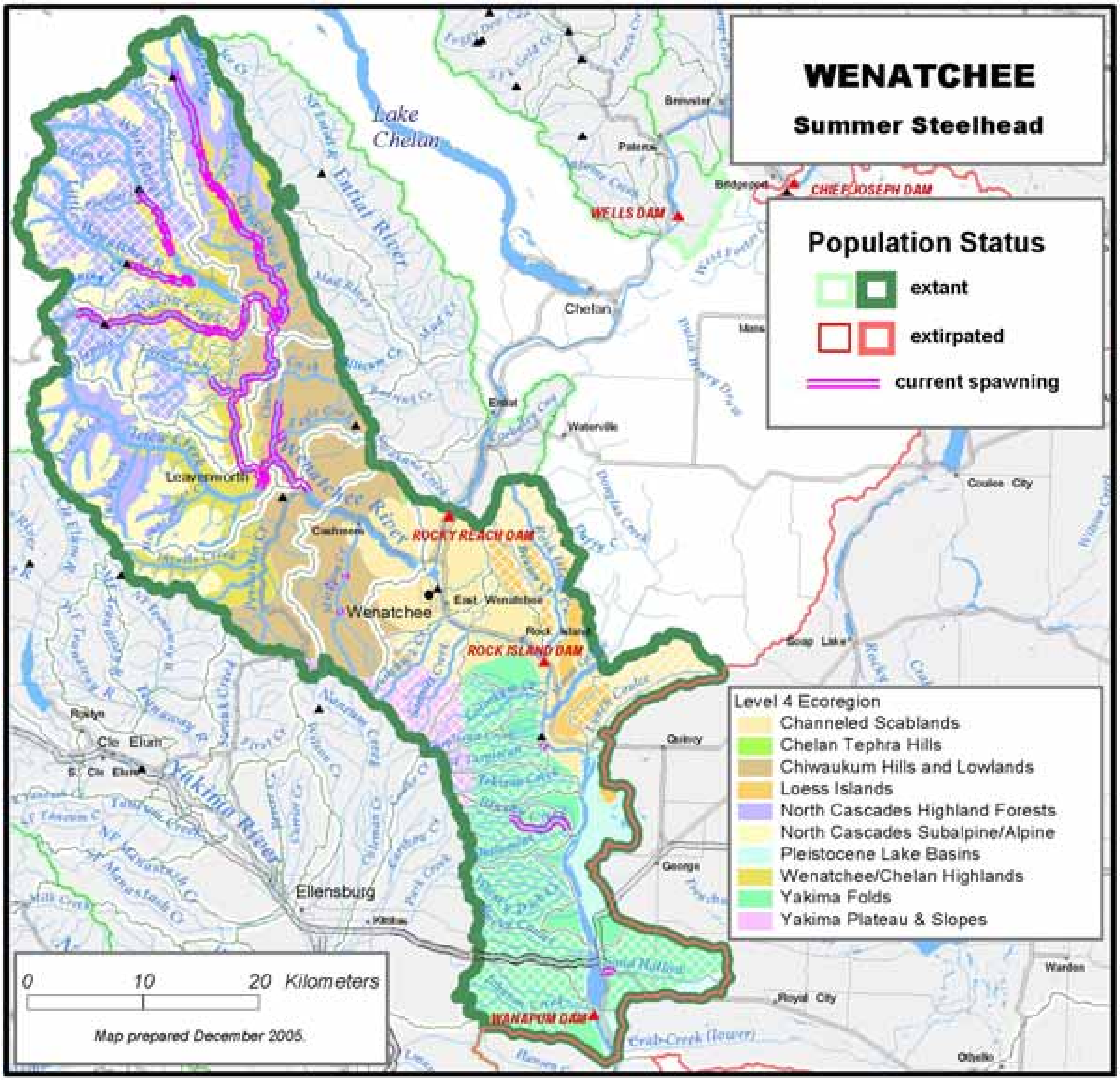

Figure 9. Wenatchee summer steelhead population across various ecoregions.

Table 5. Wenatchee summer steelhead – proportion of spawning area across various ecoregions

Ecoregion	% of historical spawning area in this ecoregion (non-temperature limited)	% of currently occupied spawning area in this ecoregion (non-temperature limited)
Channeled Scablands	11.8	0.1
Chiwaukum Hills and Lowlands	34.4	53.3
Loess Islands	0.2	0.0
North Cascades Highland Forests	14.2	3.6
North Cascades Subalpine/Alpine	0.2	0.0
Pleistocene Lake Basins	0.8	0.0
Wenatchee/Chelan Highlands	23.6	39.9
Yakima Folds	14.4	3.1
Yakima Plateau & Slopes	0.2	0.0

B.4.a. Selective change in natural processes or selective impacts.

Hydropower system: Low risk, although it has slowed out migration for early and late out migrants, but in recent years flow augmentation has reduced the impact to the middle 95% of the run.

Harvest: Low risk in recent generations. Harvest rates affect < 20% of the adults and selective gear reduces the impact of selectivity.

Hatcheries: Low risk, broodstock management of the Wenatchee supplementation program has been designed to be non-selective.

Habitat: Low risk, no known measurable effects.

Based on low risk estimates across the four sectors, we conclude that the population is at *low risk* for this metric.

Spatial Structure and Diversity Summary

The Wenatchee summer steelhead population was determined to be at low risk for goal A (allowing natural rates and levels of spatially mediated processes) but high risk for goal B (Maintaining natural levels of variation) resulting in an overall high risk rating (Table 6). The metric for genotypic variation was directly responsible for the high risk rating of Wenatchee summer steelhead. More recent samples are needed from steelhead from throughout the ESU to confirm this conclusion. For metric B.1.b. (phenotypic variation), an analysis needs to be conducted that shows that the phenotypic traits of the current population are consistent with the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting. Based on the scoring system, these metrics must be addressed in order for the status of goal B to improve to low or very low risk.

There was one metric that was rated at high risk related to spawner composition that did not directly reduce the overall risk conclusion, but should be considered a potential threat to both genotypic (B.1.3) and phenotypic variation (B.1.b). We do not have estimates of spawner composition for the various MaSAs and MiSAs of the Wenatchee steelhead population because carcasses cannot be obtained in sufficient numbers from the spawning ground surveys. We assumed that most or all of the estimated 47% hatchery fish spawner composition was from the local origin program and assessed risk accordingly. However, due to the difficulty of obtaining carcasses, it might be more appropriate to make the risk rating at the mechanism level, rather than for each of the metrics. In the future, we may need to consider ESU level risks for this metric at sampling locations such as Priest Rapids Dam.

Table 6. Spatial structure and diversity scoring table

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a	VL (2)	VL (2)	Low Risk Mean = 1	Low Risk	**High Risk**
A.1.b	M (0)	M (0)			
A.1.c	L (1)	L (1)			
B.1.a	VL (2)	VL (2)	High Risk	High Risk	
B.1.b	M (0)	M (0)			
B.1.c	H (-1)	H (-1)			
B.2.a(1)	M(0) (no data)	High Risk	High Risk		
B.2.a(2)	NA				
B.2.a(3)	H(-1)				
B.2.a(4)	NA				
B.3.a	M (0)	M (0)	M (0)		
B.4.a	L (1)	L (1)	L (1)		

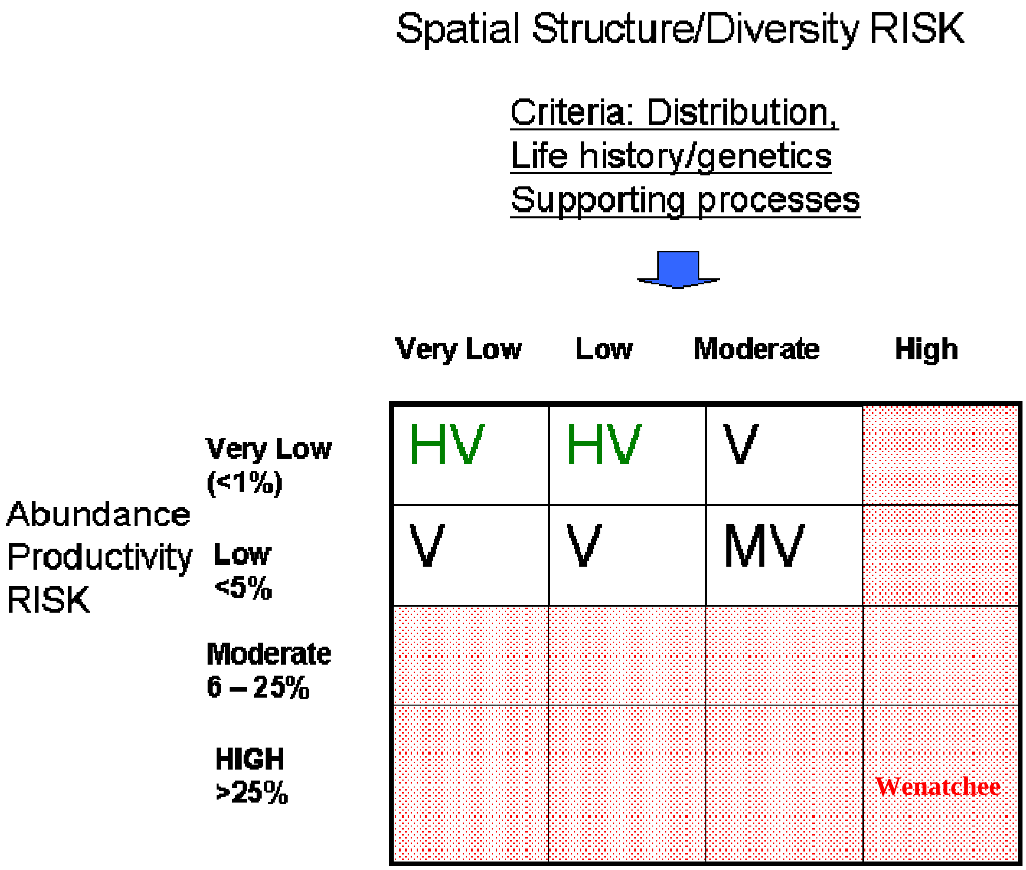

Figure 10. Abundance & productivity and spatial structure & diversity integration table

Overall Risk Rating:

The spatial structure and diversity of Wenatchee summer steelhead rated as high risk. Improvement of the spatial structure and diversity status to low risk would be required to allow the Wenatchee population to achieve a "highly viable" status (in addition to the improvements needed for abundance and productivity) (Figure 10). Based on the MPG guidelines, the Wenatchee population will need to achieve a highly viable status for recovery of the ESU (ICTRT 2005).

Entiat Spring Chinook Population

The Entiat spring Chinook population is part of the Upper Columbia ESU. This ESU contains only one extant MPG including 3 current populations—Wenatchee, Entiat, and Methow Rivers (Figure 11) (ICTRT 2004). The ICTRT classified the Entiat River spring Chinook population as "basic" in size based on historical habitat potential (ICTRT 2005) (Table 1b). This classification requires a minimum abundance threshold of 500 wild spawners with sufficient intrinsic productivity (greater than 1.0 r/s) to exceed a 5 % extinction risk on the viability curve (ICTRT 2005). Additionally, the Entiat spring Chinook population was classified as a "type A" population (based on historic intrinsic potential) because of its simple, linear tributary structure (Table 7) (ICTRT 2005).

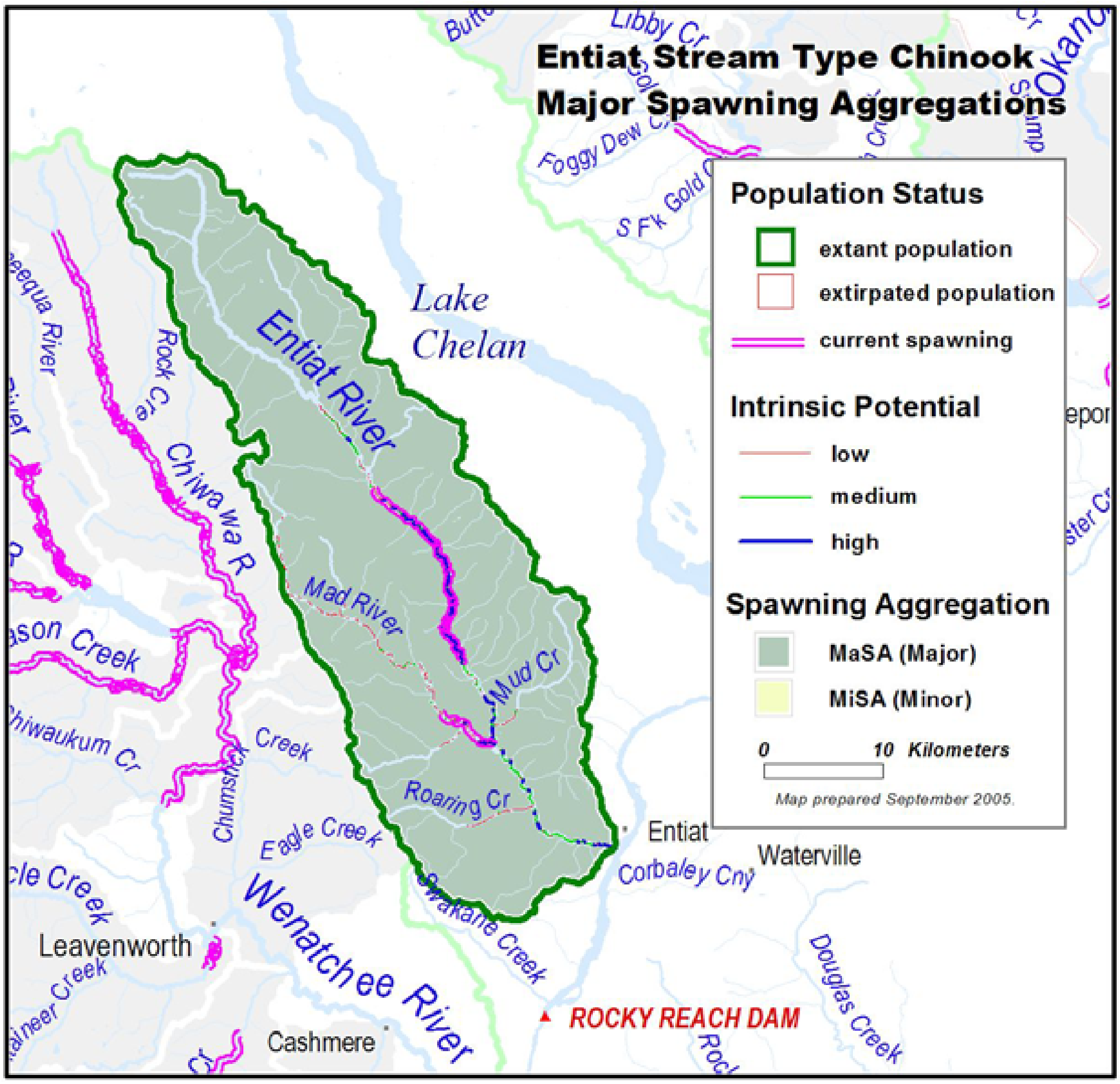

Figure 11. Entiat spring Chinook major and minor spawning aggregations.

Table 7. Entiat Spring Chinook Basin Statistics

Drainage Area (km2)	1,083
Stream lengths km* (total)	542.7
Stream lengths km* (below natural barriers)	245.4
Branched stream area weighted by intrinsic potential (km2)	0.422
Branched stream area km2 (weighted and temp. limited)	0.276
Total stream area weighted by intrinsic potential (km2)	0.537
Total stream area weighted by intrinsic potential (km2) temp limited	0.377
Size / Complexity category	Basic / A (simple linear)
Number of MaSAs	1
Number of MiSAs	0

*All stream segments greater than or equal to 3.8m bankfull width were included

**Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22^{o}C.

The ICTRT has identified one historical Major Spawning Area (MaSA)—the Entiat—and no minor spawning areas (MiSAs) within the Entiat population (Figure 12).

Currently, the primary spawning areas used by Spring Chinook in the Entiat population are the mainstem Entiat (above the Mad River), and below Entiat falls. The Entiat National Fish Hatchery has released unlisted Carson origin spring Chinook into the lower Entiat River annually since 1974. The program is intended to function as a segregated program to augment harvest, the broodstock for this program are not part of the Upper Columbia spring Chinook ESU. Spawning ground surveys in 2001-2005 substantiate that some Entiat National Fish Hatchery returns stray and spawn in upstream natural production areas.

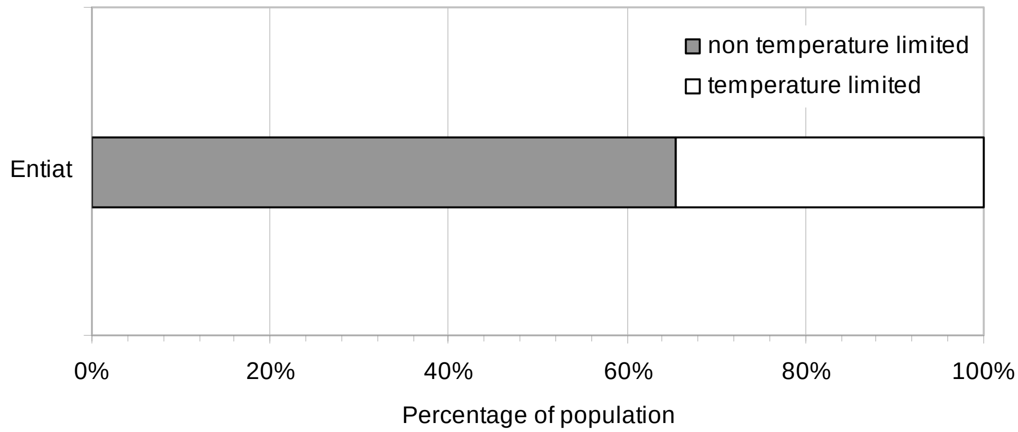

Figure 12. The Entiat River spring Chinook population has only one MaSA, and no MiSAs. Potential temperature limitations are shown in white.

Factors and Metrics

A.1.a Number and spatial arrangement of spawning areas. The Entiat Spring Chinook population has one MaSA (Entiat) and it is currently occupied. The single MaSA has been occupied during the previous 5 years (1999-2003) and 16 of the last 17 years (Hamstreet and Carie 2004). However, since the population has only one MaSA, it is classified as *high risk* for this metric, but that risk is inherent of this small population. The Mad River branch is part of the single MaSA, and its capacity is too low to offer any substantial risk moderation. The Entiat was always high risk due to historically simple spatial structure.

A.l.b. Spatial extent or range of population. The single MaSA has been occupied during the previous 5 years (1999-2003) and 14 of the last 15 years (Hamstreet and Carie 2004) so the population is at *low risk* for this metric (Figure 13).

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates. The range of spawning distribution has been reduced due to the loss of the lower Entiat mainstem as spring Chinook spawning habitat. In recent years, no spring Chinook spawning has been detected below river mile 13, presumably because of the degraded condition of the habitat due to channelization and the high abundance of summer/fall Chinook in the lower Entiat (Hamstreet and Carie 2004). This reduction in range at the lower end of the spawning distribution increases the gap to adjacent populations by more than 10 km but less than 25 km. This situation does not fit precisely within one of the risk level categories in Table 8 of the ICTRT guidance document, but is most consistent with a *moderate risk* rating (ICTRT 2005).

B.1.a. Major life history strategies. The Entiat spring Chinook population is *very low risk*, because no major life history strategies have been lost.

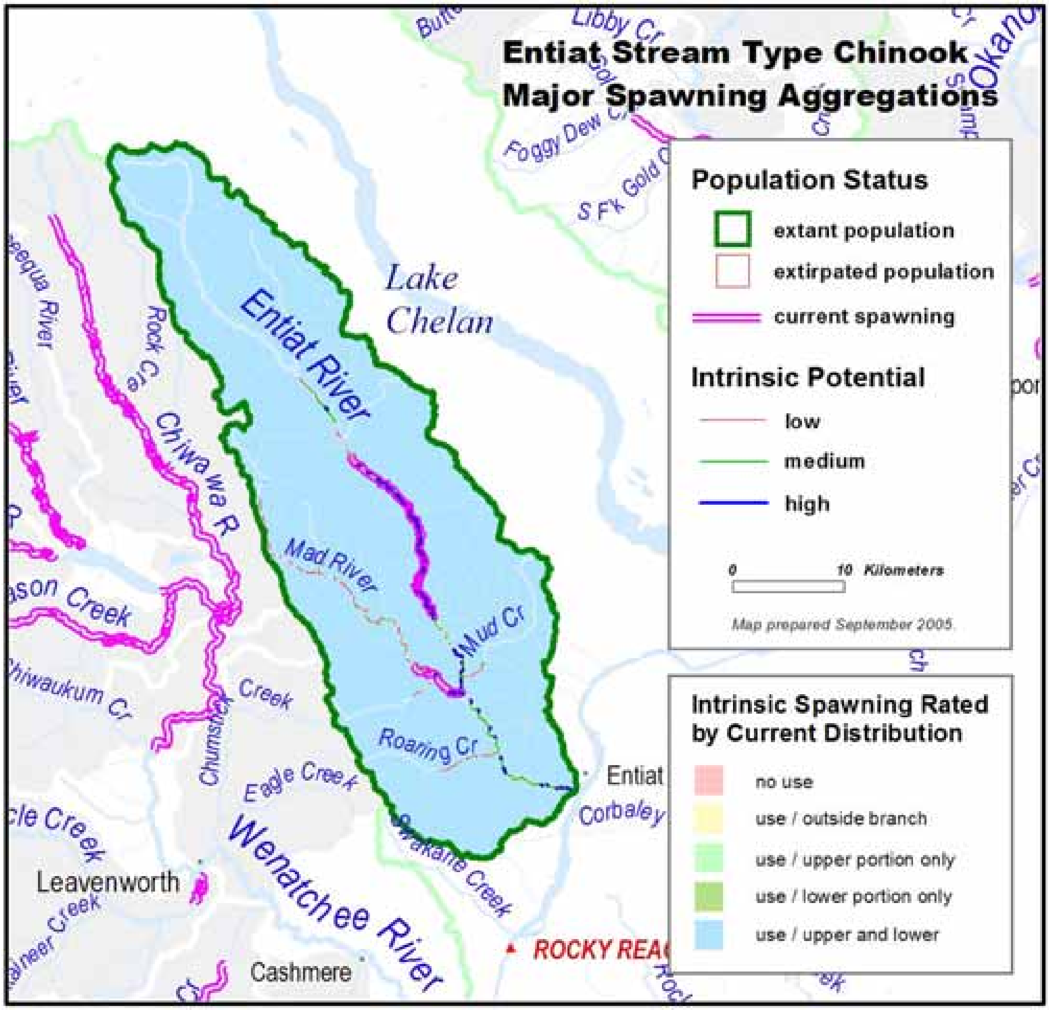

Figure 13. Current spawning distribution of the Entiat spring Chinook population

<u>B.1.b. Phenotypic variation.</u> There are no data available for this metric. Even if we determined that there was a change to one or more traits we do not know what the exact baseline is because changes likely occurred before there was biological monitoring. Therefore, we will assume that there has been some change and increase in variance for 2 or more traits placing the population at *moderate risk*.

<u>B.1.c. Genetic variation.</u> The Entiat spring Chinook population was determined to be at *high risk* for genetic variation due to a persistent homogenization from previous and ongoing fish management efforts. Microsatellite samples collected in the late 1990s and early 2000s do not show differentiation, suggesting that recent management practices may have disrupted natural gene flow (ICTRT pop id draft, in prep). The ICTRT genetic subgroup has reviewed the current status of all populations in the Interior basin. The subgroup concluded that the Entiat population has been homogenized with other UC populations due to past and ongoing hatchery practices. Their conclusion was based on high similarity to all UC hatchery samples and ANOVA analysis indicating no structure. It is possible that the true genetic risk metric for this population is lower.

If additional data becomes available indicating differentiation between and within populations (either genetic data indicating levels of divergence consistent with the time since separation; - or genetic information showing strong spatial structure), the risk level for this metric could improve to moderate or low risk.

B.2.a. Spawner composition.

(1)Out-of-ESU strays. Out-of-ESU hatchery fish averaged 32% (range 18-53%; 31% from ENFH) of the spawning population from 2000-2004 (USFWS unpublished data). Although 5 years of data may not be adequate to define the risk level with high certainty, the threat remains because the Entiat NFH propagates non-local stock and the broodstock must volunteer to the hatchery while all other spawners are allowed to migrate past the hatchery and spawn with the natural population. Therefore the Entiat spring Chinook population is *high risk* with respect to this metric.

(2) *Out of MPG strays*. The Upper Columbia ESU only has one extant MPG, so this metric is *not applicable* and no score will be given.

(3) *Out of population strays*. Out-of-population, but within ESU (and within MPG) hatchery fish averaged 11% (range 0-25%) of the spawning population from 2000-2004, with 3 of the 5 years less than 10% (USFWS unpublished data). Based on the average spawner composition for one generation the Entiat spring Chinook population is at *moderate risk* with respect to this metric.

(4) *Within-population strays*. There is no supplementation program for spring Chinook in the Entiat basin. Therefore, this metric is *not applicable* to the Entiat spring Chinook population.

B.3.a. Distribution of population across habitat types. The intrinsic potential distribution for Entiat spring Chinook covered two or three ecoregions, depending on whether a high temperature screen was applied to the historic intrinsic potential distribution (Figure 14; Table 8). If the temperature screen is applied the population is at low risk, if the temperature screen is not applied it is at moderate risk due to the loss of 1 ecoregion (see flow diagram on page 38 of ICTRT 2005). Due to the uncertainty of the historic suitability of the lower Entiat for spring Chinook, and because of the extensive use of the lower Entiat by summer Chinook (a separate ESU), we believe it is most appropriate to use the temperature screen and rate the Entiat population at *low risk* for this metric.

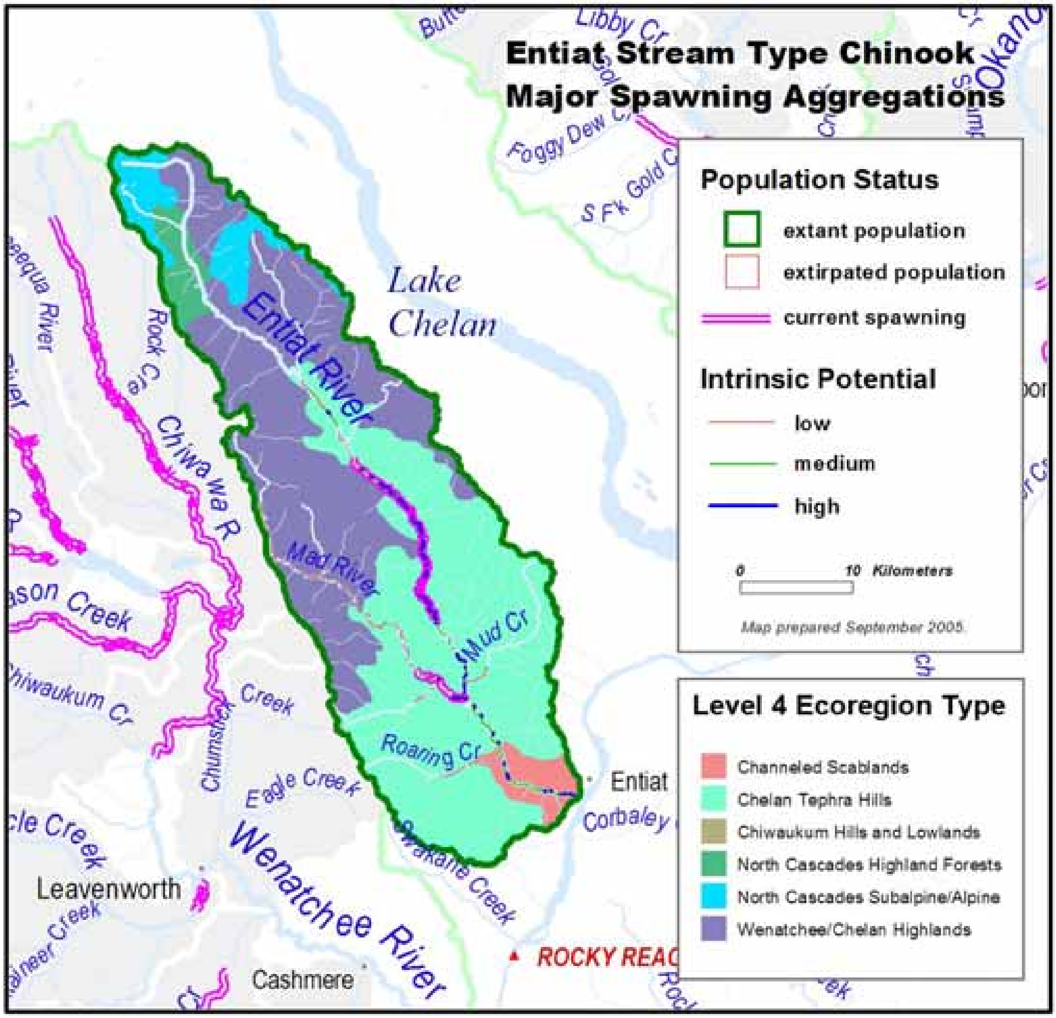

Figure 14. Distribution of the Entiat spring Chinook population across various ecoregion types.

Table 8. Entiat Spring Chinook – proportion of spawning area across various ecoregions

Ecoregion	% of historical branch spawning area in this ecoregion (non-temperature limited)	% of currently occupied spawning area in this ecoregion	% of historical branch spawning area in this ecoregion (temp. limited)
Channeled Scablands	20.7	0.0	0.0
Chelan Tephra Hills	78.8	99.0	99.1
Wenatchee/Chelan Highlands	0.6	1.0	0.9

*Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22°C.

B.4.a. Selective change in natural processes or selective impacts.

Hydropower system: Low risk. Although out migration has slowed for early and late out migrants, recent years flow augmentation has reduced the impact to the middle 95% of the run.

Harvest: Low risk in recent generations. Harvest rates affect < 20% of the adults and selective gear reduces the impact of selectivity.

Hatcheries: Not applicable.

Habitat: Low risk no known factors that would be selective.

Based on low risk estimates across the four sectors, we conclude that the population is at *low risk* for this metric.

Spatial Structure and Diversity Summary

The Entiat spring Chinook population was moderate risk for goal A (allowing natural rates and levels of spatially mediated processes) but high risk for goal B (Maintaining natural levels of variation) resulting in an overall high-risk rating (Table 9). The metric for genotypic variation (B.1.c) was directly responsible for the high-risk rating and it is likely that additional genetic analysis of natural origin Entiat spring Chinook would increase the certainty of this assessment. For B.1.b. (phenotypic variation), an analysis needs to be conducted that shows that the phenotypic traits of the current population are consistent with the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting.

There was one metric that was rated at high risk related to spawner composition that did not directly reduce the overall risk conclusion, but should be considered a potential threat to both genotypic (B.1.3) and phenotypic variation (B.1.b). The spawner composition contained a very high proportion of out-of-ESU strays, primarily from the Entiat National Fish Hatchery.

Although reproductive success of ENFH strays is unknown, it is unlikely that genotypic variation consistent with moderate-low risk can be obtained with continued high proportions of these fish on the spawning grounds.

Table 9. Spatial structure and diversity scoring table

<table>
<tr><th rowspan="2">Metric</th><th colspan="5">Risk Assessment Scores</th></tr>
<tr><th>Metric</th><th>Factor</th><th>Mechanism</th><th>Goal</th><th>Population</th></tr>
<tr><td>A.1.a</td><td>H (-1)</td><td>H (-1)</td><td rowspan="3">Moderate Risk
(Mean = 0)</td><td rowspan="3">Moderate Risk</td><td rowspan="13">High Risk</td></tr>
<tr><td>A.1.b</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>A.1.c</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.1.a</td><td>VL (2)</td><td>VL (2)</td><td rowspan="3">High Risk
(-1)</td><td rowspan="10">High Risk</td></tr>
<tr><td>B.1.b</td><td>M (0)</td><td>M (0)</td></tr>
<tr><td>B.1.c</td><td>H (-1)</td><td>H (-1)</td></tr>
<tr><td>B.2.a(1)</td><td>H (-1)</td><td rowspan="4">High Risk
(-1)</td><td rowspan="4">High Risk
(-1)</td></tr>
<tr><td>B.2.a(2)</td><td>NA</td></tr>
<tr><td>B.2.a(3)</td><td>M (0)</td></tr>
<tr><td>B.2.a(4)</td><td>NA</td></tr>
<tr><td>B.3.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
<tr><td>B.4.a</td><td>L (1)</td><td>L (1)</td><td>L (1)</td></tr>
</table>

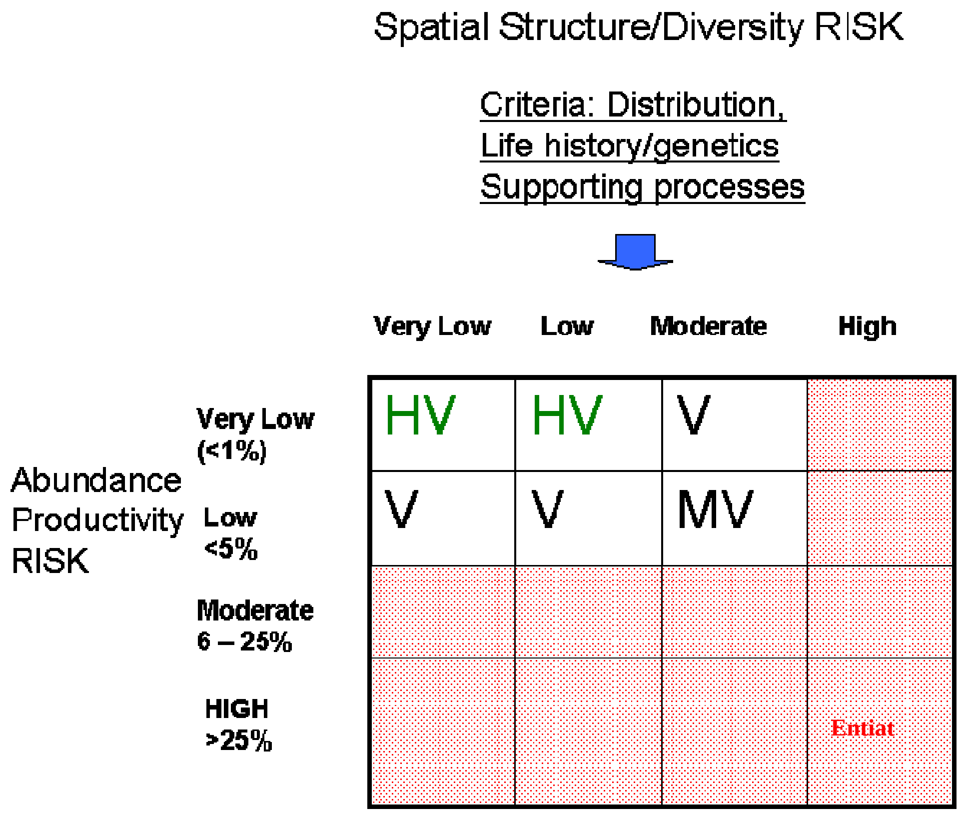

Figure 15. Abundance & productivity and spatial structure & diversity integration table.

Overall Risk Rating:

The spatial structure and diversity of the Entiat spring Chinook population is currently rated as high risk. Improvement of the spatial structure and diversity status to moderate risk would be required to allow the Entiat population to achieve a "viable" or "minimum viable" status (in addition to the improvements needed for abundance and productivity) (Figure 15). Due to the natural limitations of a basic, category A population, the Entiat could never achieve "highly viable" status. Based on the MPG and ESU guidelines, the Entiat population only needs to achieve "minimum viable" status for its contribution to recovery of the ESU.

Entiat Summer Steelhead Population

The Entiat summer steelhead population is part of the Upper Columbia ESU that only has one extant *MPG* that includes 4 current populations: Wenatchee, Entiat, Methow Rivers, and Okanogan) plus Crab Creek (Figure 16) (ICTRT 2004). The ICTRT classified the Entiat River summer steelhead population as "basic" in size based on historical habitat potential (ICTRT 2005). This classification requires a minimum abundance threshold of 500 wild spawners with sufficient intrinsic productivity (>1.0 r/s) to exceed a 5 % extinction risk on the viability curve (ICTRT 2005). Additionally, the Entiat steelhead population was classified as a "type A" population (based on historic intrinsic potential) because of its simple spatial structure (i.e., only 2 branches) (Table 10) (ICTRT 2005).

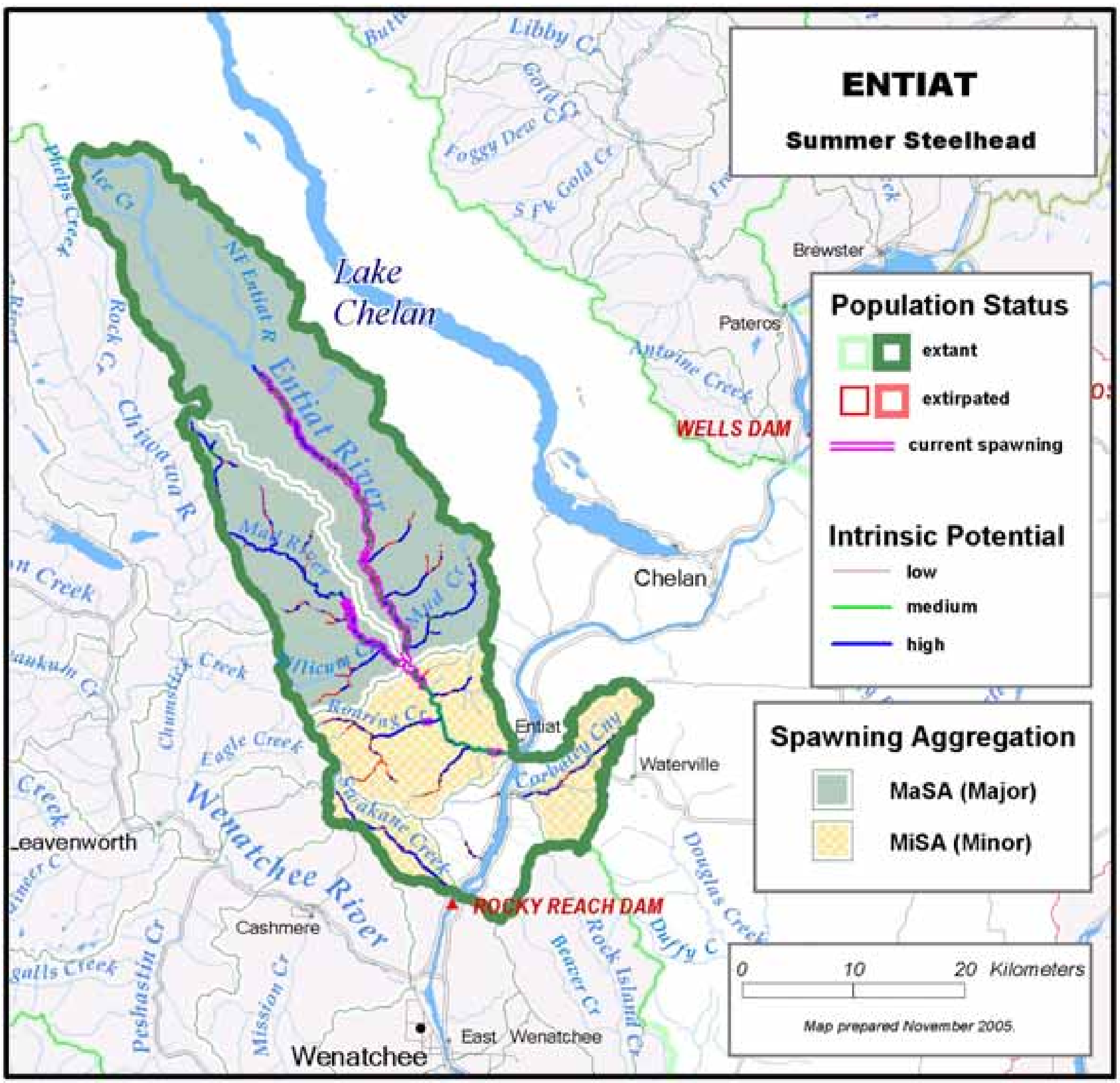

Figure 16. Entiat summer/winter steelhead major and minor spawning aggregates.

Table 10. Entiat summer/winter Steelhead Basin Statistics

Drainage Area (km2)	1.326
Stream lengths km* (total)	585
Stream lengths km* (below natural barriers)	288
Branched stream area weighted by intrinsic potential (km2)	1.196
Branched stream area km2 (weighted and temp. limited)	0.897
Total stream area weighted by intrinsic potential (km2)	1.456
Total stream area weighted by intrinsic potential (km2) temp limited	1.135
Size / Complexity category	Basic / A (simple linear)
Number of MaSAs	2
Number of MiSAs	3

*All stream segments greater than or equal to 3.8m bankfull width were included

**Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22°C.

The ICTRT identified two historical Major Spawning Areas (MaSAs) and three minor spawning areas (MiSAs) within the Entiat population (Figure 17).

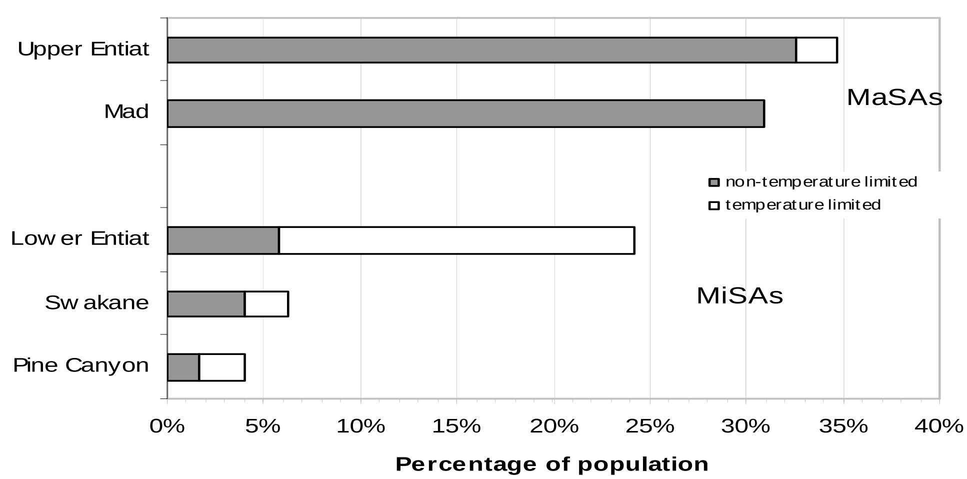

Figure 17. Percentage of historical spawning habitat by major/minor spawning area. Temperature limited portions of each MaSA/MiSA are shown in white. The Lower Entiat is considered to be a MiSA because it drops to less than 125,000 m^2 under temperature limitations.

Factors and Metrics

A.1.a Number and spatial arrangement of spawning areas. The ICTRT identified two major and three minor spawning areas for the Entiat summer steelhead population. The major spawning areas include the Upper Entiat (including Mud, Potato, and Stormy Creeks) and the Mad River (including Tillicum Creek) whereas the minor spawning areas include the Lower Entiat (including Roaring Creek), Swakane Creek, and Pine Canyon. Based on agency defined distribution, only the Upper Entiat MaSA and Lower Entiat MiSA would meet the ICTRT definition of occupied because the Mad only has spawners present in the lower portion of the intrinsic potential habitat (mouth to rkm 12). Assuming that the lower half of the Mad River MaSA and the Lower Entiat MiSA are over 75% of the capacity of a MaSA then the Entiat steelhead population is at *moderate risk* for this metric.

A.l.b. Spatial extent or range of population. Efforts to monitor the distribution and abundance of spawning steelhead have been initiated and expanded in recent years (2003-2005), but we still do not have comprehensive, long-term data sets to rate this metric for the Entiat population. Based on these recent data sets, one of the two MaSAs and one of the three MiSA in the Entiat were occupied putting the population at *moderate risk* for this metric (Figure 18). Only two official surveys have been conducted in the upper ½ of the Mad River MaSA and no redds have been detected in the relatively short stretch (~2 km) that was surveyed (Archibald et al? 2004, 2005). There has been little to no anthropogenic influence in this area so it is considered functional but unoccupied habitat and it may well have been occupied in areas or years that were not surveyed.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates. The Entiat steelhead population is at *moderate risk* for this metric because only 50% of the MaSAs are occupied, but unoccupied MaSAs have not increased gaps between MaSAs. Also, the absence of known spawning in Swakane Creek does not increase the gap between populations by more than 25 km.

B.1.a. Major life history strategies. The Entiat steelhead population is *very low risk*, because no major life history strategies have been lost (i.e. no winter run was ever present and resident *O. mykiss* are known to occur in the watershed).

B.1.b. Phenotypic variation. There are no data available for this metric. Even if we determined that there was a change to one or more traits we do not know what the exact baseline is because changes likely occurred before there was biological monitoring. Therefore, we will assume that there has been some change and increase in variance for 2 or more traits placing the population at *moderate risk*.

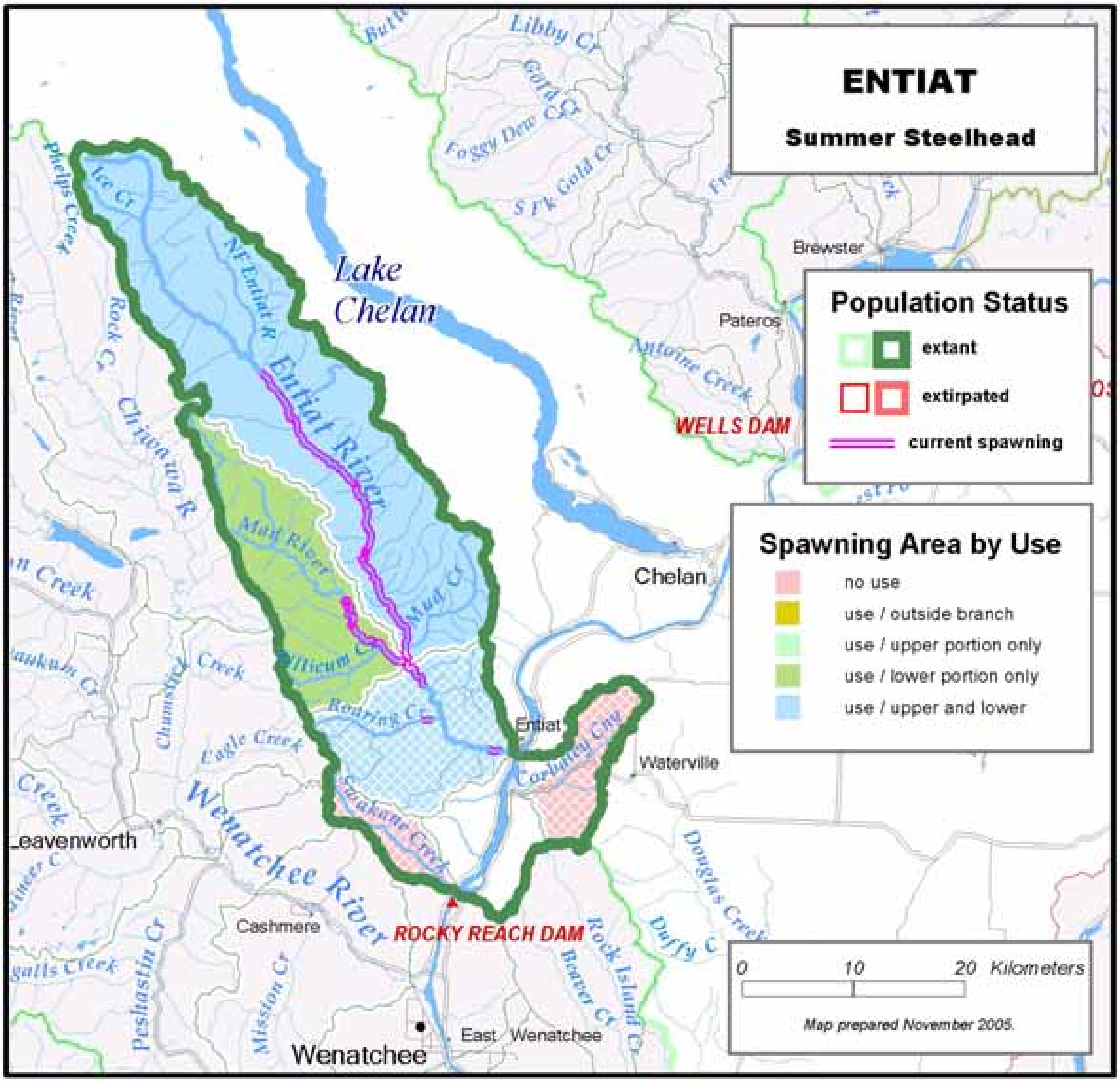

Figure 18. Entiat summer/winter Steelhead current spawning distribution.

<u>B.1.c. Genetic variation.</u> The Entiat summer steelhead population was determined to be at *high risk* for genetic variation due to a persistent homogenization from previous and ongoing fish management efforts. The genetic signal shows little differentiation between populations with strong similarity to Wells Hatchery; however, all available data are at least 20 years old. There is a possibility that the true genetic risk metric for this population should be lower, especially since there have been no targeted releases of hatchery steelhead in the basin for about 10 years. If additional data becomes available indicating differentiation between and within populations (either genetic data indicating levels of divergence consistent with the time since separation; robust straying data or genetic information showing strong spatial structure), this metric can be downgraded.

B.2.a. Spawner composition.

(1) *Out-of-ESU strays.* We have no data to evaluate the proportion of out of ESU hatchery strays on the spawning grounds of the Entiat population; therefore the default rating is *moderate risk*. However, there are no hatchery programs propagating non-local anadromous stock in the ESU and we have no reason to believe that the Entiat steelhead population is at an elevated risk level for this metric. Therefore, when considering future status reviews we may want to consider an alternative measurement location, such as Priest Rapids Dam, to determine risk to the ESU, instead of to individual populations.

(2) *Out of MPG strays*. The Upper Columbia ESU only has one extant MPG, so this metric is *not applicable* and no score will be given.

(3) *Out of population strays*. No data exists for the spawner composition of steelhead in the Entiat basin, but it is believed that a high proportion of fish spawning in the Entiat are of hatchery origin. Additionally, there is substantial risk of strays from the Wells hatchery program because of the inter-dam difference in adult counts between Rocky Reach and Wells Dam. Also, large numbers of Wenatchee River hatchery steelhead have been observed at the Wells trap, upstream of the Entiat (this program raises steelhead at Turtle Rock (Columbia River) and direct plants them in the Wenatchee basin with no acclimation). Therefore, because of these threats we conclude that the Entiat is at *high risk* for within ESU hatchery strays. However, data needs to be collected to verify if these threats are being realized on the spawning grounds of the Entiat population.

(4) *Within-population strays.* There is no supplementation program for steelhead in the Entiat basin. Therefore, this metric is *not applicable* to the Entiat steelhead population.

B.3.a. Distribution of population across habitat types. The distribution of intrinsic branches for Entiat summer steelhead covered 5 ecoregions, 3 of which were considered significant (>10%) (Figure 19; Table 11). Substantial shifts (> 67%) have occurred in 1 of the 3 ecoregions (Wenatchee/Chelan Highlands), based on no occupancy in the upper ½ of the Mad River MaSA. Therefore, the population is at *moderate risk* for this metric.

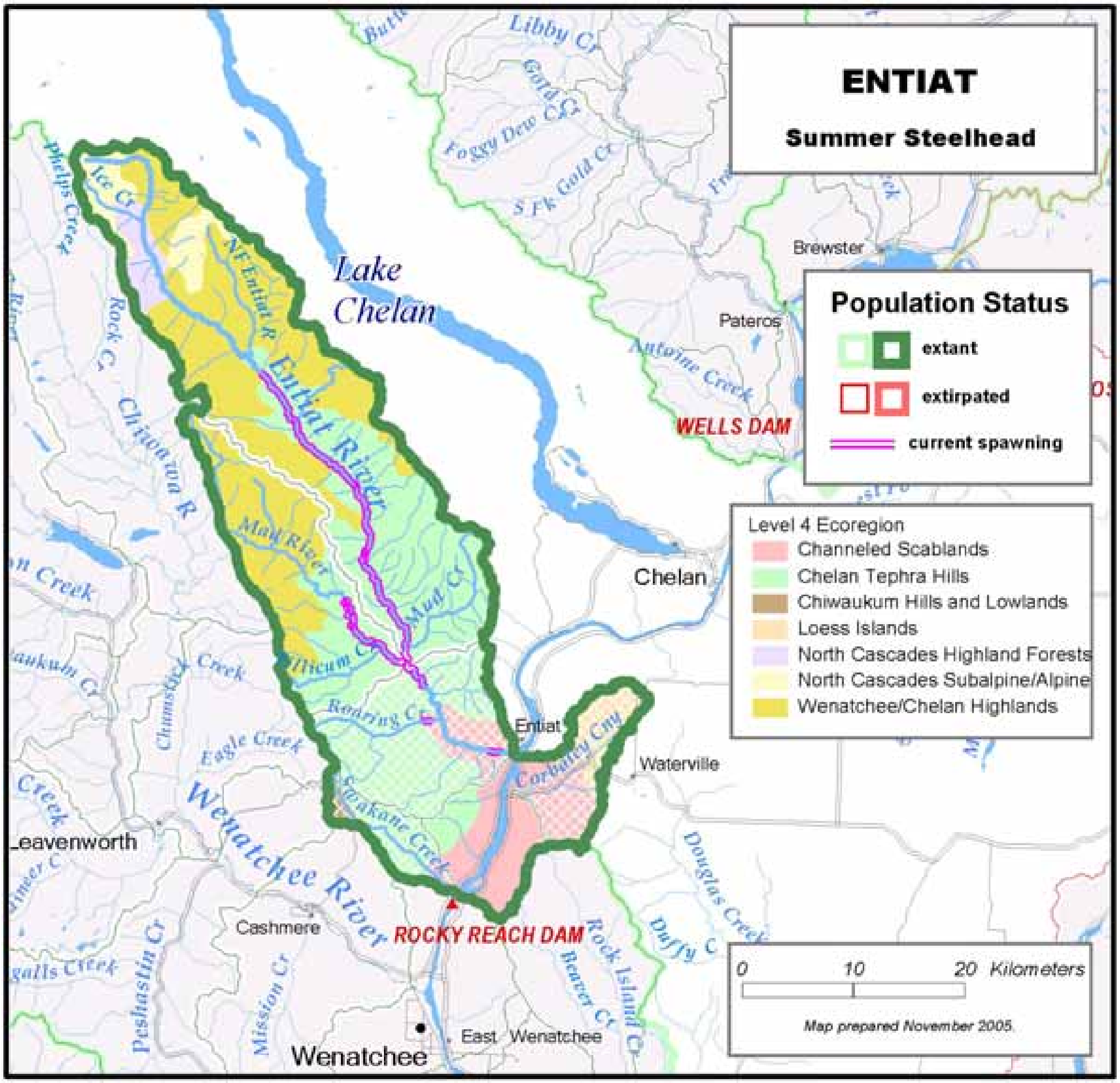

Figure 19. Entiat summer/winter steelhead population distribution across various ecoregions.

Table 11. Entiat Summer/Winter Steelhead – proportion of spawning area across various ecoregions

Ecoregion	% of historical spawning area in this ecoregion (non-temperature limited)	% of currently occupied spawning area in this ecoregion (non-temperature limited)
Channeled Scablands	17.7	6.4
Chelan Tephra Hills	66.2	93.3
Chiwaukum Hills And Lowlands	2.7	0.0
Loess Islands	1.0	0.0
Wenatchee/Chelan Highlands	12.4	0.3

B.4.a. Selective change in natural processes or selective impacts.

Hydropower system: Low risk, although it has slowed out migration for early and late out migrants, but in recent years flow augmentation has reduced the impact to the middle 95% of the run.

Harvest: Low risk in recent generations. Harvest rates affect < 20% of the adults and selective gear reduces the impact of selectivity.

Hatcheries: Low risk, broodstock management of the other Upper Columbia population supplementation programs has been designed to be non-selective.

Habitat: Low risk, no known measurable effects.

Based on low risk estimates across the four sectors, we conclude that the population is at *low risk* for this metric.

Spatial Structure and Diversity Summary

The Entiat steelhead population was determined to be at moderate risk for goal A (allowing natural rates and levels of spatially mediated processes) and high risk for goal B (maintaining natural levels of variation) resulting in an overall high risk rating (Table 12). For goal A, the lack of confirmed spawning in the upper ½ of the Mad River MaSA was causing the risk level to decrease from low to moderate for all 3 metrics. For goal B, the metric for genotypic variation was directly responsible for the moderate risk rating of Entiat summer steelhead. We concluded that there was not enough data available to determine if the level of divergence in the Wenatchee was sufficient for a low or high risk rating and therefore used a moderate risk rating. For B.1.b. (phenotypic variation), an analysis needs to be conducted that shows that the phenotypic traits of the current population are consistent with the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting. Based on the scoring system, these metrics must be addressed in order for the status of goal B to improve to low risk.

Another metric that was rated at high risk was the proportion of out-of-population (but within ESU) spawners that were hatchery fish (B.2.a.2), because of the threat of strays from the Wells and Wenatchee hatchery programs.

Table 12. Spatial structure and diversity scoring table

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a	M (0)	M (0)	Moderate Risk (Mean = 0)	Moderate Risk	High Risk
A.1.b	M (0)	M (0)			
A.1.c	M (0)	M (0)			
B.1.a	VL (2)	VL (2)	High Risk (-1)	High Risk	
B.1.b	M (0)	M (0)			
B.1.c	H (-1)	H (-1)			
B.2.a(1)	M (0)	High Risk (-1)	High Risk (-1)		
B.2.a(2)	NA				
B.2.a(3)	H (-1)				
B.2.a(4)	NA				
B.3.a	M (0)	M (0)	Moderate Risk (0)		
B.4.a	L (1)	L (1)	Low Risk (1)		

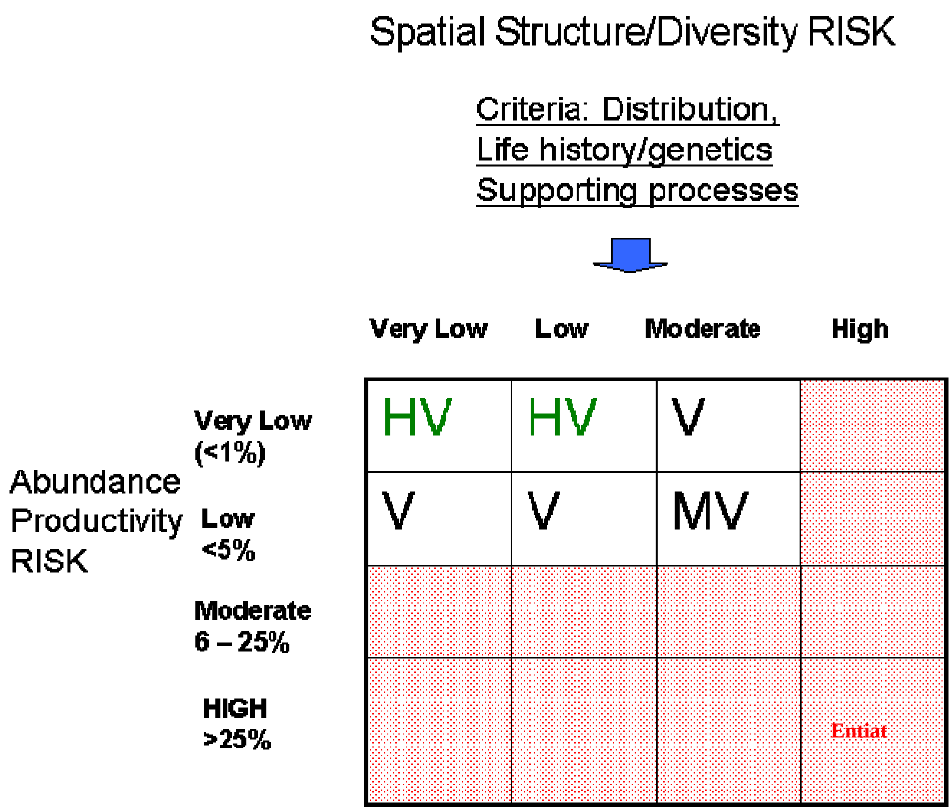

Figure 20. Abundance & productivity and spatial structure & diversity integration table.

Overall Risk Rating:

The spatial structure and diversity of the Entiat summer steelhead population is currently rated as high risk. Improvement of the spatial structure and diversity status to moderate risk would be necessary to allow the Entiat population to achieve a “minimum viable” status (in combination with low risk A&P) or “viable” status (with very low risk A&P) (Figure 20). Based on the MPG guidelines, the Entiat population will only need to achieve a minimum viable status for recovery of the ESU (ICTRT 2005).

Methow Spring Chinook Population

The Methow spring Chinook population is part of the Upper Columbia ESU. This ESU contains only one extant MPG including 3 current populations—Wenatchee, Entiat, and Methow Rivers (Figure 21) (ICTRT 2004). The ICTRT classified the Methow River spring Chinook population as “very large” in size based on historical habitat potential (ICTRT 2005). This classification requires a minimum abundance threshold of 2000 wild spawners with sufficient intrinsic productivity (>1.75 r/s) to exceed a 5 % extinction risk on the viability curve (ICTRT 2005). Additionally, the Methow spring Chinook population was classified as a “type B” population (based on historic intrinsic potential) because it has dendritic tributary structure with multiple major spawning areas (Table 13) (ICTRT 2005).

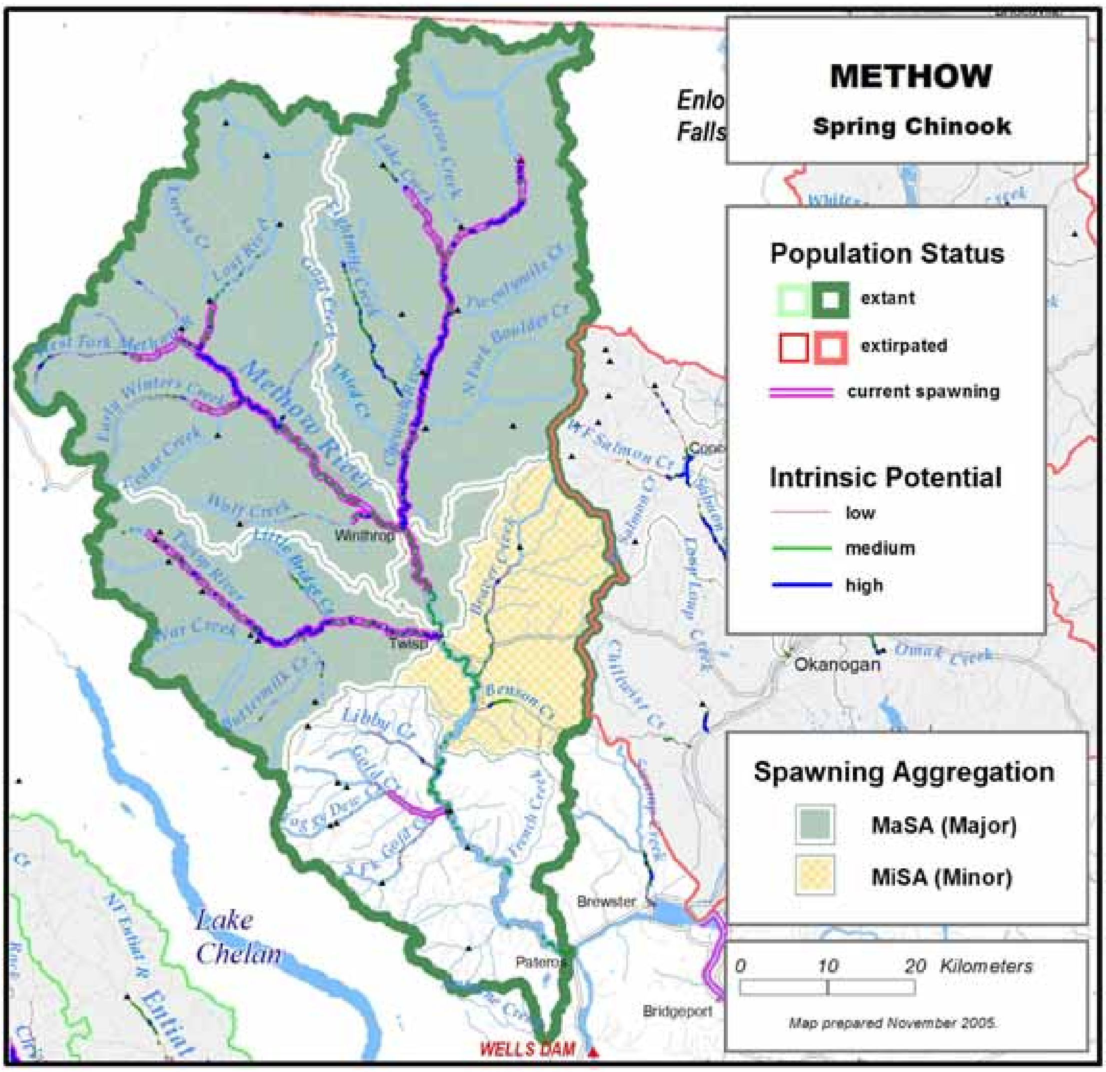

Figure 21. Methow spring Chinook major and minor spawning aggregations

Table 13. Methow spring Chinook basin statistics

Drainage Area (km2)	4,722
Stream lengths km* (total)	1,996.0
Stream lengths km* (below natural barriers)	889.0
Branched stream area weighted by intrinsic potential (km2)	1.497
Branched stream area km2 (weighted and temp. limited)	1.310
Total stream area weighted by intrinsic potential (km2)	2.036
Total stream area weighted by intrinsic potential (km2) temp limited	1.725
Size / Complexity category	Very Large / B (dendritic structure)
Number of MaSAs	4
Number of MiSAs	1

*All stream segments greater than or equal to 3.8m bankfull width were included

**Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22^{o}C.

The ICTRT has identified four historical Major Spawning Areas (MaSAs) and one minor spawning area (MiSA) within the Methow population (Figure 22). The four MaSAs are: Chewuch, Upper Methow, Middle Methow, and Twisp.

Currently, the primary spawning areas used by Spring Chinook in the Methow population are the mainstem Methow (above the Twisp confluence), Twisp, and Chewuch rivers. Additional spawning has been documented in Gold Creek, Wolf Creek, Robinson Creek, Lake Creek, and Early Winters Creek. Hatchery origin spring Chinook returns to natural spawning areas within the Methow basin originate from two separate programs. Winthrop National Fish Hatchery has planted spring Chinook in the Methow basin since 1941 (continuously since 1974). Beginning in 1998, broodstock for this program was shifted to a Methow “composite” stock. Since 1992, WDFW has operated the Methow Hatchery as a central facility to carry out release programs from acclimation facilities in three tributaries within the Methow River—the Methow, Chewuch and Twisp drainages. Broodstock for the Twisp program are collected from returns to the Twisp system. In recent years, a composite broodstock has been used for the Chewuch and Methow releases. The majority of returns from these programs spawn in their natal watersheds although there has been a relatively high rate of straying among areas within the Methow.

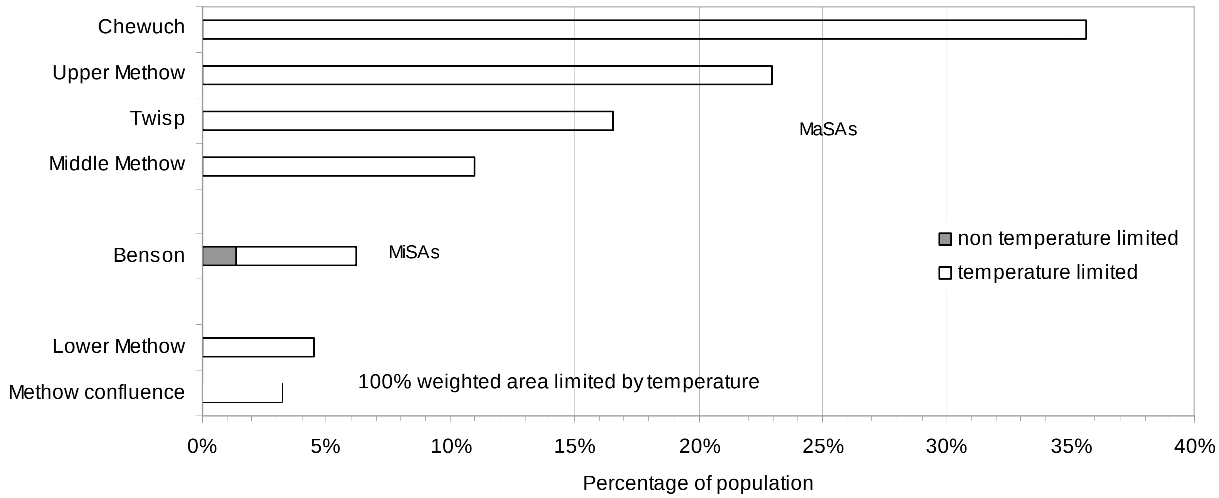

Figure 22. Percentage of historical spawning habitat (of the population) by major/minor spawning area. White portions are subject to temperature limitations. The Lower Methow and Methow confluence are 100% limited by temperature, therefore they are not included as MiSAs.

Factors and Metrics

A.1.a Number and spatial arrangement of spawning areas. The Methow Spring Chinook population has four MaSAs (Chewuch, Upper Methow, Middle Methow, and Twisp) and they are all currently occupied (based on agency defined distribution) so it is at *very low risk.*

A.l.b. Spatial extent or range of population. The Methow spring Chinook population has four MaSAs (Chewuch, Twisp, Upper Methow, and middle Methow mainstem), but only 3 of the 4 MaSAs meet the occupancy definition so it is at *low risk* (Figure 23). The MaSA that failed to meet minimum occupancy requirements was the middle Methow mainstem (between the Chewuch and Twisp confluences), which only had more than 4 redds in 3 of the last 5 years and 6 of the last 15 years (Humling and Snow 2005).

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates. There has been no increase or decrease in gaps greater than 10 km between MaSAs for the Methow spring Chinook population so it is at *low risk* for this metric.

B.1.a. Major life history strategies. The Methow spring Chinook population is *very low risk*, because no major life history strategies have been lost.

B.1.b. Phenotypic variation. There are no data available for this metric. Even if we determined that there was a change to one or more traits we do not know what the exact baseline is because changes likely occurred before there was biological monitoring. Therefore, we will assume that there has been some change and increase in variance for 2 or more traits placing the population at *moderate risk*.

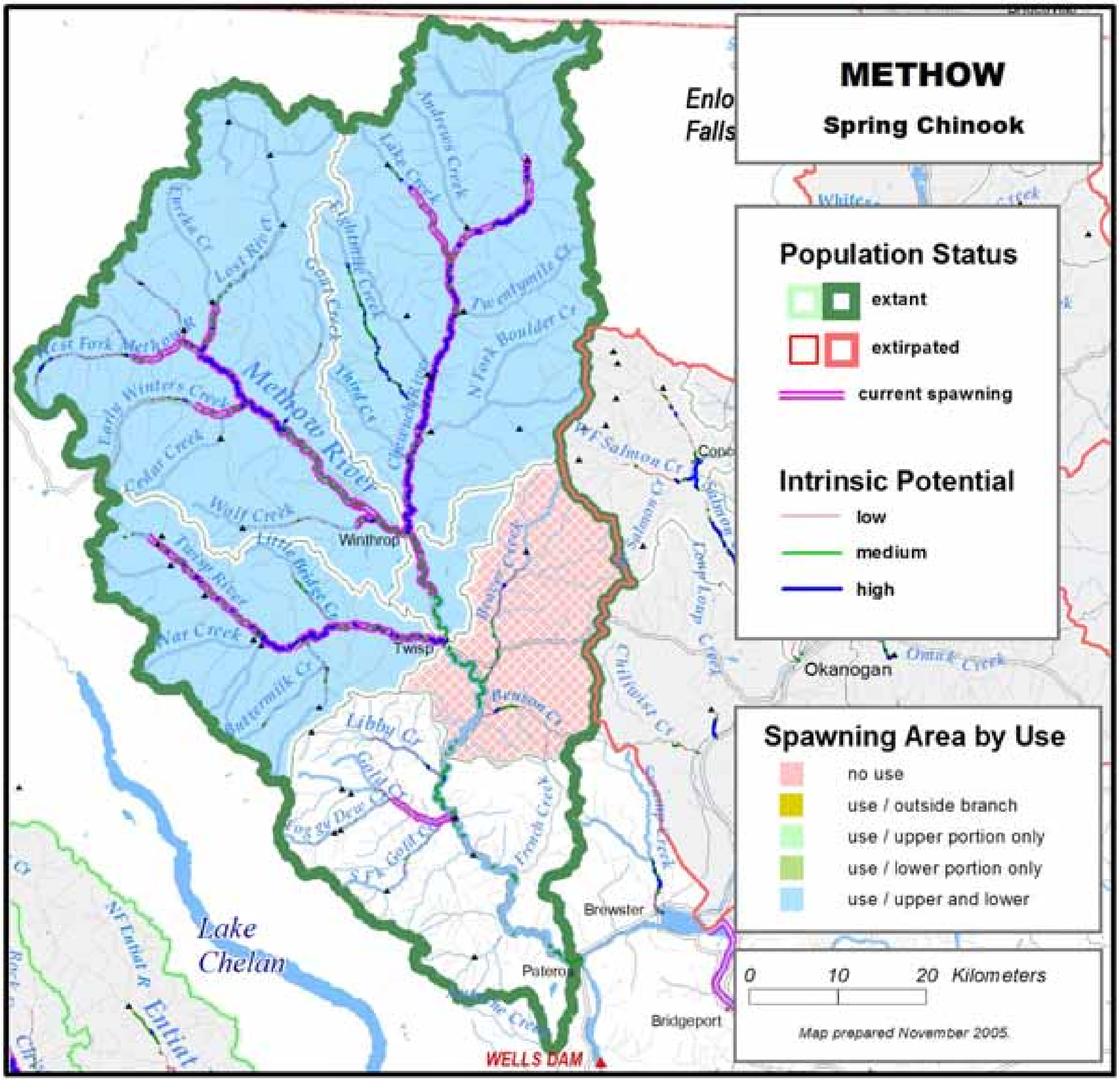

Figure 23. Methow spring Chinook current distribution

<u>B.1.c. Genetic variation.</u> The Methow spring Chinook population was determined to be at *high risk* for genetic variation due to a persistent homogenization from previous fish management efforts. Analyses based on allozymes collected in the 1980s suggest that there was some differentiation between subpopulations consistent with the level of differentiation expected in that time frame, particularly in the Twisp drainage. However, microsatellite samples collected in the late 1990s and early 2000s do not show this same differentiation, suggesting that recent management practices may have disrupted natural gene flow (ICTRT pop id draft, in prep). The ICTRT genetic subgroup has reviewed the current status of all populations in the Interior basin. The subgroup concluded that the Methow population has been homogenized with other UC populations due to past practices. Their conclusion was based on high similarity to all UC hatchery samples and ANOVA analysis indicating no structure. Additionally, the hatchery stocks

currently used in the upper Methow and Chewuch programs still contain a large percentage of Carson lineage, and hatchery fish comprise high proportions (40-98%) of fish on the spawning grounds (Humling and Snow 2004), so the threats to genetic variation have not been completely removed. It is possible that the true genetic risk metric for this population is lower. If additional data becomes available indicating differentiation between and within populations (either genetic data indicating levels of divergence consistent with the time since separation; robust straying data, or genetic information showing strong spatial structure), the risk level for this metric could improve to moderate or low risk.

B.2.a. Spawner composition.

(1) *Out-of-ESU strays*. In 2003, there was a 1% spawner composition (Humling and Snow 2004) of hatchery fish from outside the population, but the Methow State Hatchery and the Winthrop National Fish Hatchery are propagating a composite stock that has outside the ESU lineage, so the population is at *moderate risk* for this metric.

(2) *Out of MPG strays*. The Upper Columbia ESU only has one extant MPG, so this metric is *not applicable* and no score will be given.

(3) *Out of population strays*. Methow comp hatchery fish contain a high proportion of Carson stock in their lineage and cannot be considered "best management practices". These fish consistently comprise more than 90% of the spawner composition on the spawning grounds (Humling and Snow 2005); therefore, the population is at *high risk* with respect to this metric.

(4) *Within-population strays*. This metric is *not applicable* because of the high proportion of Carson lineage in the Methow comp stock that is being propagated for the supplementation program.

B.3.a. Distribution of population across habitat types. The intrinsic potential distribution for Methow Spring Chinook covered three ecoregions (Table 4). Current distribution also encompasses 3 ecoregions with no losses or substantial shifts in distribution among ecoregions (Figure 24; Table 14). Therefore, the population was at *low risk* for this metric.

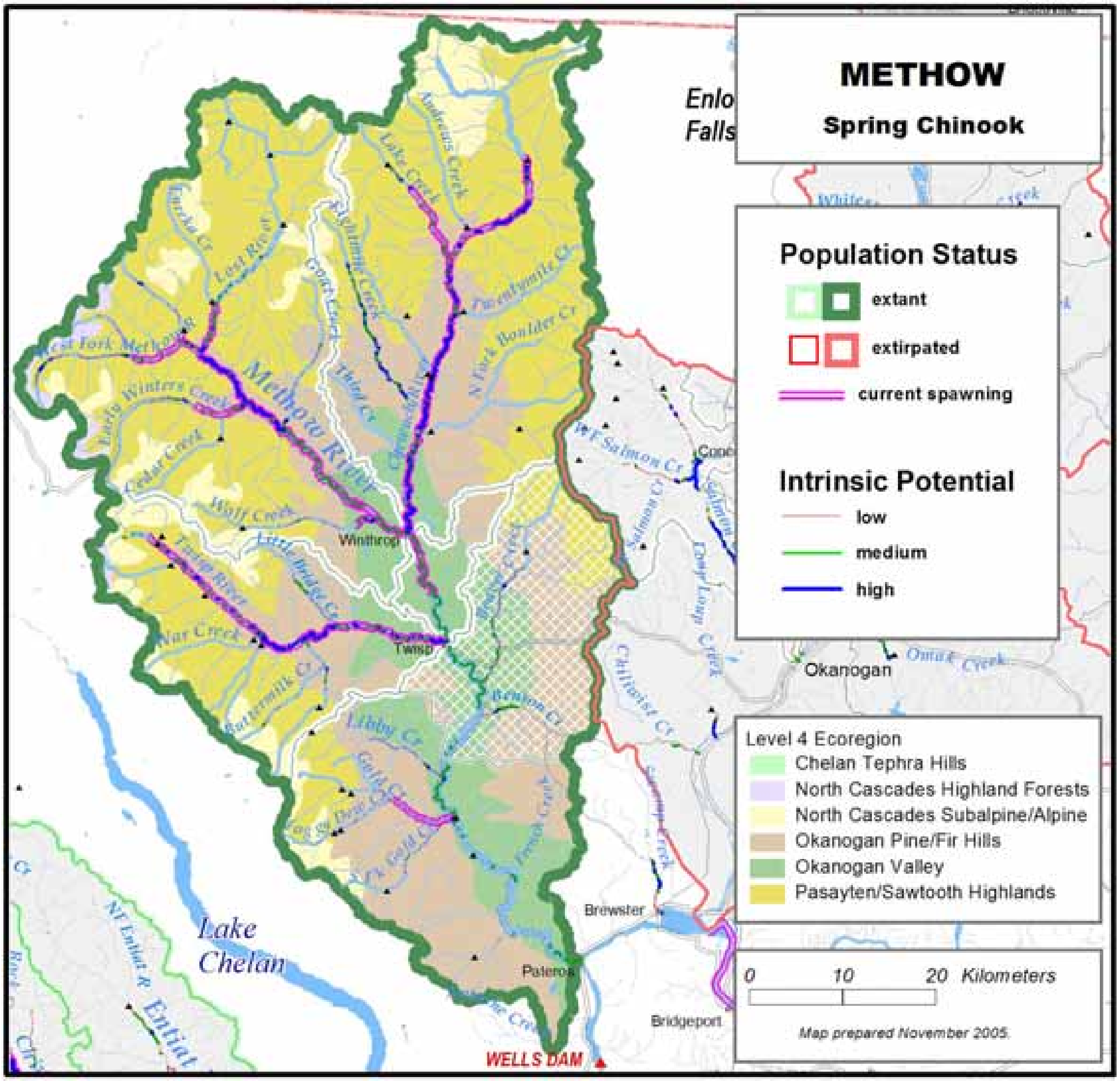

Figure 24. Methow spring Chinook population distribution across various ecoregions.

Table 14. Methow spring Chinook – proportion of spawning area across various ecoregions

Ecoregion	% of historical branch spawning area in this ecoregion (non-temperature limited)	% of historical branch spawning area in this ecoregion (temp. limited)	% of currently occupied spawning area in this ecoregion
Okanogan Pine/Fir Hills	44.0	50.3	50.4
Okanogan Valley	45.4	37.6	34.8
Pasayten/Sawtooth Highlands	10.6	12.1	14.8

*Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22°C.

B.4.a. Selective change in natural processes or selective impacts.

Hydropower system: Low risk, although it has slowed out migration for early and late out migrants, but in recent years flow augmentation has reduced the impact to the middle 95% of the run.

Harvest: Low risk in recent generations. Harvest rates affect <20% of the adults and selective gear reduces the impact of selectivity.

Hatcheries: Low risk, broodstock management of the Methow-comp supplementation program has been designed to be non-selective.

Habitat: Low risk, although low flow and high temperatures in some areas could prohibit run timing for late arriving adults.

Based on low risk estimates across the four sectors, we conclude that the population is at *low risk* for this metric.

Spatial Structure and Diversity Summary

The Methow spring Chinook population was determined to be at low risk for goal A (allowing natural rates and levels of spatially mediated processes) but high risk for goal B (maintaining natural levels of variation) resulting in an overall high risk rating (Table 15). The metric for genotypic variation was directly responsible for the high risk rating of Methow spring Chinook. For B.1.b. (phenotypic variation) to improve from moderate to low risk, an analysis needs to be conducted that shows that the phenotypic traits of the current population are consistent with the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting.

There was one metric that was rated at high risk related to spawner composition (B.2.a.3.) that did not directly reduce the overall risk conclusion, but should be considered a potential threat to both genotypic (B.1.3) and phenotypic variation (B.1.b). Met-comp hatchery fish contain a high proportion of Carson stock in their lineage and cannot be considered "within population" hatchery fish for the spawner composition metric. These fish consistently comprise more than 90% of the spawner composition on the spawning grounds (Humling and Snow 2005). However, due to the scoring system this high-risk rating was averaged in with other metrics and did not directly cause an increased risk rating.

Table 15. Spatial structure and diversity scoring table

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a	VL (2)	VL (2)	Low Risk Mean = 1.25	Low Risk	**High Risk**
A.1.b	L (1)	L (1)			
A.1.c	L (1)	L (1)			
B.1.a	VL (2)	VL (2)	High Risk (-1)	High Risk	
B.1.b	M (0)	M (0)			
B.1.c	H(-1)	(H-1)			
B.2.a(1)	M (0)	High Risk (-1)	High Risk (-1)		
B.2.a(2)	NA				
B.2.a(3)	H (-1)				
B.2.a(4)	NA				
B.3.a	L (1)	L (1)	L (1)		
B.4.a	L (1)	L (1)	L (1)		

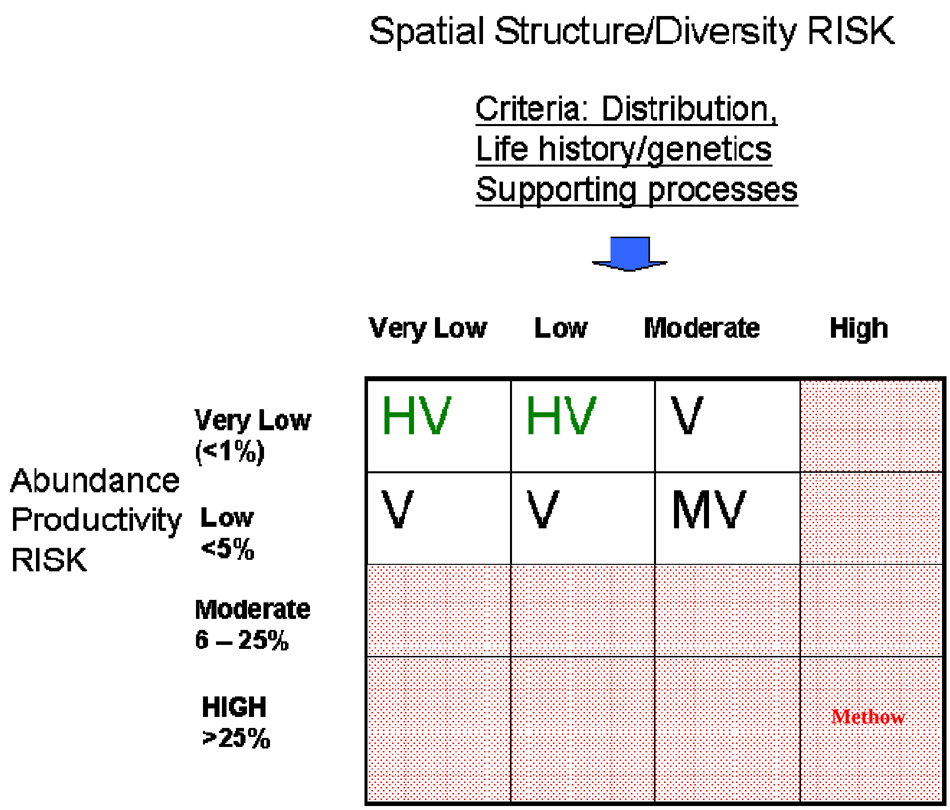

Figure 25. Abundance & productivity and spatial structure & diversity integration table.

Overall Risk Rating:

The spatial structure and diversity of the Methow spring Chinook population is currently rated as high risk. Improvement of the spatial structure and diversity status to low risk would be required to allow the Methow population to achieve a "highly viable" status (in addition to the improvements needed for abundance and productivity) (Figure 25). Based on the MPG guidelines, the Methow population will need to achieve a highly viable status for recovery of the ESU (ICTRT 2005).

Methow Summer Steelhead Population

The Methow summer steelhead population is part of the Upper Columbia ESU that only has one extant *MPG* that includes four current populations (Wenatchee, Entiat, Methow, and Okanogan Rivers) plus Crab Creek. (Figure 26) (ICTRT 2004). The size category of the Methow River summer steelhead population is “large” based on historical habitat potential (ICTRT 2005). This classification requires a minimum abundance threshold of 1,500 wild spawners with sufficient intrinsic productivity (>1.0 r/s) to exceed a 5 % extinction risk on the viability curve (ICTRT 2005). Additionally, the Methow summer steelhead population was classified as a type (B) population (based on historic intrinsic potential) because it has dendritic tributary structure with multiple major spawning areas (Table 16) (ICTRT 2005).

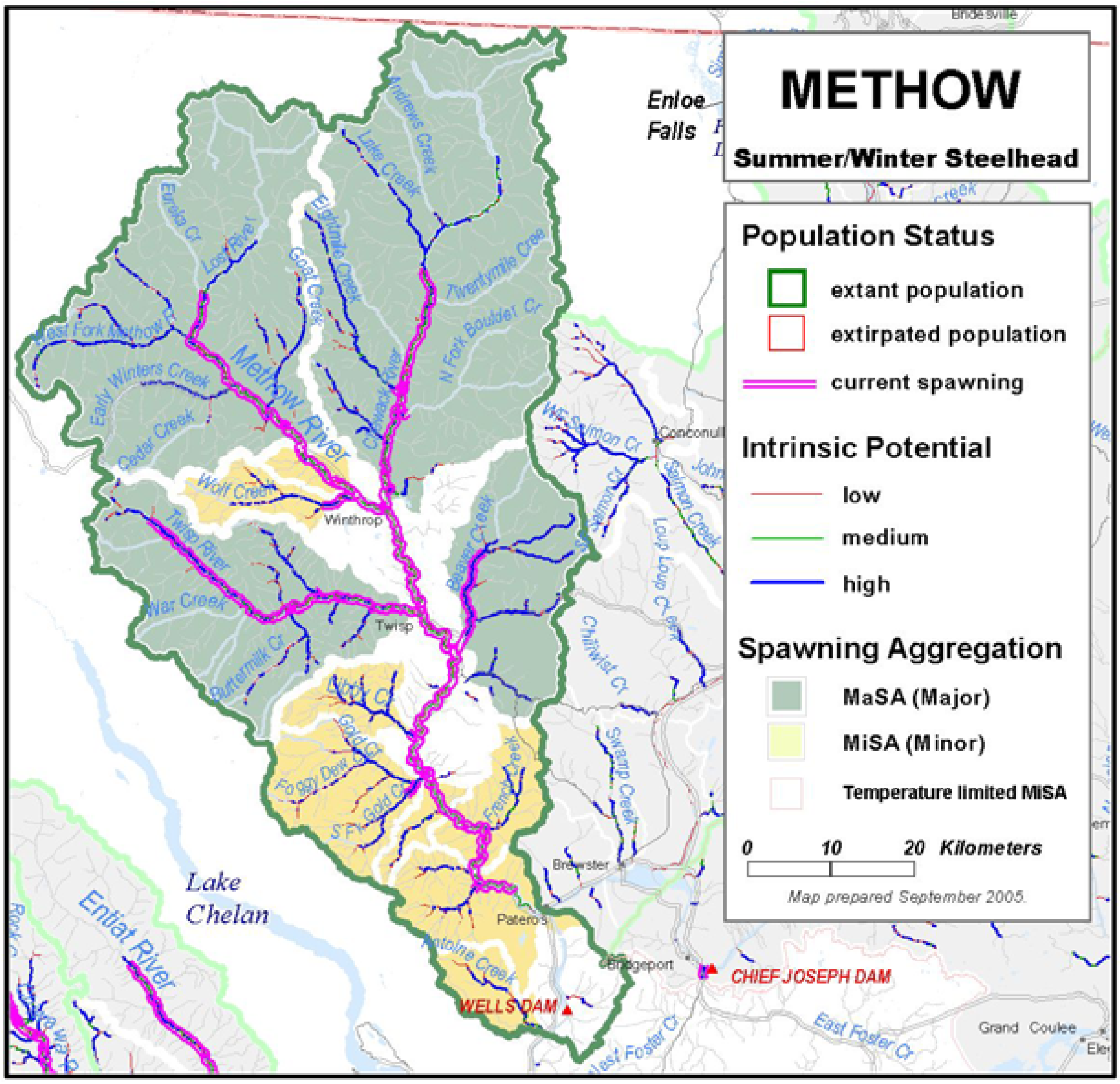

Figure 26. Major and minor spawning aggregations of the Methow summer/winter Steelhead population.

Table 16. Methow summer Steelhead basin statistics

Drainage Area (km2)	4,936
Stream lengths km* (total)	2,039
Stream lengths km* (below natural barriers)	918
Branched stream area weighted by intrinsic potential (km2)	3.491
Branched stream area km2 (weighted and temp. limited)	3.268
Total stream area weighted by intrinsic potential (km2)	5.694
Total stream area weighted by intrinsic potential (km2) temp limited	4.414
Size / Complexity category	Large / B (dendritic structure)
Number of MSAs	4
Number of mSAs	8

*All stream segments greater than or equal to 3.8m bankfull width were included

**Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22^{o}C.

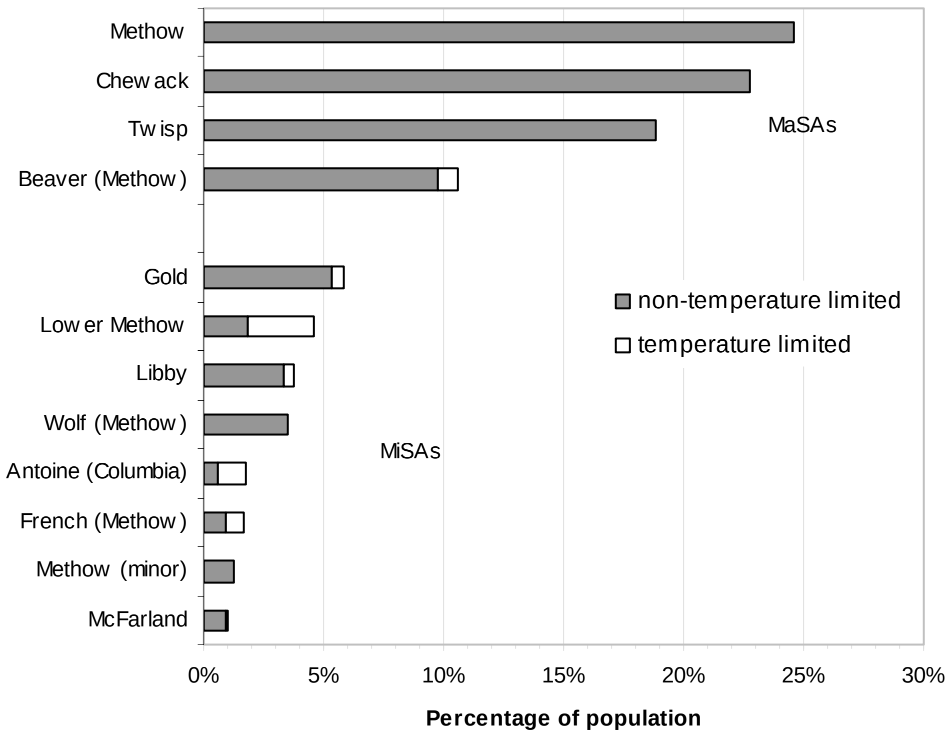

Figure 27. Percentage of historical spawning habitat by major/minor spawning areas in the Methow summer/winter Steelhead population. Temperature limited portions of the MiSA/MaSAs are shown in white.

Factors and Metrics

A.1.a Number and spatial arrangement of spawning areas. The ICTRT intrinsic potential analysis identified four major and eight minor spawning areas for the Methow summer steelhead population (Figure 27). Based on agency defined distribution, all of the MaSAs are occupied along with at least half of the MiSAs (Gold, Libby, Wolf Creeks, and the Lower Methow River putting the Methow steelhead population at *very low risk* for this metric.

A.l.b. Spatial extent or range of population. Based on agency defined distribution, all of the MaSAs are occupied along with at least half of the MiSAs (Gold, Libby,Wolf Creeks, and the Lower Methow River putting the Methow steelhead population at *low risk* for this metric (Figure 28).

Efforts to monitor the distribution and abundance of spawning steelhead have been initiated and expanded in recent years (2001-2005), but we still do not have comprehensive, long-term data to rate this metric for the Methow population. However, based on recent spawning ground surveys, all four MSA's were occupied in the upper and lower halves from 2001-2004, with the lowest average of 41 redds (2002-2004) occurring in Beaver Creek (Snow 2003; Humling and Snow 2004). These estimates do not separate out the hatchery fish and since natural origin fish were only approximately 10% of the population (based on fish trapped at Wells Dam), it’s possible that there were few to no natural origin steelhead present in Beaver Creek in 2003.

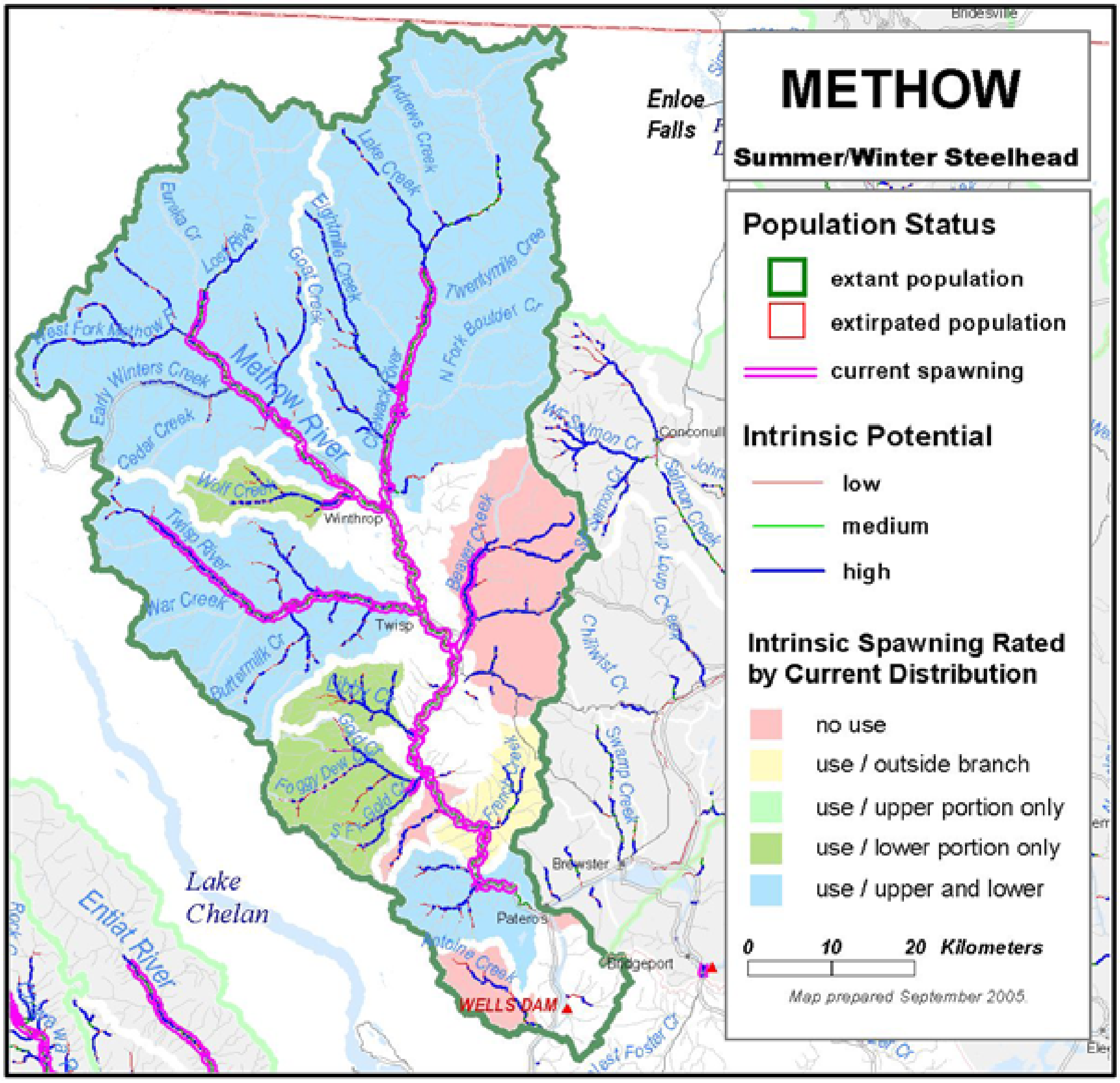

Figure 28. Current distribution of the Methow population.

<u>A.1.c. Increase or decrease in gaps or continuities between spawning aggregates.</u> The Methow steelhead population is at *low risk* for this metric because all of the MaSAs are occupied (no gaps) and unoccupied MiSAs have not increased gaps to adjacent populations by more than 25 km. However, several of the MiSAs appear to not be occupied, or have not been formally surveyed, based on recent redd surveys conducted by WDFW (Snow 2003; Humling and Snow 2004). Although two redds were located in Gold Creek in 2003, no redds were found there in 2002 or 2004 and no redds were found in Black Canyon Creek in 2004 (Snow 2003; Humling

and Snow 2004). We are not aware of any surveys in McFarland or French Creeks and they were not considered “potential” habitat based on agency-defined distribution. However, French Creek is included in a rotating panel design and will be surveyed once every 5 years starting in 2006 (Humling and Snow 2004).

B.1.a. Major life history strategies. The Methow steelhead population is *very low risk*, because no major life history strategies have been lost (i.e. no winter run was ever present and resident *O. mykiss* are known to occur in the watershed).

B.1.b. Phenotypic variation. There are no data available for this metric. Even if we determined that there was a change to one or more traits we do not know what the exact baseline is because changes likely occurred before there was biological monitoring. Therefore, we will assume that there has been some change and increase in variance for 2 or more traits placing the population at *moderate risk*.

B.1.c. Genetic variation. The Methow summer steelhead population was determined to be at *high risk* for genetic variation due to a persistent homogenization from previous and ongoing fish management efforts. The genetic signal shows little differentiation between populations with strong similarity to Wells Hatchery; however, all available data at least 20 years old. There is a possibility that the true genetic risk metric for this population should be lower. If additional data becomes available indicating differentiation between and within populations (either genetic data indicating levels of divergence consistent with the time since separation; robust straying data or genetic information showing strong spatial structure), this metric can be downgraded.

B.2.a. Spawner composition.

(1) *Out-of-ESU strays*. The Methow steelhead population is at *low risk* since there is no evidence of non-local (outside the ESU) hatchery fish passing Wells Dam.

(2) *Out of MPG strays*. The Upper Columbia ESU only has one extant MPG, so this metric is *not applicable* and no score will be given.

(3) *Out of population strays*. There are no estimates of spawner composition for the various MaSAs and MiSAs of the Methow steelhead population because carcasses cannot be obtained in sufficient numbers from the spawning ground surveys. However, in 2004 only 9.5 % of the steelhead passing Wells Dam were natural origin (Humling and Snow 2004). This is similar to the proportion of wild fish from previous years (Kirk Truscott, personal communication). This high proportion of hatchery origin spawners would result in *high risk*, regardless of whether or not the program was considered best management practices. However, the program was not considered best management practices because adult steelhead are trapped at Wells Dam (mainstem Columbia River) and they could have originated from any of the MaSAs within the Methow or from the Okanogan. Additionally, steelhead releases occur at various locations throughout the Methow and Okanogan, thereby mixing the progeny from various MaSAs of two independent populations and not encouraging local adaptation within the population or between the Methow and Okanogan population.

Although the Wells hatchery program does use wild fish, the NMFS BiOp restricts the broodstock to no more than 33% natural origin fish, regardless of the run size (NMFS 2002). This constraint limits the opportunity to meet production requirements with all wild fish during years of high abundance, a practice that would reduce the genetic risk of the hatchery program.

Finally, there has been high numbers of Wenatchee steelhead observed passing Wells Dam in recent years, presumably because they are reared on Columbia River water at the Turtle Rock facility before direct release with no acclimation in the Wenatchee (Kirk Truscott, personal communication). There is currently no information to determine if Wenatchee steelhead do show up on the spawning grounds of the Methow basin and efforts to monitor this risk need to be conducted. Therefore, given the extremely high proportion of hatchery fish passing Wells Dam, the mixing of Methow and Okanogan fish in the broodstock, the release of smolts into the Methow that could have originated from Okanogan parents, and the threat that the Wenatchee strays pose, suggest that the population is at *high risk* for this metric.

(4) *Within-population strays*. No score will be given for this metric because the Wells hatchery stock was rated for metric B.2.a.3 and therefore this metric is *not applicable*. The Wells hatchery program mixes Methow and Okanogan origin adults and therefore does not meet best management practices.

B.3.a. Distribution of population across habitat types. The distribution of intrinsic branches for Methow summer steelhead covered four ecoregions, three of which were considered significant (>10%) (Figure 29; Table 17). Substantial shifts (>67%) have occurred in 1 of the 3 ecoregions (Pasayten/Sawtooth Highlands). Therefore, the population is at *moderate risk* for this metric. The majority of the currently unoccupied habitat in the Pasayten/Sawtooth Highlands Ecoregion is in the upper Twisp, Upper Methow, and Upper Chewuch where the habitat is in pristine conditions and there are few to no anthropogenic effects limiting spatial structure in these areas.

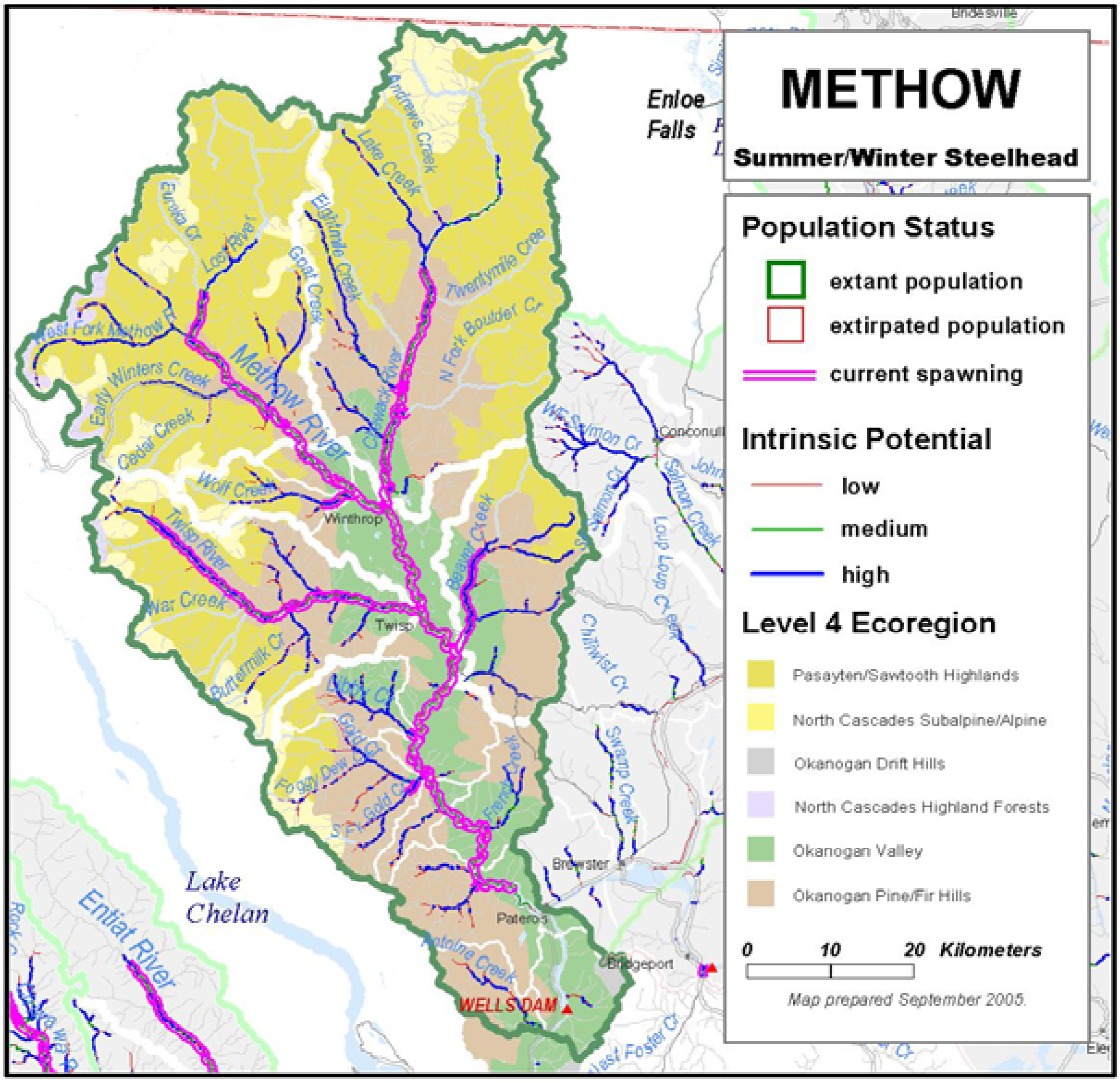

Figure 29. Distribution of the Methow steelhead population across various ecoregions.

Table 17. Methow summer Chinook – proportion of spawning area across various ecoregions

Ecoregion	% of historical spawning area in this ecoregion (non-temperature limited)	% of currently occupied spawning area in this ecoregion (non-temperature limited)
North Cascades Highland Forests	0.0	0.0
North Cascades Subalpine/Alpine	0.1	0.0
Okanogan Pine/Fir Hills	50.4	30.6
Okanogan Valley	20.3	64.9
Pasayten/Sawtooth Highlands	29.0	4.6

B.4.a. Selective change in natural processes or selective impacts.

Hydropower system: Low risk, although it has slowed out migration for early and late out migrants, but in recent years flow augmentation has reduced the impact to the middle 95% of the run.

Harvest: Low risk in recent generations. Harvest rates affect < 20% of the adults and selective gear reduces the impact of selectivity.

Hatcheries: Low risk, broodstock management of the Methow\Okanogan composite stock program has been designed to be non-selective.

Habitat: Low risk, no known measurable effects.

Based on low risk estimates across the four sectors, we conclude that the population is at *low risk* for this metric.

Spatial Structure and Diversity Summary

The Methow steelhead population was determined to be at low risk for goal A (allowing natural rates and levels of spatially mediated processes) and high risk for goal B (Maintaining natural levels of variation) resulting in an overall high risk rating (Table 18). For goal B, the metrics for genotypic variation was directly responsible for the high risk rating of Methow summer steelhead. For B.1.b. (phenotypic variation), an analysis needs to be conducted that shows that the phenotypic traits of the current population are consistent with the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting. Based on the scoring system, these metrics must be addressed in order for the status of goal B to improve to low risk.

Another metric that was rated at high risk was the proportion of out-of-population (but within ESU) spawners that were hatchery fish (B.2.a.2). There were several factors that lead to a high risk rating, even though we did not have data that directly measured the origin of adults the spawning grounds. These risks included the extremely high proportion of hatchery fish passing Wells Dam (~90%), the mixing of Methow and Okanogan fish in the broodstock, the release of smolts into the Methow that could have originated from Okanogan parents, and the threat from the high number of Wenatchee origin steelhead passing Wells Dam. It is likely that genotypic and phenotypic variation have been influenced by past hatchery practices and that it will be difficult to achieve low risk levels for metrics B.1.b (phenotype) and B.1.c (genotype) given the continued threats outlined in metric B.2.a.2 (spawner composition).

Table 18. Spatial structure and diversity scoring table

	Risk Assessment Scores				
Metric	Metric	Factor	Mechanism	Goal	Population
A.1.a	VL (2)	VL (2)	Low Risk (Mean = 1.33)	Low Risk	High Risk
A.1.b	L (1)	L (1)			
A.1.c	L (1)	L (1)			
B.1.a	VL (2)	VL (2)	High Risk (-1)	High Risk	
B.1.b	M (0)	M (0)			
B.1.c	H(-1)	H(-1)			
B.2.a(1)	L (1)	High Risk (-1)	High Risk (-1)		
B.2.a(2)	NA				
B.2.a(3)	H(-1)				
B.2.a(4)	NA				
B.3.a	M (0)	M (0)	Moderate Risk (0)		
B.4.a	L (1)	L (1)	Low Risk (1)		

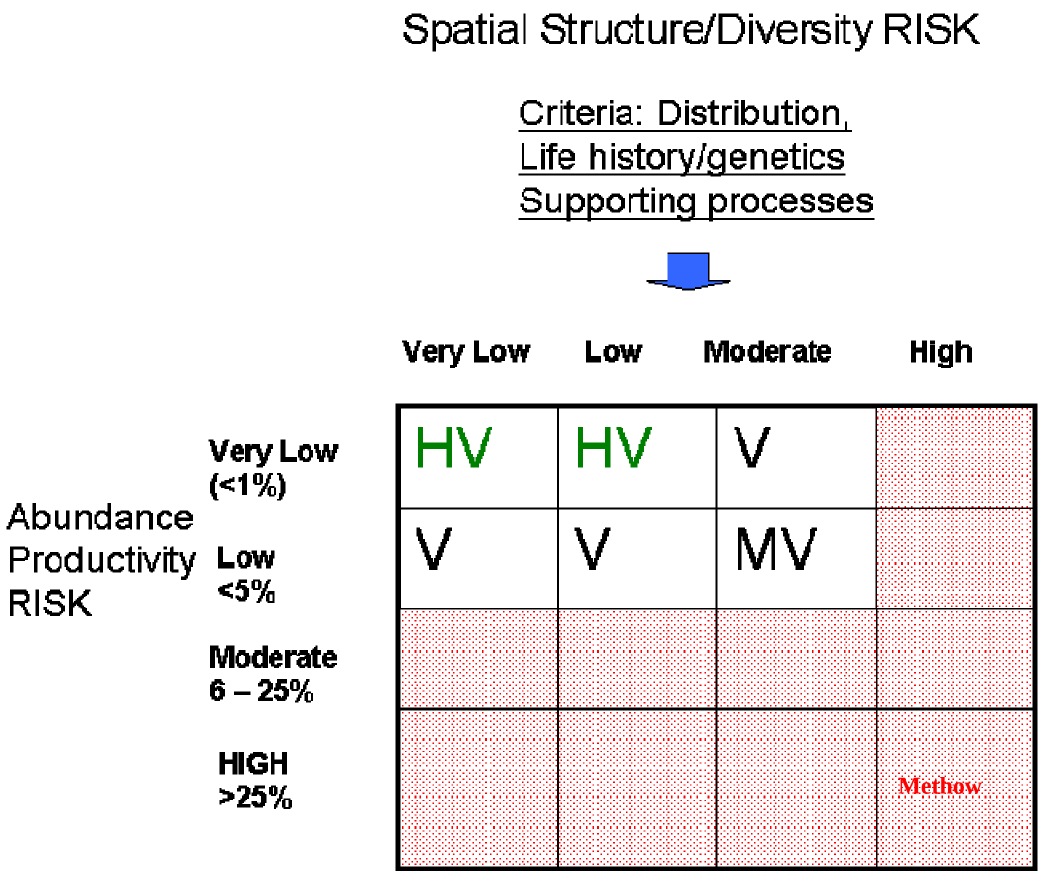

Figure 30. Abundance & productivity and spatial structure & diversity integration table.

Overall Risk Rating

The spatial structure and diversity of the Methow summer steelhead population is currently rated as high risk. Improvement of the spatial structure and diversity status to low risk will be necessary to allow the Methow population to achieve a "highly viable" status (in combination with very low risk A&P) (Figure 30). Based on the MPG guidelines, the Methow population will need to achieve a highly viable status for recovery of the ESU (ICTRT 2005).

Okanogan Summer Steelhead Population

The Okanogan Steelhead population is part of the Upper Columbia ESU that only has one extant *MPG* that includes four current populations (Wenatchee, Entiat, Methow, and Okanogan Rivers) plus Crab Creek (Figure 31) (ICTRT 2004).

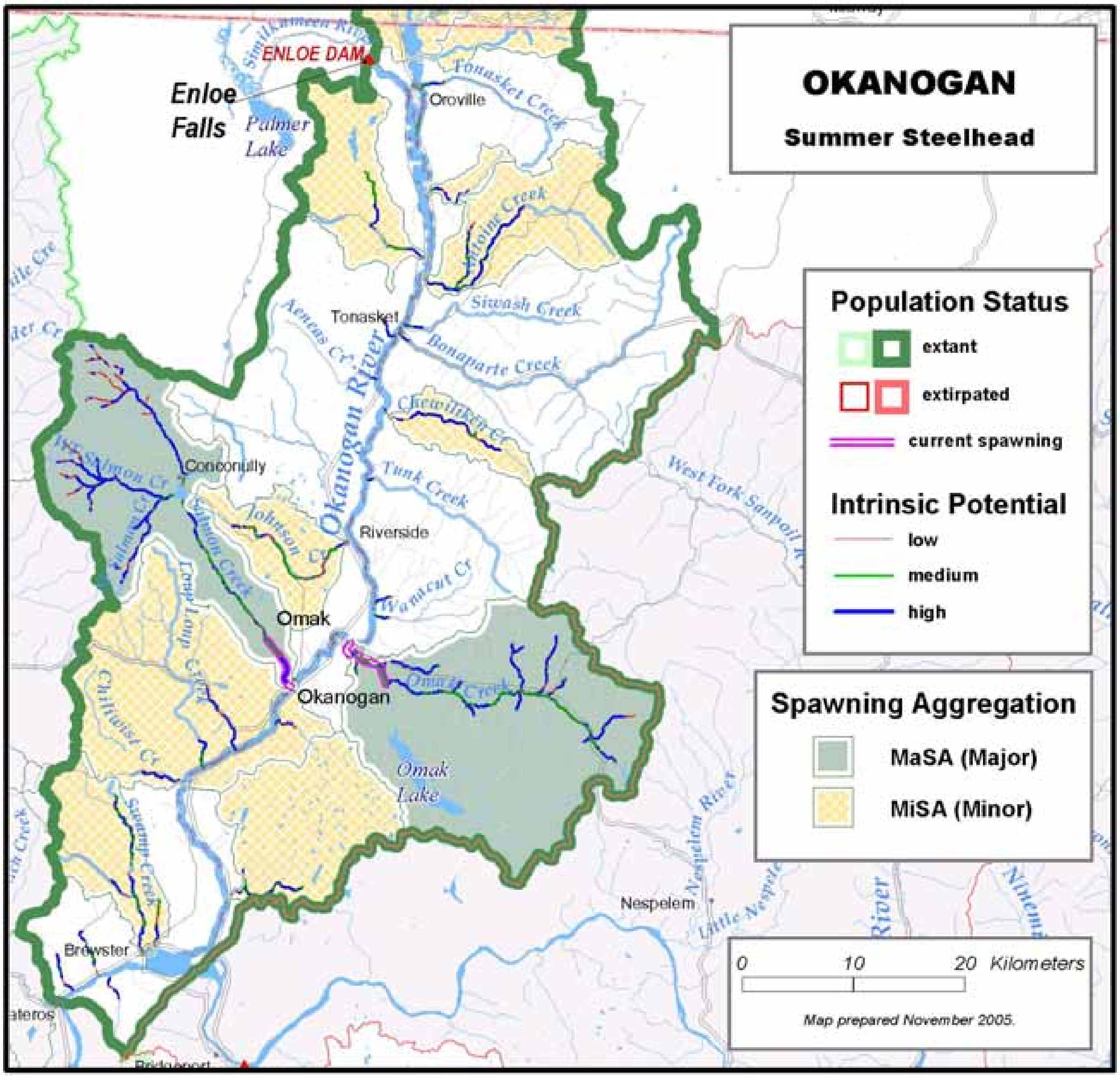

Figure 31. Okanogan summer Steelhead major and minor spawning aggregates.

The size category of the Okanogan River summer steelhead population is “intermediate” based on historical habitat potential (ICTRT 2005). This classification includes areas of intrinsic potential in Canada and requires a minimum abundance threshold of 1,000 wild spawners with sufficient intrinsic productivity (greater than 1.0 R/S) to exceed a 5 % extinction risk on the viability curve (ICTRT 2005). Data for fish distribution, abundance, and ecoregion classification were not available for Canada; therefore, we only conducted the status review for the U.S. portion of the population. The U.S. portion of the population only has enough habitat to be classified as "basic", and would require a minimum abundance threshold of 500 spawners and a productivity greater than 1.0 r/s to exceed 5% extinction risk on the viability curve. Additionally, the Okanogan summer steelhead population was classified as a type B population (based on historic intrinsic potential) because it has dendritic tributary structure with multiple major spawning areas (Table 19) (ICTRT 2005).

Table 19. Okanogan steelhead basin statistics

Drainage Area (km2)	5,725
Stream lengths km* (total)	913
Stream lengths km* (below natural barriers)	553
Branched stream area weighted by intrinsic potential (km2)	7.120
Branched stream area km2 (weighted and temp. limited)	6.409
Total stream area weighted by intrinsic potential (km2)	3.181
Total stream area weighted by intrinsic potential (km2) temp limited	0.882
Size / Complexity category	Intermediate / B (dendritic structure)
Number of MaSAs	10
Number of MiSAs	24

*All stream segments greater than or equal to 3.8m bankfull width were included

**Temperature limited areas were assessed by subtracting area where the mean weekly modeled water temperature was greater than 22^{o}C.

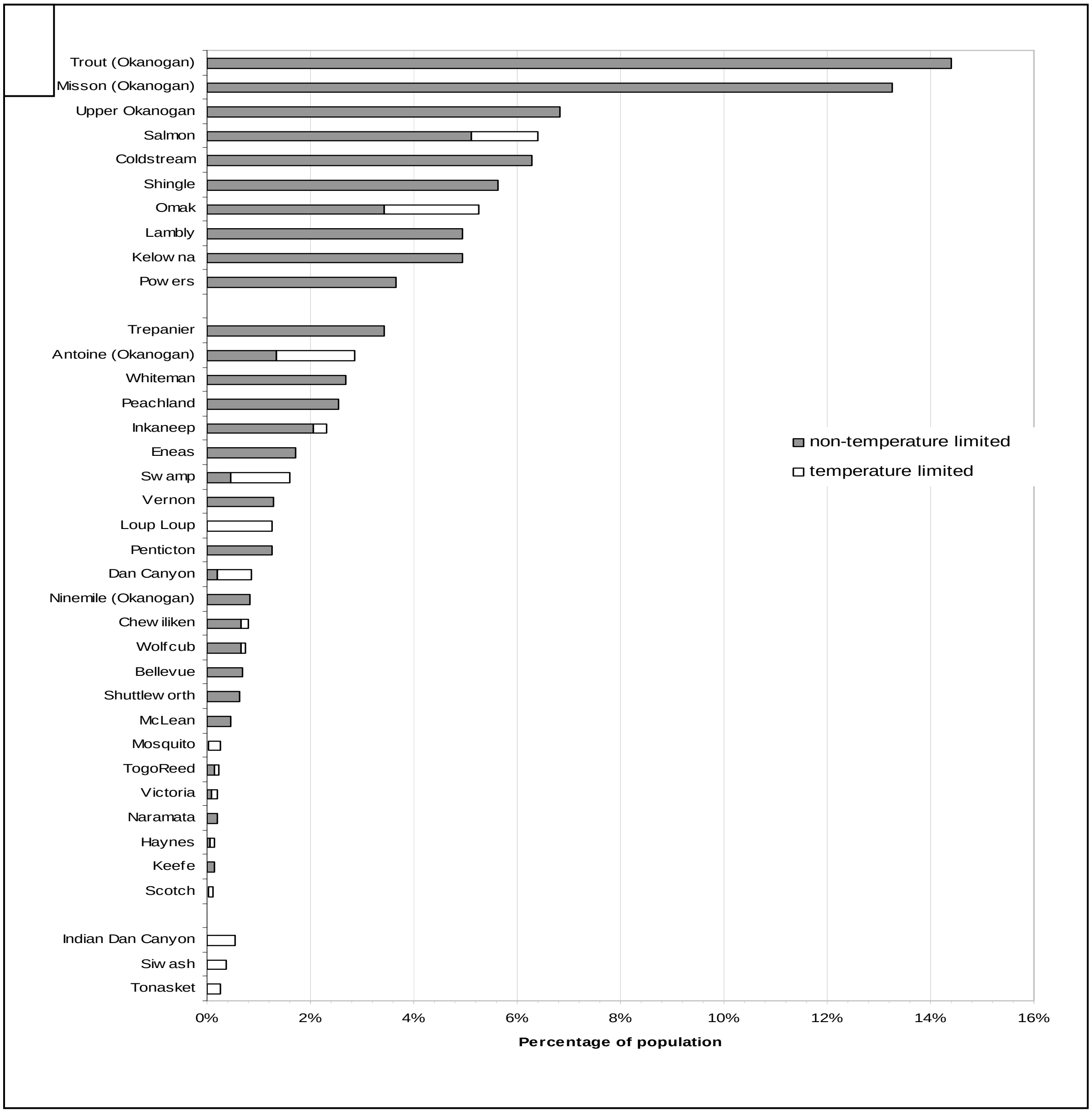

Figure 32. Percentage of historical spawning habitat in the Okanogan by major/minor spawning area. Temperature limited portions of major/minor spawning aggregates are shown in white. Three MiSAs were dropped due to temperature limitations: Indian Dan Canyon, Siwash, and Tonasket.

Factors and Metrics

A.1.a Number and spatial arrangement of spawning areas. The ICTRT identified 10 major and 24 minor spawning areas for the Okanogan summer steelhead population (Figure 32). However, only two major and five minor spawning areas are within the U.S. portion. Although recent redd surveys have identified spawning in the mainstem Okanogan and Similkameen Rivers (Arterburn et al. 2005), extensive hatchery releases occur in these areas and it is uncertain if these areas can, or ever could, support viable components of the population due to high temperatures limiting juvenile survival. The intrinsic potential major spawning areas in the U.S. portion include Salmon Creek and Omak Creek, whereas the minor spawning areas include Ninemile, Whitestone, Bonaparte, Antoine, and Loup Loup Creeks (Figure 4). However, recent surveys have identified spawners in Ninemile, Bonneparte, Tunk and Tonasket Creeks, as well as the mainstem Okanogan and Similkameen Rivers (Arterburn et al. 2005). Based on agency defined distribution, only the lower portions of Salmon Creek and Omak Creek were occupied, therefore the population is at *high risk* for this metric.

A.l.b. Spatial extent or range of population. Efforts to monitor the distribution and abundance of spawning steelhead have been initiated and expanded in recent years (2004-2005), but we still do not have comprehensive, long-term data sets to rate this metric for the Okanogan population. Based on these recent but limited data sets, neither of the two U.S. MaSAs have multiple redds in the upper halves of their intrinsic potential habitat (above Haley Creek in the Omak Creek MaSA and above the forks in the Salmon Creek MaSA) so they do not meet minimum occupancy definition, putting the population at *high risk* for this metric (Figure 33). A rating of moderate risk could be achieved with occupancy of the upper ½ of either Omak Creek or Salmon Creek MaSAs.

A.1.c. Increase or decrease in gaps or continuities between spawning aggregates. The Okanogan steelhead population was at *high risk* for this metric because neither of the two U.S. MaSAs have multiple redds in the upper halves of their intrinsic potential habitat (above Haley Creek in the Omak Creek MaSA and above the forks in the Salmon Creek MaSA) so they do not meet minimum occupancy definition. Also, the absence of known spawning at the downstream MiSA (Loup Loup Creek), did not increase the gap between populations by more than 25 km. A rating of moderate risk could be achieved with occupancy of the upper ½ of either Omak Creek or Salmon Creek MaSAs.

B.1.a. Major life history strategies. The Okanogan steelhead population is *very low risk*, because no major life history strategies have been lost (i.e. no winter run was ever present and resident *O. mykiss* are known to occur in the watershed).

B.1.b. Phenotypic variation. There are no data available for this metric. Even if we determined that there was a change to one or more traits we do not know what the exact baseline is because changes likely occurred before there was biological monitoring. Therefore, we will assume that there has been some change and increase in variance for 2 or more traits placing the population at *moderate risk*.

B.1.c. Genetic variation. There are no genetic data for Okanogan steelhead. Throughout the rest of the Upper Columbia, the genetic signal shows little differentiation between populations, with a strong similarity to Wells Hatchery. Additionally, given the low escapement of natural origin fish and the high numbers of Wells origin smolts released in this basin there is sufficient evidence to assume the population is at *high risk* for this metric. There is a possibility that the true genetic risk metric for this population should be lower. If additional data becomes available indicating differentiation between and within populations (either genetic data indicating levels of divergence consistent with the time since separation or genetic information showing strong spatial structure), this metric could be assigned a moderate or low risk rating.

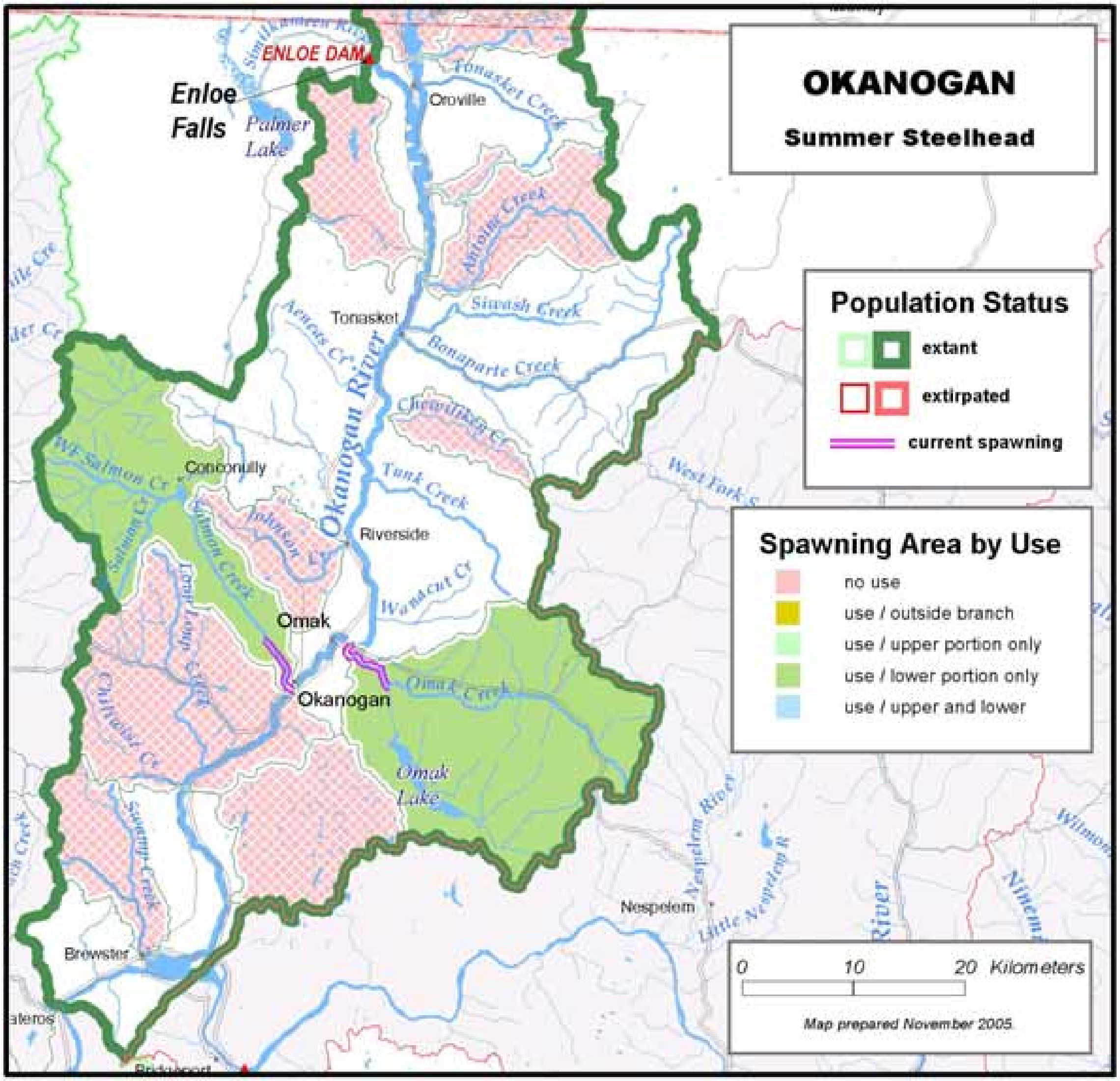

Figure 33. Okanogan summer steelhead current distribution.

B.2.a. Spawner composition.

(1) *Out-of-ESU strays*. The Okanogan steelhead population is at *low risk* since there is no evidence of non-local (outside the ESU) hatchery fish passing Wells Dam.

(2) *Out of MPG strays*. The Upper Columbia ESU only has one extant MPG, so this metric is *not applicable* and no score will be given.

(3) *Out of population strays*. We do not have estimates of spawner composition for the various MaSAs and MiSAs of the Okanogan steelhead population because carcasses cannot be obtained in sufficient numbers from the spawning ground surveys. However, in 2004 only 9.5 % of the steelhead passing Wells Dam were natural origin (Humling and Snow 2004). This is similar to

the proportion of wild fish from previous years (Kirk Truscott, personal communication). This high proportion of hatchery origin spawners would result in *high risk*, regardless of whether or not the program was considered best management practices. However, the program was not considered best management practices because adult steelhead are trapped at Wells Dam (mainstem Columbia River) and they could have originated from any of the MaSAs within the Methow or from the Okanogan. Additionally, steelhead releases occur at various locations throughout the Methow and Okanogan, thereby mixing the progeny from various MaSAs of two independent populations and not encouraging local adaptation within the population or between the Methow and Okanogan populations.

Although the Wells hatchery program does use wild fish, the NMFS BiOp restricts the broodstock to no more than 33% natural origin fish, regardless of the run size (NMFS 2002). This constraint limits the opportunity to meet production requirements with all wild fish during years of high abundance, a practice that would reduce the genetic risk of the hatchery program.

Finally, there has been high numbers of Wenatchee steelhead observed passing Wells Dam, presumably because they are reared on Columbia River water at the Turtle Rock facility before direct release with no acclimation in the Wenatchee (Kirk Truscott, personal communication). There is currently no way to determine if Wenatchee steelhead do show up on the spawning grounds of the Okanogan basin and efforts to monitor this risk need to be conducted. Therefore, given the extremely high proportion of hatchery fish passing Wells Dam, the mixing of Methow and Okanogan fish in the broodstock, the release of smolts into the Okanogan that could have originated from Methow parents, and the threat stray Wenatchee steelhead, suggest that the population is at *high risk* for this metric.

(4) *Within-population strays*. No score will be given for this metric because the Wells hatchery stock was rated for metric B.2.a.3 and therefore this metric is *not applicable*. The Wells hatchery program mixes Methow and Okanogan origin adults and therefore does not meet best management practices.

<u>B.3.a. Distribution of population across habitat types</u>. The distribution of intrinsic branches for Okanogan summer steelhead within the U.S. covered six ecoregions, three of which were considered significant (>10%) (Figure 34; Table 20). Substantial shifts (>67%) have occurred in 2 of the 3 ecoregions (Okanogan Pine/Fir Hills and Western Okanogan Semiarid Foothills). Therefore, the population is at *high risk* for this metric. Within the U.S., it appears that this metric would improve to moderate or low risk if the middle portion of Salmon Creek and the middle-upper portions of Omak Creek were occupied (Figure 34). Additionally, we could not analyze this metric for Canada (where 79% of the intrinsic potential habitat occurs) because ecoregion data does not exist and we are not aware of any distribution data for summer steelhead. Therefore, inclusion of Canadian watersheds into the occupied ecoregion analysis in the future could also change the results for this metric.

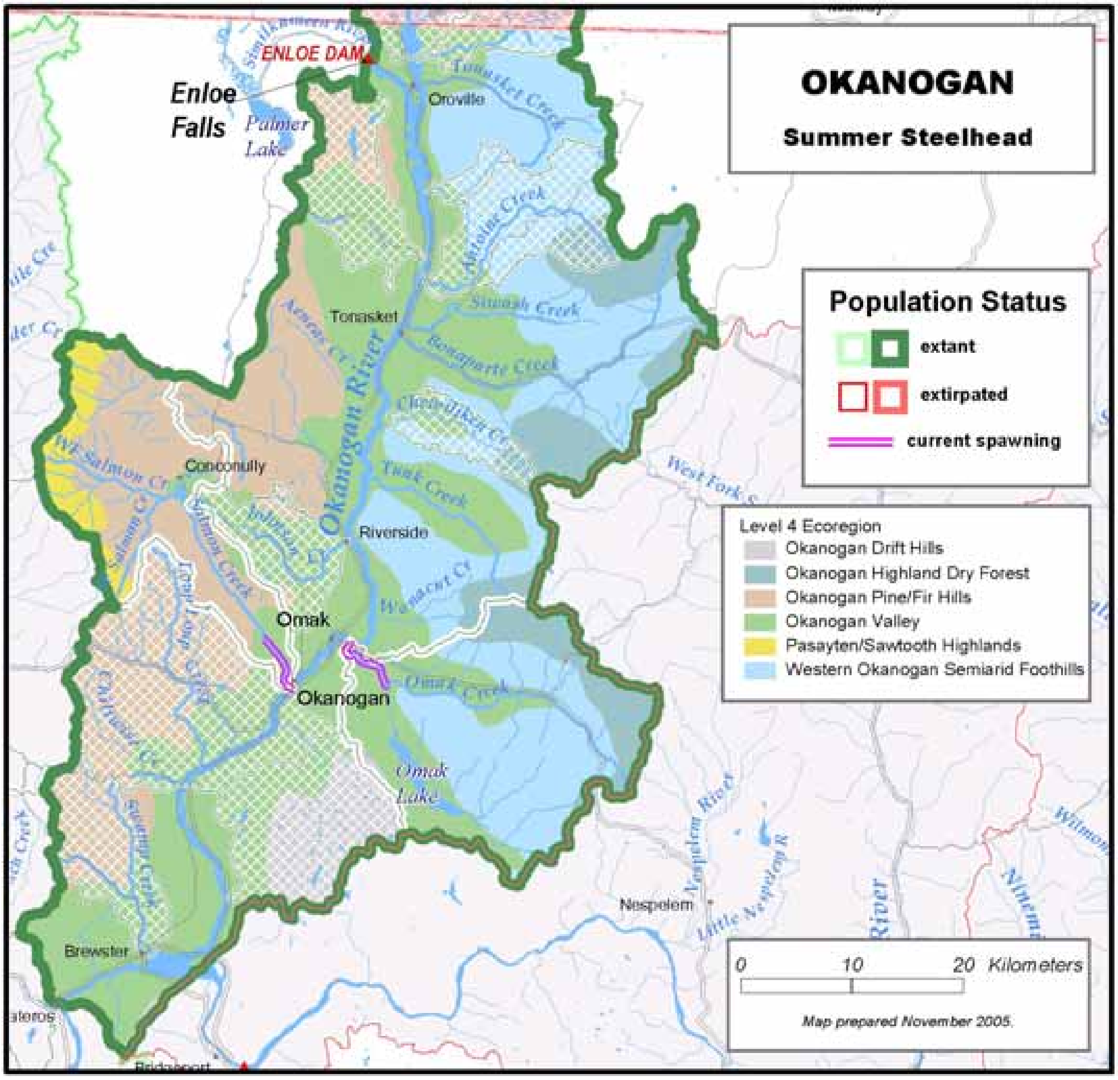

Figure 34. Okanogan Summer Steelhead distribution across various ecoregions.

Table 20. Okanogan steelhead – proportion of spawning area across various ecoregions. 79% of the population habitat falls within Canada, but ecoregion designations for this region are unknown. Therefore, the table takes into account only the US portions of the Okanogan steelhead population.

Ecoregion	% of historical spawning area in this ecoregion (non-temperature limited)	% of currently occupied spawning area in this ecoregion (non-temperature limited)
Okanogan Drift Hills	1.7	0.0
Okanogan Highland Dry Forest	1.2	0.0
Okanogan Pine/Fir Hills	27.3	0.0
Okanogan Valley	55.7	100.0
Pasayten/Sawtooth Highlands	0.6	0.0
Western Okanogan Semiarid Foothills	13.5	0.0

B.4.a. Selective change in natural processes or selective impacts.

Hydropower system: Low risk, although it has slowed out migration for early and late out migrants, but in recent years flow augmentation has reduced the impact to the middle 95% of the run.

Harvest: Low risk in recent generations. Harvest rates affect < 20% of the adults and selective gear reduces the impact of selectivity.

Hatcheries: Low risk, broodstock management of the Methow\Okanogan composite stock program has been designed to be non-selective.

Habitat: Low risk, no known measurable effects.

Based on low risk estimates across the four sectors, we conclude that the population is at *low risk* for this metric.

Spatial Structure and Diversity Summary

The Okanogan steelhead population was determined to be at high risk for goal A (allowing natural rates and levels of spatially mediated processes) and high risk for goal B (Maintaining natural levels of variation) resulting in an overall high risk rating (Table 21). For goal B, the metrics for genotypic and phenotypic variation were directly responsible for the high-risk rating. Although no genetic data existed for Okanogan steelhead, we assumed high risk based on the genetic results for the rest of the ESU and the very low escapement estimates for natural origin steelhead versus the high proportion of hatchery origin adults passing Wells Dam. For B.1.b. (phenotypic variation), an analysis needs to be conducted that shows that the phenotypic traits of the current population are consistent with the assumed historical condition or with unaltered reference populations in a similar habitat, geologic, and hydrologic setting. Based on the scoring system, these metrics must be addressed in order for the status of goal B to improve to low risk.

Another metric that was rated at high risk was the proportion of out-of-population (but within ESU) spawners that were hatchery fish (B.2.a.2). There were several factors that lead to a high risk rating, even though we did not have data that directly measured the origin of adults the spawning grounds. These risks included the extremely high proportion of hatchery fish passing Wells Dam (~90%), the mixing of Methow and Okanogan fish in the broodstock, the release of smolts into the Okanogan that could have originated from Methow parents, and the threat from the high number of Wenatchee origin steelhead passing Wells Dam. It is likely that genotypic and phenotypic variation have been influenced by past hatchery practices and that it will be difficult to achieve low risk levels for metrics B.1.b (phenotype) and B.1.c (genotype) given the continued threats outlined in metric B.2.a.2 (spawner composition).

Table 21. Spatial structure and diversity scoring table

Metric	Risk Assessment Scores				
	Metric	Factor	Mechanism	Goal	Population
A.1.a	H (-1)	H (-1)	High Risk (Mean = -1)	High Risk	**High Risk**
A.1.b	H (-1)	H (-1)			
A.1.c	H (-1)	H (-1)			
B.1.a	VL (2)	VL (2)	High Risk	High Risk	
B.1.b	M (0)	M (0)			
B.1.c	H (-1)	H (-1)			
B.2.a(1)	L (1)	High Risk (-1)	High Risk (-1)		
B.2.a(2)	NA				
B.2.a(3)	H (-1)				
B.2.a(4)	NA				
B.3.a	H (-1)	H (-1)	H (-1)		
B.4.a	L (1)	L (1)	L (1)		

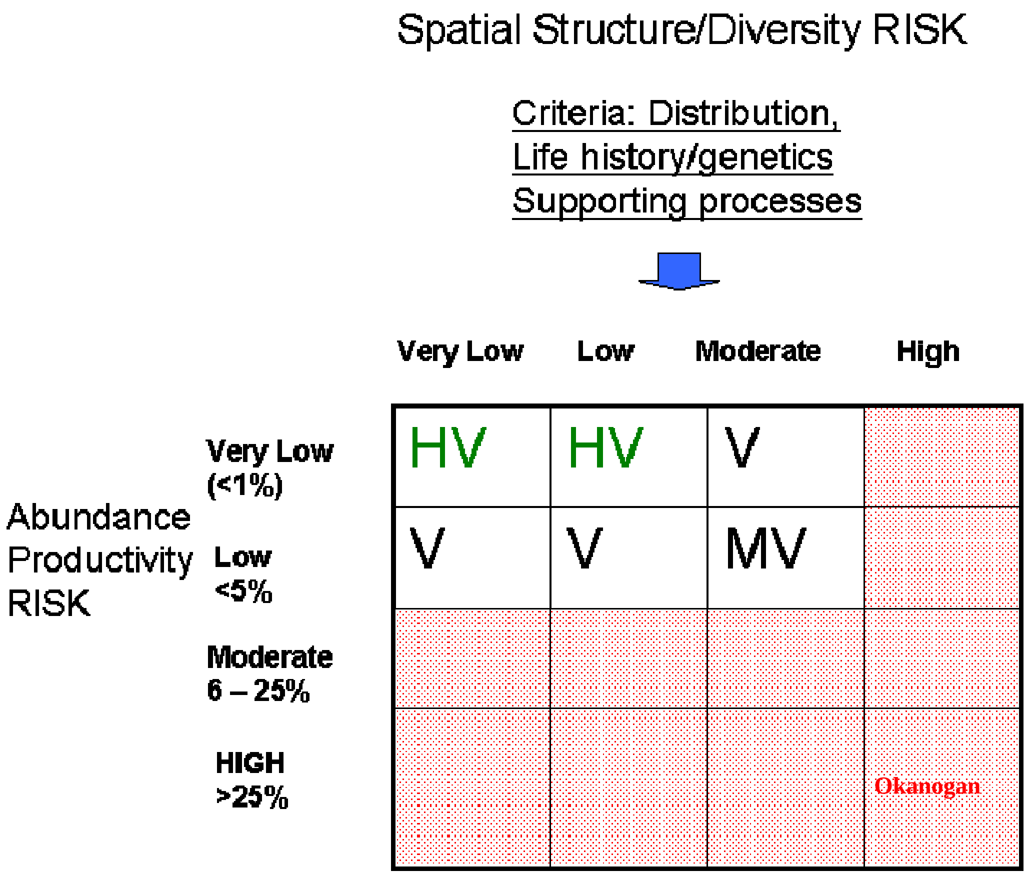

Figure 35. Abundance & productivity and spatial structure & diversity integration table.

Overall Risk Rating

The spatial structure and diversity of the Okanogan summer steelhead population is currently rated as high risk. Improvement of the spatial structure and diversity status to low risk will be necessary to allow the Okanogan population to achieve a "highly viable" status (in combination with very low risk A&P) (Figure 35). Based on the MPG guidelines, the Okanogan population will need to achieve a highly viable status for recovery of the ESU (ICTRT 2005).

Appendix C

Analyses to determine steelhead spawner abundance, returns, returns per spawner, and associated 12-year geometric means

Introduction

Reconstructing steelhead runs in the Upper Columbia ESU has been difficult in the past because of lack of spawning ground information, discrepancies between dam counts, and their complicated life histories. We have created a relatively simplified method that can more readily be used by researchers and regulators to determine the status of the population in terms of abundance (escapement) and productivity (returns per spawner).

Data Set

Dam counts

Since spawning ground counts are not available for a long time series for steelhead in the Upper Columbia, it is necessary to use dam counts, which go back to 1933 for Rock Island and 1962 and 1967 for Rocky Reach and Wells dams, respectively.

In examination of dam count differences (which could be a measure of tributary turn off between Rock Island, Rocky Reach, and Wells Dams), many problems arise. In some years, the fish count from the dam upstream was higher than the dam immediately downstream (this occurs primarily between Rocky Reach and Wells Dams).

Steelhead dam counts have been analyzed in different ways by different researchers. A common way to break down the counts is to use the "cycle count." This is the number of steelhead counted from June-November in year 1 and adding April and May in year 2 to get a total spawning brood. The assumption has been that this is a more accurate estimate of the brood year population; however, it may not be necessary and using annual counts may be as precise.

Chapman et al. (1994) looked at the percent passage of steelhead per month at Rock Island Dam between the 1930s and the 1980s (Figure 1). They found that the percentage of fish ascending the dams in April and May has decreased since the 1930s and 1940s. English et al. (2003) found that, in two years of research, about 13% of the steelhead (both hatchery and naturally produced, with most hatchery fish) over-wintered and stayed in the mainstem Columbia River between Priest Rapids and Chief Joseph dams (never ascended a tributary). Whether they spawned in any of these reaches has not been determined, but it does demonstrate another factor in the inaccuracy of using cycle counts to determine a particular year's spawning aggregate.

Finally, a comparison between cycle counts and regular calendar year (April – November) counts at Priest Rapids and Wells dams show little difference between cycle and calendar counts (Figures 2 and 3). Annual counts are more readily available, and we decided to use them instead of cycle counts in our analyses.

Separating the Entiat and Wenatchee Populations

Because of the difficulties mentioned above concerning the dam count differences between Rocky Reach and Wells Dams, Cooney et al. (2001) choose to combine the Entiat and

Wenatchee populations in their analyses. This causes problems in determining the health and listing status of the *independent* populations within the Wenatchee and Entiat Rivers. Therefore, a method was developed to separate these two populations.

The difference in the annual counts between Rock Island and Wells (fish passed upstream) were used as the basis for the analysis. This gave the total population between the two projects, where the Wenatchee (upstream of Rock Island) and Entiat (upstream of Rocky Reach) enter the Columbia River. English et al. (2001, 2003) found that of the naturally produced fish that over-wintered in the area between Rock Island and Wells dams, in the two years that they observed, an average of 9.5% (8.3-11.5%; based on a very small sample size) stayed in the Entiat and 74.3% in the Wenatchee (65.4-79.2%; Table 1). In lieu of comprehensive spawning ground counts, or tributary-specific counts (e.g., at a dam or weir), this was considered the best available information to determine the percentage of fish using each tributary. **In future years, as more data becomes available for spawning ground counts, this metric will be reevaluated.**

Separating the Methow and Okanogan Populations

The number of steelhead that ascended Wells Dam (after capture for broodstock) was used as the basis for the analysis. For naturally produced steelhead upstream of Wells, English et al. (2001, 2003) found that an average of 19.5% over-wintered in the Okanogan River (18.2-20.8%; sample size of 9) and 73.9% in the Methow (72.7-75.0%; Table 1). Using this information, the average percent was applied to the composite data sets to determine proportions of the runs to the tributaries between Rock Island and upstream from Wells.

Harvest

Harvest numbers were used from Chapman et al. (1994) or from updated information provided by WDFW. Harvest was applied equally to the composite populations for the Wenatchee/Entiat, or Upstream from Wells Dam (Methow/Okanogan). Fish harvested in the mainstem Columbia were added also (Rock Island-Wells Dams for Wenatchee/Entiat, and upstream from Wells for Methow/Okanogan).

The harvest on the naturally produced proportion of the run was assumed to be proportional to the total harvest (i.e., harvest rate was assumed equal between hatchery and naturally produced fish; if 100 fish were harvested and the naturally produced percentage of the total run was 25%, then 25 naturally produced fish were harvested). Beginning in 1986, after regulations began that restricted harvest on naturally produced fish, a 2% harvest rate was assumed for naturally produced fish (from catch and release).

Since 2002, recreation fishing has begun again upstream from Rocky Reach Dam. We maintained a 2% harvest rate on naturally produced fish, which may be conservative. No harvest is assumed in the Wenatchee/Entiat during this time frame since there are no targeted fisheries, although a very small number of naturally produced fish may be incidentally impacted between Rocky Reach and the mouth of the Entiat.

For all populations, a 10% pre-spawning mortality was assumed (and added to "harvest")

Naturally produced proportion of the run

The naturally produced proportion of the run has been estimated at Priest Rapids Dam since 1985 and Wells Dam since 1982. The percentage of naturally produced fish in the Wenatchee

River has been estimated by Brown (personal communication) and is based on the estimates from Priest Rapids and Wells Dams. To obtain proportions of naturally produced fish prior to 1982, values were estimated based on historical knowledge of when hatchery introductions began in earnest in the specific tributary in question (in general, hatchery returns began to dominate the runs in the late 1960s).

Age at return

Age at return was obtained from sampling efforts of naturally produced fish sampled at Priest Rapids (since 1986) and Wells (since 1982) dams. For years prior to these sampling efforts, an average was assumed.

Escapement

Escapement was estimated by first determining the appropriate aggregate run (between Rock Island and Wells or upstream of Wells). The naturally produced proportion was then extracted from the aggregate run. Harvest was then subtracted, and a 10% pre-spawning mortality was included into the harvest proportion. This resulted in an aggregate estimate of escapement. The proportion of fish to the appropriate tributary was then determined by applying the average percentages from the radio telemetry information (see above).

Return per spawner

The return per spawner was determined by taking the estimated escapement per tributary and multiplying it by the age of return, which gave a return of each age group per brood year. The return from a given spawning year was the summation of each appropriate age group (year 3 + year 4, etc., so returns for a given brood year are the summation of up to 5 or more years of returns). The returns per spawner was the quotient of the number of fish escaping in year x divided by the total returns for that brood year.

Reproductive success of hatchery fish

One of the greater unknowns concerning hatchery fish that spawn in the wild is how reproductively effective they are, both in terms of the number of offspring they produce and whether they are spawning in appropriate areas at the appropriate time.

Because of these concerns, two estimates of returns per spawner were calculated. One with the assumption that hatchery fish are as effective as naturally produced fish in terms of the number of returning adults, and the other, that they contribute nothing to the returning escapement. The truth is most likely somewhere in between, but the extremes are graphically shown.

For some years in the late 1970s and early 1980s, the returns per spawner were unrealistically high (> 10) and were omitted. These large estimates appear to be based on the extremely low number of naturally produced fish that escaped the fisheries in those years (almost zero).

Finally, it is important to note that the productivity (return/spawner) is very conservative since factors such as inter-dam loss and lower Columbia River fisheries are omitted from the analyses. The actual productivity of these steelhead runs is somewhat greater than shown here, but most likely would still not be great enough to reach de-listing criteria.

It is also important to reemphasize that this method should be reviewed and potentially modified as we begin to collect more tributary-specific information on steelhead from future monitoring and evaluation information.

Results

Wenatchee and Entiat Rivers

Between 1967 and 2003, an average of 761 naturally produced steelhead spawned in the Wenatchee River (range; 70-2,864; Table 2; Figure 4). In the Entiat River, spawning escapement has ranged from 9 to 366, averaging 97 fish (Table 2; Figure 5). The 12-year geometric mean of spawners in the Wenatchee River has ranged from 185 to 919, and is currently (2003) 716 (Table 2). For the Entiat River, the 12-year geometric mean has ranged from 24 to 118 and is currently 92 (Table 2).

The returning number of fish to both tributaries is auto-correlated since they were derived from the same aggregate. Therefore, the return per spawner is reported for both populations combined. In the Wenatchee and Entiat rivers, the return per spawner has averaged 1.42 (range; 0.13-4.73) if hatchery fish produce the equivalent number of returning spawners as naturally produced fish, and averages 0.28 (range; 0.05-0.79) if hatchery fish do not produce any returning spawners (Table 2; Figure 6). The 12-year geometric mean of the return per spawner has averaged 1.22 (range 0.71-1.96) if hatchery fish are equivalents to naturally produced fish, or 0.26 (0.18-0.32) if they do not contribute (Table 2; Figure 6).

Methow and Okanogan Rivers

Between 1967 and 2002, an average of 206 naturally produced steelhead spawned in the Methow River (range; 1-587; Table 3; Figure 7). In the Okanogan River, spawning escapement has ranged from 1 to 156, averaging 55 fish (Table 3; Figure 8). The 12-year geometric mean of spawners in the Methow River has ranged from 36 to 242, and is currently (2002) 202 (Table 3). For the Okanogan River, the 12-year geometric mean has ranged from 11 to 64 and is currently 53 (Table 3).

In the Methow and Okanogan rivers, the return per spawner has averaged 1.82 (range; 0.08-8.65) if hatchery fish do not produce any returning spawners, and averages 0.19 (range; 0.01-1.20) if hatchery fish produce the equivalent number of returning spawners as naturally produced fish (Table 3; Figure 9). The 12-year geometric mean of the return per spawner has averaged 1.32 (range 0.82-2.28) if hatchery fish are equivalents to naturally produced fish, or 0.12 (0.07-0.16) if they do not contribute (Table 3; Figure 10).

It is important to note for all stocks when examining the return per spawner ratios and making assumptions on the effectiveness of hatchery produced spawners that we do not mean to imply that their effectiveness is either zero or 100%. The "truth" is somewhere in between. Studies being conducted currently for spring Chinook in the Wenatchee River and in the future for steelhead in one or more rivers will give researchers better information to assess the naturally produced steelhead populations in the Upper Columbia Region.

Table 1 Naturally produced radio-tagged steelhead distribution prior to kelting upstream of Rock Island Dam, 1999-2000 and 2001-2002 (from English et al. 2001, 2003)

Location	2001-2002		1999-2000		Total Number	Average Percent
	Number	Percent	Number	Percent		
Wenatchee River	17	65.4	38	79.2	55	74.3
Entiat River	3	11.5	4	8.3	7	9.5
Mainstem Columbia (between RI and Wells)	6	23.1	4	8.3	10	13.5
Wells Hatchery (non-broodstock)	0	0.0	2	4.2	2	2.7
Total	**26**		**48**		**74**	
Methow River	16	72.7	18	75.0	34	73.9
Okanogan River	4	18.2	5	20.8	9	19.6
Mainstem Columbia (upstream of Wells)	2	100.0	1	100.0	3	
Total	**22**		**24**		**46**	

Table 2 Summary statistics for determining naturally produced (NP) steelhead escapement and run reconstruction for the Wenatchee and Entiat Rivers

	Stlhd. Passed	% NP	NP Escapement		NP escpmt.		GEO-M NP escpmt.		Returns		Return per spawner for Wenatchee and Entiat			
				> harvest & presp.										GEO-M
	(RI-WLS)	Wen., Ent.	<hrvst.	mortality	Wen.	Ent.	Wen.	Ent.	Wen.	Ent.	H. eff. = 0	effect. = 1	H. eff. = 0	H. eff. = 1
1967	4,032	0.80	3226	1771	1316	168			257	33	0.20	GEO-M 0.14		
1968	5,768	0.70	4038	2527	1878	240			244	31	0.13	0.08		
1969	3,588	0.50	1794	1155	858	110				22	0.20	0.09		
1970	1,547	0.35	541	185	138	18			173	18	0.99	0.31		
1971	4,530	0.20	906	507	377	48			137	14	0.29	0.05		
1972	2,919	0.15	438	202	150	19			110	24	1.27	0.17		
1973	3,337	0.15	501	295	219	28			191	38	1.37	0.18		
1974	1,305	0.15	196	110	82	10			300 284	36	3.46	0.47		
1975	2,208	0.15	331	130	97	12			229	29	2.37	0.32		
1976	3,156	0.23	725	248	184	24				32	1.35	0.28		
1977	4,644	0.22	1043	605	450	58			249	32	0.55	0.11		
1978	1,727	0.19	335	197	146	19	290	37	249 276	35	1.88	0.33	0.75	0.18
1979	3,729	0.21	776	410	305	39	256	33	459	59	1.51	0.28	0.88	0.19
1980	3,574	0.20	714	237	176	22	210	27	774	99	4.40	0.79	1.19	0.22
1981	3,463	0.22	763	478	355	45	196	25	1034	132	2.91	0.58	1.48	0.26
1982	1,895	0.25	475	94	70	9	185	24	1368	175			1.54	0.26
1983	10,141	0.14	1414	914	679	87	194	25	13 18	168	1.94	0.24	1.83	0.30

	Stlhd. Passed	% NP	NP Escapement		NP escpmt.		GEO-M NP escpmt.		Returns		Return per spawner for Wenatchee and Entiat			
			<hrvst.	> harvest & presp.										GEO-M
	(RI-WLS)	Wen., Ent.		mortality	Wen.	Ent.	Wen.	Ent.	Wen.	Ent.	H. eff. = 0	effect. = 1	H. eff. = 0	H. eff. = 1
1984	8,464	0.17	1463	919	683	87	220	28	1883	241	2.76	GEO-M 0.43	1.96	0.32
1985	12,132	0.21	2515	1859	1382	177	257	33	1406	180	1.02	0.19	1.91	0.32
1986	9,582	0.21	1967	1770	1315	168	323	41	1011	129	0.77	0.20	1.66	0.30
1987	7,239	0.41	2980	2682	1993	255	416	53	723	92	0.36	0.16	1.40	0.28
1988	4,840	0.33	1588	1430	1062	136	482	62	1125	144	1.06	0.36	1.37	0.29
1989	4,751	0.53	2507	2256	1676	214	538	69	536	69	0.32	0.18	1.31	0.30
1990	3,131	0.28	888	800	594	76	604	77	524	67	0.88	0.26	1.22	0.29
1991	3,176	0.49	1550	1395	1036	133	669	86	432	55	0.42	0.26	1.08	0.29
1992	5,451	0.23	1241	1117	830	106	761	97	485	62	0.58	0.15	0.90	0.25
1993	2,335	0.32	759	683	507	65	784	100	437	56	0.86	0.28	0.81	0.23
1994	3,457	0.20	704	634	471	60	919	118	301	39	0.64	0.13	0.79	0.22
1995	3,233	0.31	1006	906	673	86	919	117	369	47	0.55	0.18	0.71	0.22
1996	3,177	0.19	588	529	393	50	877	112	1111	142	2.82	0.56	0.71	0.22
1997	3,619	0.17	614	552	410	52	793	101	1941	248	4.73	0.74	0.81	0.25
1998	1,979	0.21	408	367	273	35	696	89						
1999	2,765	0.24	663	597	443	57	614	78						
2000	4,236	0.42	1789	1610	1196	153	620	79						
2001	10,084	0.42	4284	3855	2864	366	648	83						
2002	5,817	0.33	1931	1738	1291	165	691	88						

	Stlhd. Passed (RI-WLS)	% NP Wen., Ent.	NP Escapement <hrvst.	NP Escapement > harvest & presp. mortality	NP escpmt. Wen.	NP escpmt. Ent.	GEO-M NP escpmt. Wen.	GEO-M NP escpmt. Ent.	Returns Wen.	Returns Ent.	Return per spawner for Wenatchee and Entiat H. eff. = 0	Return per spawner for Wenatchee and Entiat effect. = 1	Return per spawner for Wenatchee and Entiat H. eff. = 0	Return per spawner for Wenatchee and Entiat GEO-M H. eff. = 1
2003	17,481	0.28	2375	2137	1588	203	716	92				**GEO-M**		
Avg.:	**4,825**	**0.29**	**1,352**	**1,024**	**761**	**97**	**534**	**68**	**643**	**82**	**1.42**	**0.28**	**1.22**	**0.26**
Min.:	**1,305**	**0.14**	**196**	**94**	**70**	**9**	**185**	**24**	**110**	**14**	**0.13**	**0.05**	**0.71**	**0.18**
Max.:	**17,481**	**0.80**	**4,284**	**3,855**	**2,864**	**366**	**919**	**118**	**1,941**	**248**	**4.73**	**0.79**	**1.96**	**0.32**

RI-WLS Rock Island dam to Wells Dam; Wen = Wenatchee, Ent = Entiat; Stlhd = Steelhead; hrvst = harvest; escpmt = escapement; Geo-M = Geometric mean; H. eff = Hatchery Effective

Table 3 Summary statistics for determining naturally produced (NP) steelhead escapement and run reconstruction for the Methow and Okanogan Rivers

	Stlhd. passed	% NP	NP escapement		NP escpmt.		GEO-M NP escpmt.		Returns		Return per spawner for Methow and Okanogan			
				> harvest & presp.									GEO-M	
Year	> Wells	Met., Okn.		mortality	Met.	Okn.	Met.	Okn.	Met.	Okn.	H. eff. = 0	H. eff. = 1	H. eff. = 0	H. eff. = 1
1967	1,474	0.70	1032	183	135	36			161	43	1.19	0.75		
1968	2,112	0.70	1478	765	565	150			124	33	0.22	0.14		
1969	1,391	0.50	696	363	268	71			30	8	0.11	0.05		
1970	1,597	0.35	559	93	69	18			17	5	0.24	0.08		
1971	3,782	0.20	756	376	278	74			21	6	0.08	0.01		
1972	1,894	0.10	189	48	35	9			68	18	1.92	0.17		
1973	1,820	0.05	91	37	27	7			112	30	4.12	0.19		
1974	580	0.05	29	15	11	3			84	22	7.49	0.34		
1975	517	0.15	78	1	1	1			57	15				
1976	4,664	0.10	466	128	95	25			66	17	0.70	0.06		
1977	5,282	0.10	528	217	161	43			99	26	0.62	0.06		
1978	1,621	0.10	162	24	17	5	57	17	151	40	8.65	0.78	0.82	0.13
1979	3,695	0.10	370	137	101	27	55	16	128	34	1.26	0.11	0.83	0.11
1980	3,443	0.10	344	13	9	2	39	12	124	33		1.20	0.95	0.13
1981	4,096	0.10	410	194	143	38	37	11	185	49	1.29	0.12	1.21	0.14
1982	7,984	0.06	519	252	186	49	41	12	264	70	1.42	0.08	1.44	0.14
1983	19,525	0.01	252	105	77	21	36	11	290	77	3.75	0.04	2.13	0.16
1984	16,632	0.03	416	170	125	33	41	12	474	126	3.78	0.09	2.28	0.15

Year	Stlhd. passed > Wells	% NP Met., Okn.	NP escapement	NP escapement > harvest & presp. mortality	NP escpmt. Met.	NP escpmt. Okn.	GEO-M NP escpmt. Met.	GEO-M NP escpmt. Okn.	Returns Met.	Returns Okn.	Return per spawner for Methow and Okanogan H. eff. = 0	H. eff. = 1	H. eff. = 0	H. eff. = 1
1985	19,867	0.04	838	324	239	64	49	14	392	104	1.64	0.06	2.08	0.14
1986	13,303	0.03	394	355	262	70	63	19	364	97	1.39	0.08	1.75	0.12
1987	5,493	0.12	681	613	453	120	105	28	340	90	0.75	0.13 GEO-M	1.62	0.12
1988	4,401	0.11	475	428	316	84	116	31	455	121	1.44	0.24	1.73	0.13
1989	4,600	0.13	603	542	401	106	126	33	147	39	0.37	0.08	1.65	0.14
1990	3,815	0.12	473	426	315	83	160	42	99	26	0.31	0.06	1.22	0.11
1991	7,751	0.11	829	746	552	146	184	49	68	18	0.12	0.02	0.99	0.10
1992	7,027	0.05	379	342	252	67	242	64	91	24	0.36	0.04	0.91	0.07
1993	2,494	0.08	195	175	130	34	240	64	130	35	1.01	0.10	0.89	0.07
1994	2,163	0.06	135	121	90	24	226	60	116	31	1.29	0.07	0.89	0.07
1995	942	0.12	116	104	77	20	226	60	213	56	2.76	0.31	0.86	0.08
1996	4,128	0.05	211	189	140	37	228	60	374	99	2.67	0.14	0.84	0.09
1997	4,107	0.02	99	89	66	17	205	54						
1998	2,984	0.08	227	204	151	40	195	52						
1999	3,504	0.14	490	441	326	86	190	50						
2000	6,280	0.08	474	427	316	84	190	50						
2001	18,528	0.05	883	794	587	156	196	52						
2002	9,478	0.07	653	588	434	115	202	53						
2003														

Year	Stlhd. passed > Wells	% NP Met., Okn.	NP escapement		NP escpmt.		GEO-M NP escpmt.		Returns		Return per spawner for Methow and Okanogan			
				> harvest & presp. mortality	Met.	Okn.	Met.	Okn.	Met.	Okn.	H. eff. = 0	H. eff. = 1	H. eff. = 0	H. eff. = 1
Avg.:	5,638	0.14	459	279	206	55	138	37	175	46	1.82	0.19	1.32	0.12
Min.:	517	0.01	29	1	1	1	36	11	17	5	0.08	0.01	0.82	0.07
Max.:	19,867	0.70	1,478	794	587	156	242	64	474	126	8.65	GEO-M 1.20	2.28	0.16

Wen = Wenatchee, Ent = Entiat; Stlhd = Steelhead; hrvst = harvest; escpmt = escapement; Geo-M = Geometric mean; H. eff = Hatchery Effective

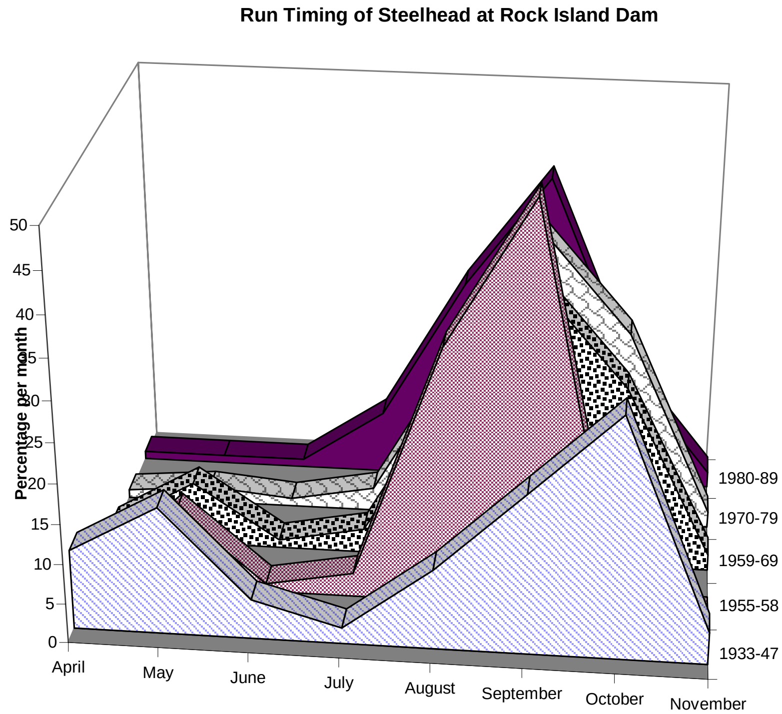

Figure 1 Percent passage of steelhead at Rock Island Dam between 1933-1989 (from Peven 1992; Chapman et al. 1994)

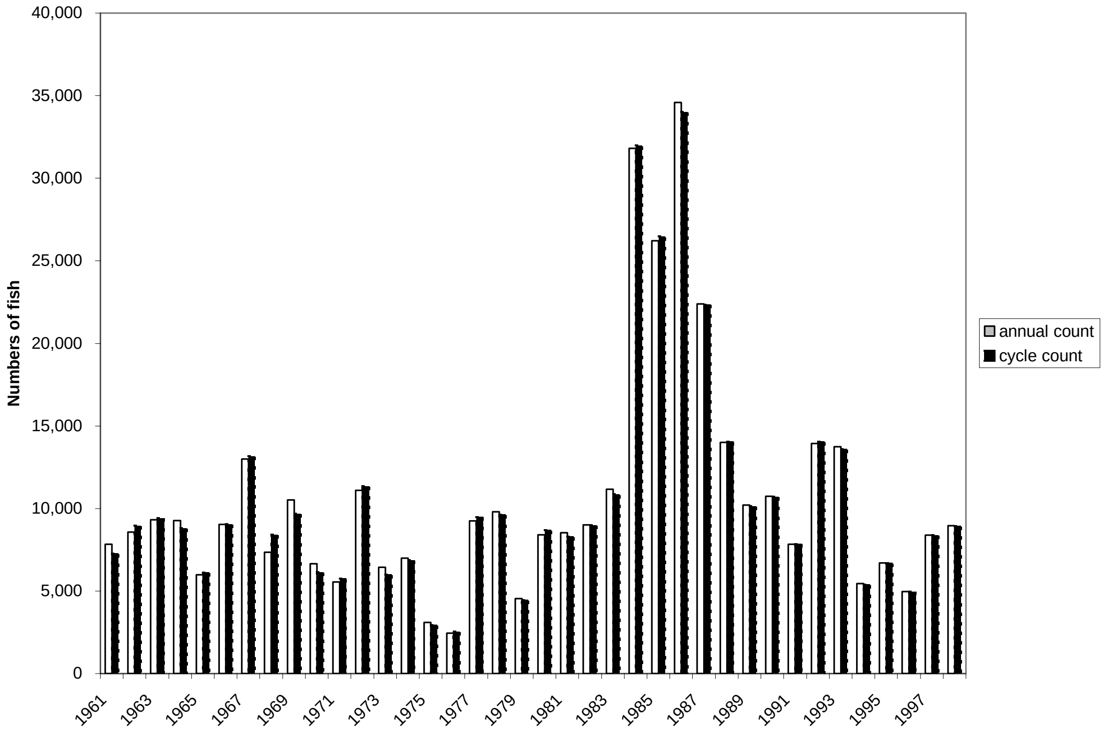

Figure 2 Comparison of cycle and calendar year counts for steelhead passing Priest Rapids Dam

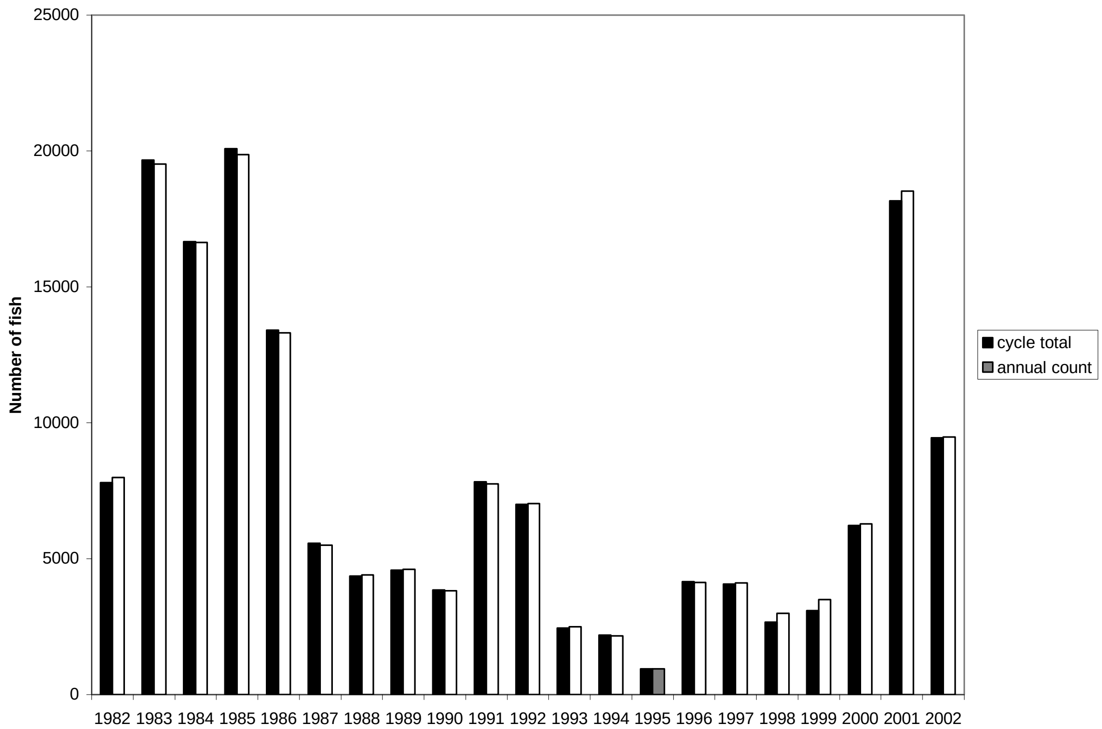

Figure 3 Comparison of cycle and calendar year counts for steelhead passing Wells Dam

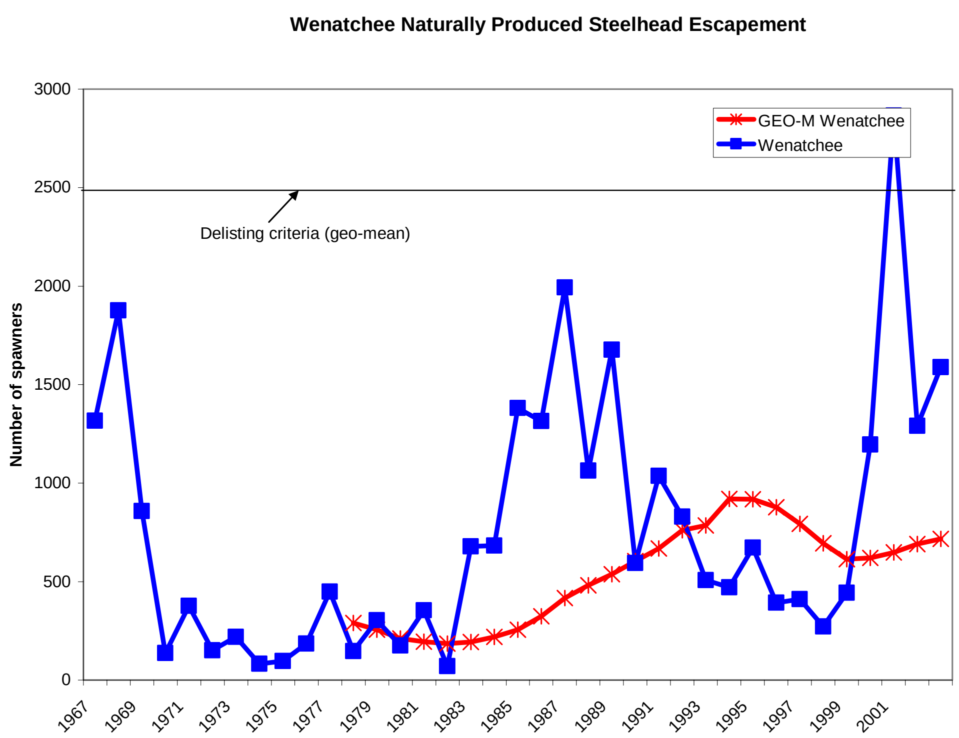

Figure 4 Naturally produced escapement of steelhead in the Wenatchee River

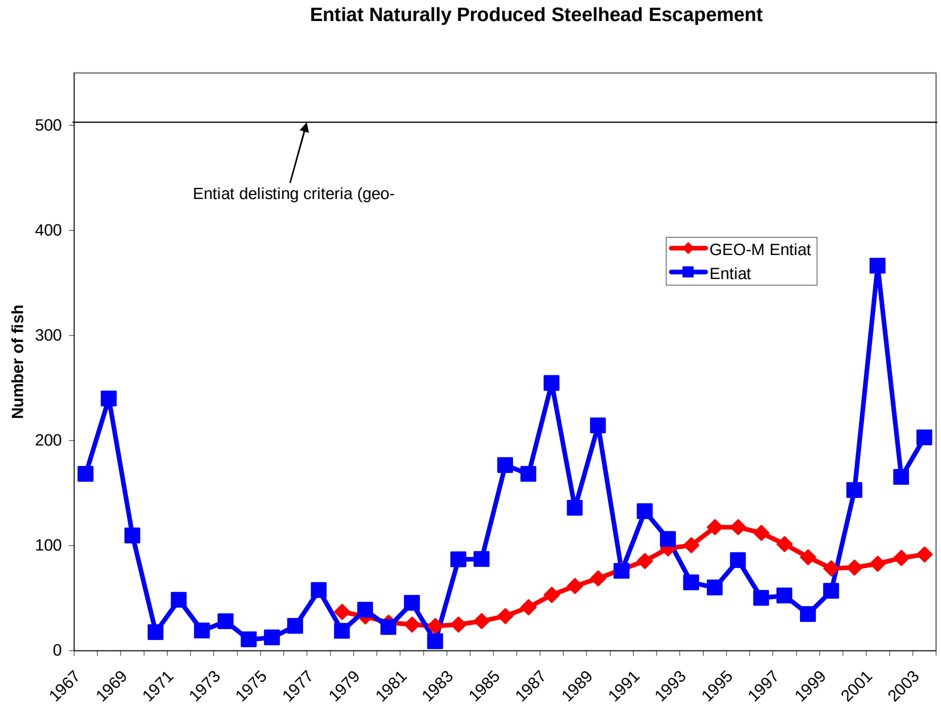

Figure 5 Naturally produced escapement of steelhead in the Entiat River

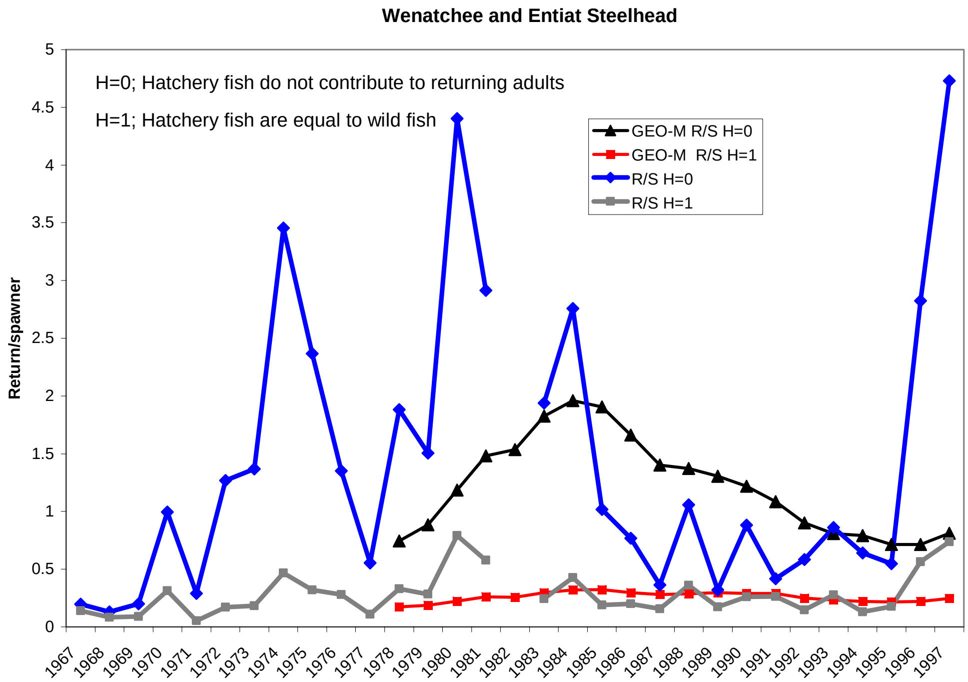

Figure 6 The return per spawner of naturally produced steelhead in the Wenatchee and Entiat Rivers. Two estimates of hatchery spawner reproductive success are shown; one if they are as effective and the second if they do not produce any returning adults to the spawning escapement

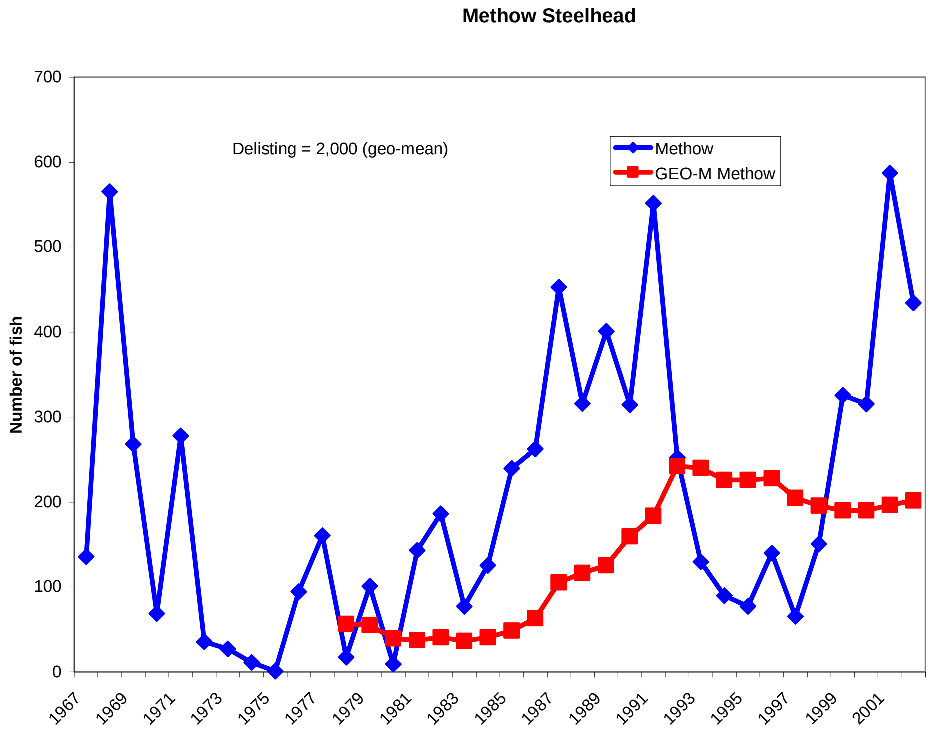

Figure 7 Naturally produced escapement of steelhead in the Methow River

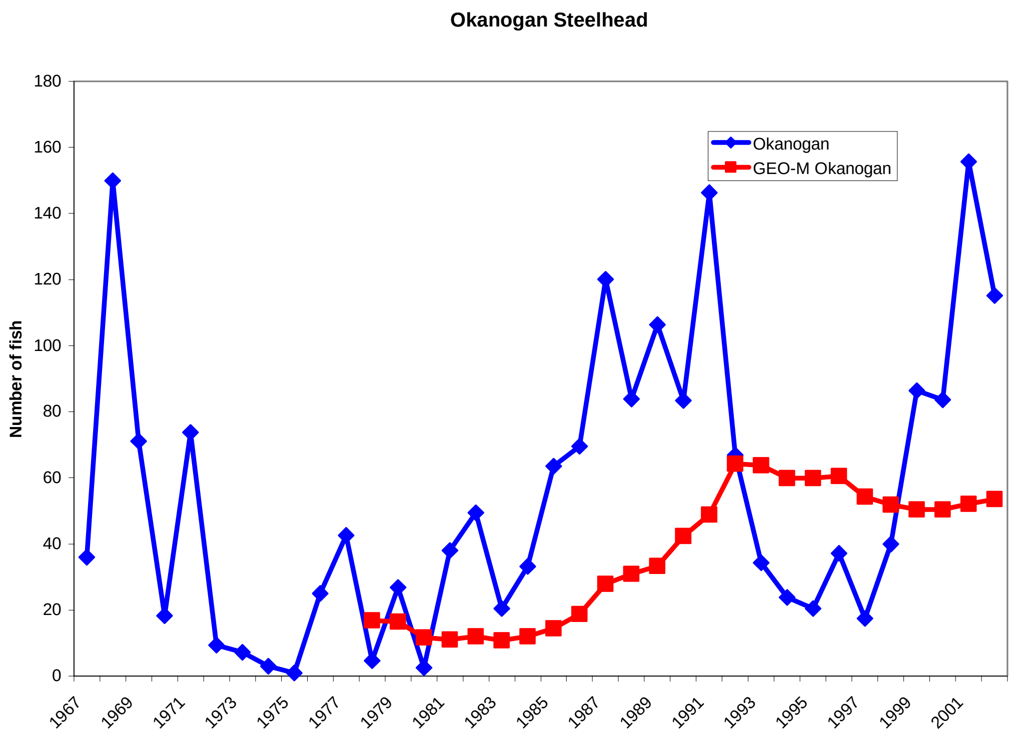

Figure 8 Naturally produced escapement of steelhead in the Okanogan River

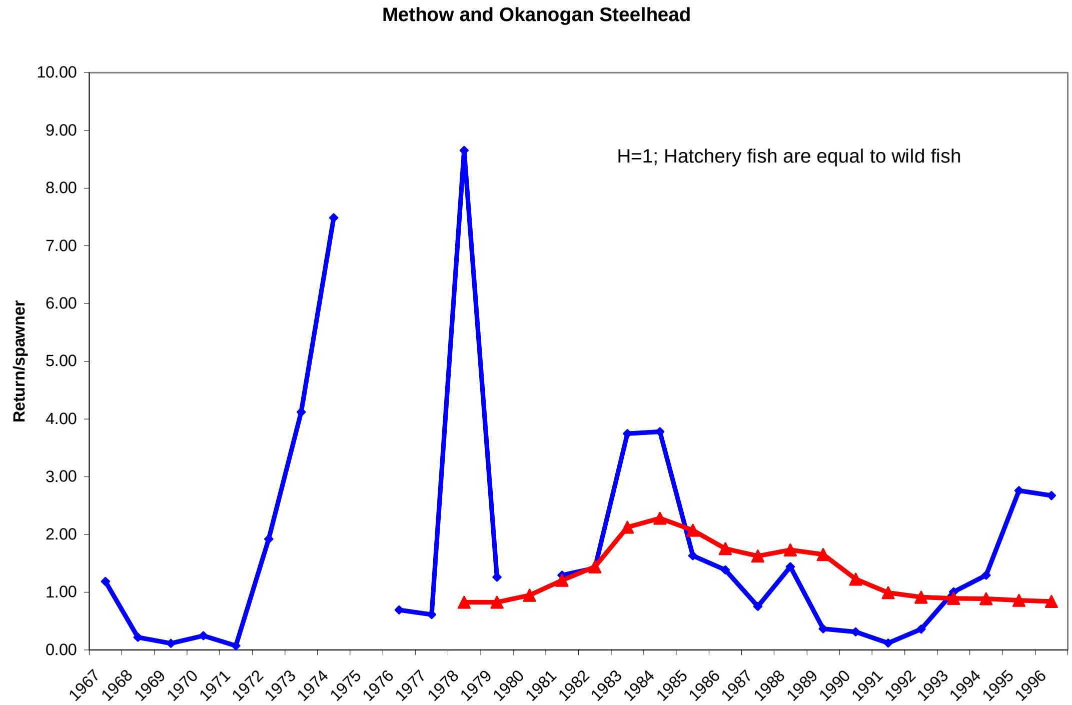

Figure 9 The return per spawner of naturally produced steelhead in the Methow and Okanogan Rivers. Hatchery spawner reproductive success is equivalent to naturally produced spawners

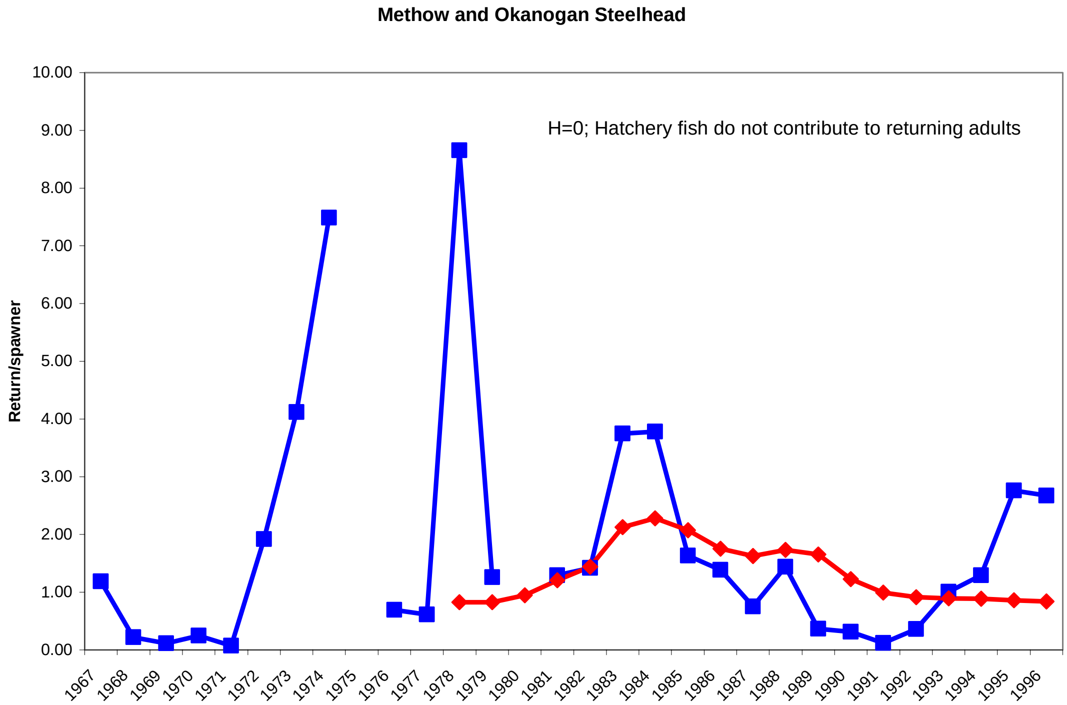

Figure 10 The return per spawner of naturally produced steelhead in the Methow and Okanogan Rivers. Hatchery spawners do not contribute to returning spawners

Appendix D

Local Government Policy and Program Threat Criteria

The local governments (cities, towns, counties, PUDs) in the Upper Columbia Region and Colville Tribes have a significant and substantial role in the development, adoption, implementation and enforcement of land use regulations. In Washington State, land use planning and a wide array of environmental protection programs are mandated at the state level, but developed, adopted and implemented at the local level (e.g. counties, cities and towns). The same is generally true with the Colville Tribes, although their statutory authority is derived from federal regulations and related obligations. This means that threats to recovery of listed species from future development, land uses and land and facilities management activities must be addressed by local governments and the Tribes including criteria regarding development, adoption, implementation, monitoring and enforcement of land use and environmental protection regulations that affect the habitat of listed species.

Programs and regulations that potentially effect listed species can be divided into the following categories:

- Comprehensive Plans (land use, water, wastewater, stormwater, solid waste etc…)
- Implementing Regulations (zoning, critical areas, shorelines, development standards, etc…)
- Permitting Processes (conditional use, substantial development, building, variance, exemption, etc…)
- Code Enforcement/Compliance
- Environmental Review (SEPA and NEPA)

The local governments in the Upper Columbia Region and Tribes have numerous policies, regulations, and programs that are designed to avoid or minimize impacts to the environment from activities associated with human land use and management activities. The decline in salmon habitat has resulted from numerous diverse human activities and natural processes over a biologically short period of time. Many of the activities that contributed to decline in salmon habitat conditions occurred before today's policies, regulations, and programs were enacted. Therefore, the existence of degraded salmon habitat does not necessarily mean that local government and Tribal policies, regulations, and programs are inadequate as most were non-existent during the period of decline. However, as part of the recovery planning process, a review of programs that are now in place was undertaken to determine if either compliance or implementation can be improved to aid in recovery. Thus, this Chapter identifies current policies, regulations, and programs that may affect the habitat for listed species, provides recommendations for review and revision of existing plans, programs and regulations where applicable, and provides threat criteria.

The first step in the review process was to generate a list of the specific plans, programs and activities under the purview of local government, describe their purpose and relationship to recovery of listed species, relationship to VSP parameters and finally a review for relationship to ESA threat criteria. Table X provides a summary of this step in the review.

The relationship of the plans and programs to VSP parameters and two of the ESA Threat Criteria are listed as either direct (those that may involve actions, e.g. wastewater discharge, critical areas regulation, etc…, that directly impact listed species) or indirect (those that entail primarily goals and policies that do not directly impact listed species). In general establishing the relationship based on a direct or indirect impact is relatively straightforward and is primarily based on whether the plan or program entails a physical action, however, a determination of the adequacy of existing regulations required more analysis.

Each of the plans and programs was evaluated regarding adequacy of existing regulatory programs to determine: whether any mechanism existed; whether a mechanism existed but needed work; and whether the existing mechanism was deemed adequate. The results provided in the following tables represent a general summary or average of the status of local government plans and programs in the Region.

An important assumption in the evaluation is that local compliance with state growth management planning (specifically critical areas) and shoreline master programming mandates is the benchmark for measurement of adequacy. This assumption is based on the fact that both the Growth Management Act and Shoreline Management Act have been revised in recent years as part of the State's efforts to recover listed species. Both Acts require local governments to plan and implement programs aimed at protection, restoration and enhancement of fish and wildlife habitat and related environmental attributes.

It is clear from Table 1 that local governments and the Colville Tribes have an important role to play in the recovery of listed species. The wide range of mandated planning and regulatory programs provide a solid foundation for local governments to implement and enforce actions needed to recover listed species. The table illustrates the relationship between local government land use permitting and management activities and recovery of listed species.

Table 1 needs to be printed on 11" X 17" paper

Table 1 The relationship between local government permitting and management activities and recovery of listed species

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct** **X - indirect**		**Y - direct** **X - indirect**	**1 - Little or no regulatory mechanism** **2 - basic mechanism in place, needs revision/ update** **3 - existing mechanism adequate**	**Y - direct** **X - indirect**
Land Use Element	The Land Use Element of the Comprehensive Plan provides the vision and general goals and policies to direct where and how a community will grow. It is important that future planning acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	Y	3	Y
Capital Facilities Element	The Capital Facilities Element of the Comprehensive Plan provides the basis and specific goals and policies for how capital facilities are operated, maintained and developed for the present and future. This element may consist of a stand alone Capital Facilities Plan or may only contain the goals and policies with reference to the CFP. It is important that present and future operations, maintenance and development of capital facilities acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	3	X
Utilities Element	The Uilities Element of the Comprehensive Plan provides the specific goals and policies for the utilities required to serve the county, or community for the present and future. This element may consist of required individual utility plans (e.g. Water Comprehensive Plan) or may only contain the goals and policies with reference to the specific plans. It is important that present and future operations, maintenance and development of utilities facilities acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	3	X

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct** **X - indirect**		**Y - direct** **X - indirect**	**1 - Little or no regulatory mechanism** **2 - basic mechanism in place, needs revision/ update** **3 - existing mechanism adequate**	**Y - direct** **X - indirect**
Rural Areas Element	The Rural Areas Element of the Comprehensive Plan provides specific goals and policies for development in identified rural areas. It is important that future planning for land uses and management in rural areas acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	3	X
Transportation Element	The Transportation Element of the Comprehensive Plan provides specific goals, policies and recommendations for maintenance, operation and development of the transportation system. It is important that present and future operations, maintenance and development of utilities facilities acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	Y	3	Y
Urban Growth Area Element	The Land Use Element of the Comprehensive Plan provides specific goals and policies for expansion of urban type development. It is important that future planning for expansion of the urban area acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	Y	3	Y
Lands for Public Purpose and Open Space Corridors Element	The Lands for Public Purpose and Open Space Corridors Element of the Comprehensive Plan provides specific goals and policies to guide maintenance, acquisition, development and maintenance of public purpose and open space lands. It is important that future planning for maintenance, acquisition, development and maintenance of public purpose and open space lands acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	Y	3	Y

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct** **X - indirect**		**Y - direct** **X - indirect**	**1 - Little or no regulatory mechanism** **2 - basic mechanism in place, needs revision/ update** **3 - existing mechanism adequate**	**Y - direct** **X - indirect**
Economic Development Element	The Economic Development Element of the Comprehensive Plan provides specific goals, policies and recommendations for economic development. It is important that future economic development planning acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	3	X
Parks and Recreation Element	The Parks and Recreation Element of the Comprehensive Plan (often a stand alone Parks and Recreation Plan) provides the specific goals, policies and recommendations for maintenance, operation and development of parks and recreation facilities and opportunities. It is important that future planning for parks and recreation facilities and opportunities acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	Y	3	Y
Water Comp Plan	The Water Comprehensive Plan provides the specific goals, policies and recommendations for maintenance, operation and development of the public water system. It is important that future planning for water supply, distribution and storage acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	Y	Y	Y	3	Y
Wastewater Comp Plan	The WasteWater Comprehensive Plan (and related design reports) provides the specific goals, policies and recommendations for maintenance, operation and development of the public sewer system. It is important that future planning for wastewater collection, treatment and biosolids disposal acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	Y	Y	Y	3	Y

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		Y - direct X - indirect		Y - direct X - indirect	1 - Little or no regulatory mechanism 2 - basic mechanism in place, needs revision/ update 3 - existing mechanism adequate	Y - direct X - indirect
Stormwater Management Plan	The Stormwater Management Plan provides the specific goals, policies and recommendations for maintenance, operation and development of the public storm drainage system. It is important that future planning for storm water collection, treatment and disposal acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	Y	Y	Y	2	Y
Solid Waste Management Plan	The Solid Waste Management Plan provides the specific goals, policies and recommendations for maintenance, operation and development of the public solid waste disposal system. It is important that future planning for collection and disposal of solid waste acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	3	X
Road Management and Abandonment Plan RCW 76.09.410 and 76.09.420	Road management plans are optional for local governments. Road management plans typically provide specific standards for the maintenance, operation and development of a jurisdiction's road system including best management practices geared to protect, restore and enhance water quality and riparian habitat.	Y	Y	Y	2	Y
Watershed Plans	Local watershed plans are authorized under the State's Watershed Planning Act (RCW 90.82) adopted in 1998. The state established a framework for developing local solutions to water issues on a watershed basis. The comprehensive watershed planning process is based on watersheds known as Water Resources Inventory Areas (WRIAs). This process is optional and allows local governments to collaborate and join with citizens and tribes to form watershed management planning units to develop watershed management plans.	Y	Y	Y	2	Y
Implementing Regulations						

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct** **X - indirect**		**Y - direct** **X - indirect**	**1 - Little or no regulatory mechanism** **2 - basic mechanism in place, needs revision/ update** **3 - existing mechanism adequate**	**Y - direct** **X - indirect**
Zoning	Zoning is the primary tool for regulation of land use at the local level. Such regulations typically divide a jurisdiction into zoning districts that limit uses, provide bulk, height, setback and lot size and coverage limitations, and specific other standards for development. Zoning regulations also contain provisions for variances from some of the standards and requirements of the regulation. It is important that zoning regulations acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	Y	Y	Y	3	Y
Subdivision/Platting	Subdivision regulations are the primary means of managing how and where land is divided into smaller parcels. Such regulations typically provide regulations related to open space, required improvements, lot layout, access, etc... In addition, long plats, depending how their are defined at the local level, are subject to SEPA review. It is important that subdivision regulations acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	Y	Y	Y	2	Y
Development Standards	Development standards typically provide minimum standards for utility, transportation and storm drainage improvements. It is important that development standards acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	Y	Y	Y	2	Y
Planned Development	Planned Development regulations are an optional means for managing how and where land is divided into smaller parcels for development. Such regulations typically permit increased densities, require open space, required improvements, lot layout, access, etc... In addition planned developments are subject to SEPA review. It is important that planned development regulations acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	Y	Y	Y	3	Y

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct X - indirect**		**Y - direct X - indirect**	**1 - Little or no regulatory mechanism 2 - basic mechanism in place, needs revision/ update 3 - existing mechanism adequate**	**Y - direct X - indirect**
Critical Areas	Critical Areas regulations are required under the state Growth Management Act (as amended) have become the primary tool for regulation of development in frequently flooded areas, wetlands, aquifer recharge areas, geologically hazardous areas and critical fish and wildlife habitat at the local level. The regulations are intended to protect, restore and enhance critical areas using best available science. Critical Areas regulations also must provide a "reasonable use" provision that may allow for the waiving of requirements if the strict application of the regulation would deny all use of a piece of property. In addition permits for development in critical areas are generally subject to SEPA review.	Y	Y	Y	2	Y
Flood Damage Prevention	Flood Damage Prevention regulations are required under the state and federal flood damage prevention statutes and regulate development in identified 100 year flood plain areas. The regulations are intended to reduce flood hazards to private property through requirements for flood proofing, elevation of structures and limitations on development in floodway and floodplains. In addition, floodplain development permits are subject to SEPA review. It is important that flood damage prevention regulations acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	Y	Y	Y	2	Y
Clearing and Grading	Clearing and grading regulations, related to the Uniform Building Code, are an option available to local government to provide a means to review and mitigate impacts from clearing and grading of land. It is important that clearing and grading regulations are considered that acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	Y	Y	Y	1	Y

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct** **X - indirect**		**Y - direct** **X - indirect**	**1 - Little or no regulatory mechanism** **2 - basic mechanism in place, needs revision/ update** **3 - existing mechanism adequate**	**Y - direct** **X - indirect**
International Building Code	The International Building Codes has been adopted by most local governments, in compliance with State law, to provide regulations to ensure protection of the public health, safety and welfare. These codes provide optional sections that address issues (clearing, grading, fill, etc....) that potentially could impact listed species. It is important that building codes are considered that acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	3	X
Shoreline Master Program	Local Shoreline Master Programs (SMP) are required under the State Shoreline Management Act for those jurisdictions with rivers or streams with mean annual flow of 20 cfs or lake over 20 acres. The SMP provides goals, policies and regulations for development with shoreline jurisdiction which at a minimum includes that land lying 200 feet landward on a horizontal plane, from the ordinary-high-water-mark or the floodway boundary, whichever is greater. It is important that local SMPs acknowledge existing and desired future conditions for a wide range of issues that affect listed species. In addition permits for development in shoreline areas are generally subject to SEPA review.	Y	Y	Y	2	Y
Administrative Procedures	Administrative procedures for implementation and enforcement of local land use and environmental regulations are critical to the success of a local planning program. Timing of review processes, appeals and the number and type of public hearings are set forth in state statute with the local government have some limited options (e.g. hearing body, reviewing agencies, permit type, etc...). It is important that local SMPs acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	2	X

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct X - indirect**		**Y - direct X - indirect**	**1 - Little or no regulatory mechanism 2 - basic mechanism in place, needs revision/ update 3 - existing mechanism adequate**	**Y - direct X - indirect**
Resource/Rural Lands	Resource/Rural lands regulations are required under the state Growth Management Act (as amended) have become the primary tool for regulation of development on timber, mineral and agricultural resource lands of long-term commercial significance. The regulations are intended to protect resource lands from incompatiable land uses. It is important that local SMPs acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	Y	2	Y
Permit Processes						
Conditional Uses	Conditional Use Permits are for permitted uses that due to the type of use or location require a public hearing and placement of conditions on the development in order to mitigate potential impacts. There are two types of CUPs, those required by zoning regulations and those required under local shoreline master programs (Shoreline CUPs require approval of Ecology). Both types of CUP's require SEPA review. The authority to develop conditions is fairly broad, but conditions are generally limited to those needed to address the direct impacts of the project. Since CUP's can occur in locations where develoonent would potentially impact listed species, it is important that the CUP process acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	2	Y

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct X - indirect**		**Y - direct X - indirect**	**1 - Little or no regulatory mechanism 2 - basic mechanism in place, needs revision/ update 3 - existing mechanism adequate**	**Y - direct X - indirect**
Variances	Variances are generally limited to bulk, height and setback regulations contained in zoning and shoreline regulations (shoreline variances require approval of Ecology). With the exception of shoreline variances, such actions may be exempted from SEPA. Variances typically require a public hearing and approval must include findings that the variance meets standard criteria related to hardship, topography and existing development patterns. The authority to deny or approve variances is fairly broad and does provide opportunities to place conditions on the approval that address the direct impacts of the project. Since variances may be requested where development could potentially impact listed species, it is important that the approval process acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	2	Y
Exemptions	Exemptions are available in specific circumstances to allow for the reasonable use of property when strict application of regulations would eliminate all use or, in the case of shorelines master programs, a specific list of exemptions set forth in the Shoreline Management Act. Exemptions are generally also exempt from SEPA review. The authority to deny or approve exemptions is fairly broad and provides opportunities to place conditions on the approval that address the direct impacts of the project. Since exemptions may be requested where development could potentially impact listed species, it is important that the approval process acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	2	Y

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct** **X - indirect**		**Y - direct** **X - indirect**	**1 - Little or no regulatory mechanism** **2 - basic mechanism in place, needs revision/ update** **3 - existing mechanism adequate**	**Y - direct** **X - indirect**
Substantial Development	Substantial Development permits are a requirement of the Shoreline Management Act and are generally administratively approved at the local level. These permits are subject to SEPA review. The authority to deny or approve substantial development permits is fairly broad and provides opportunities to place conditions on the approval that address the direct impacts of the project. Since all SDPs will be for development that could potentially impact listed species, it is important that the approval process acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	2	Y
Approach/Access	Approach permits are issued for new access points to County roads and city streets. Access permits are for new and or expanded access onto state highways. Approach permits are local decisions while access permits in unincorporated areas are administered by the Department of Transportation and by the local municipality within corporate limits. Approach and Access permits are generally exempt from SEPA review. The authority to deny or approve approaches or accesses provides opportunities to place conditions on the approval that address the direct impacts of the project. Since approaches or accesses may be requested where development could potentially impact listed species, it is important that the approval process acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	2	Y

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct** **X - indirect**		**Y - direct** **X - indirect**	**1 - Little or no regulatory mechanism** **2 - basic mechanism in place, needs revision/ update** **3 - existing mechanism adequate**	**Y - direct** **X - indirect**
Septic	Septic permits are review and issues by local Health Districts under statutory authority of state and federal Clean Water Act and related laws. Septic approvals are generally exempted from local SEPA review. The authority to deny or approve septic permits provides opportunities to place conditions on the approval that address the direct impacts of the project. Since septic permits may be requested where development could potentially impact listed species, it is important that the approval process acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	2	Y
Subdivision/Platting/Planned Development/ Binding Site Plans	Approval of long and short plats, planned developments and binding site plans are local decisions. Subdivisions and plats entail the division of property into 2 or more parcels while planned developments and binding site plans offer alternative to traditional platting. Generally short plats, which are administratively approved and exempt from SEPA, contain 9 or fewer lots, while long plats, planned developments and binding site plans are subject public hearing and SEPA review. The authority to deny or approve subdivisions is fairly broad and provides opportunities to place conditions on the approval that address the direct impacts of the project. Since such developments may be requested where construction could potentially impact listed species, it is important that the approval process acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	2	Y

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct** **X - indirect**		**Y - direct** **X - indirect**	**1 - Little or no regulatory mechanism** **2 - basic mechanism in place, needs revision/ update** **3 - existing mechanism adequate**	**Y - direct** **X - indirect**
Utility Connections	Utility connections are approved by utility providers for water, wastewater and stormwater utilities. Such connections are typically exempt from SEPA. The authority to deny or approve connections provides opportunities to place conditions on the approval that address the direct impacts of the project. Since connections may be requested where development could potentially impact listed species, it is important that the approval process acknowledge existing and desired future conditions for a wide range of issues that affect listed species.	X	X	X	2	Y
R-O-W permits	Local and state governments may authorize a variety of uses within the public right-of-way. Such uses may have the potential to negatively affect listed species.	X	X	X	2	X
Hydraulics Permits*	Hydraulic permits, required by the State Hydraulics Code for all development below the ordinary-high-water-mark, are administered by the State Department of Fish and Wildlife. Local governments are usually involved as the first contact for a land owner inquiring about or making application for a local land use (variance, building, shoreline, floosplain development, conditional use, exemption, etc...) permit. The partnership between WDFW and local government has resulted in the Joint Aquatic Review Permit Application (JARPA), in common use by local governments for shoreline and floodplain development processes.	Y	Y	Y	2	Y
Water Quality Modification*	Water Quality Modification permits, required state and federal clean water laws, are administered by the State Department of Ecology. Local governments are usually involved as the first contact for a land owner inquiring about or making application for a local land use (variance, building, shoreline, floosplain development, conditional use, exemption, etc...) permit. Ecology is usually notifed by the local government as a commenting agency.	Y	Y	Y	2	Y

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	Spatial Structure/ Diversity	The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed	The inadequacy of existing regulatory mechanisms	Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.
Land Use Comprehensive Plans (Elements):		**Y - direct** **X - indirect**		**Y - direct** **X - indirect**	**1 - Little or no regulatory mechanism** **2 - basic mechanism in place, needs revision/ update** **3 - existing mechanism adequate**	**Y - direct** **X - indirect**
Corps Permits*	Corps permits (Sections 10 and 404) required by the federal Clean Water Act when development takes place below the ordinary-high-water-mark and in wetlands, are administered by the U.S. Army Corps of Engineers. Local governments are usually involved as the first contact for a land owner inquiring about or making application for a local land use (variance, building, shoreline, floodplain development, conditional use, exemption, etc...) permit. The JARPA, in common use by local governments for shoreline and floodplain development processes is the usual trigger for Corps Permits. Corps permits usually require a Biological Assessment and other stringent environmental review.	Y	Y	Y	2	Y
Water Rights*	The Department of Ecology is responsible for adminstration of state water law. Washington State law requires certain users of public waters to receive approval from the state prior to use of the water - in the form of a water right permit or certificate. Any use of surface of water (lakes, ponds, rivers, streams, or springs) which began after the state water code was enacted in 1917 requires a water-right permit or certificate. This rule establishes the framework under which the department can provide for the organization of its work, prioritize basins to be assessed, conduct basin assessments, prioritize investigations of water right applications by geographic areas, and establish criteria for priority processing of applications for new water rights and applications for change or transfer of existing water rights.	X	X	X	2	X
* - state or federal permit, local government may be initial point of contact or need review/action by state or federal agency prior to issuance of local government approvals.						
Compliance Program						

Policy/ Program/ Regulation	Relationship to Recovery of Listed Species	Relationship to VSP Parameters		ESA Threat Criteria		
		Abundance/ Productivity	**Spatial Structure/ Diversity**	**The present or threatened destruction, modification, or curtailment of its habitat or range and how these threats will be removed**	**The inadequacy of existing regulatory mechanisms**	**Other natural or manmade factors (with authorities under local government jurisdiction, such as grading permits, variance policy etc.) affecting its continued existence" and how these threats will be removed.**
Land Use Comprehensive Plans (Elements):		**Y - direct X - indirect**		**Y - direct X - indirect**	**1 - Little or no regulatory mechanism 2 - basic mechanism in place, needs revision/ update 3 - existing mechanism adequate**	**Y - direct X - indirect**
Code Enforcement/Compliance Position	Fair and equitable code enforcement and inspection/monitoring of projects to ensure completion of required mitigation, conditions, etc…. is critical to enforcement of existing plans, regulations and codes that require protection, restoration or enhancement of critical and shoreline areas.	X	X	X	2	X
Environmental Review						
SEPA	SEPA regulations are required under the State Environmental Policy Act (as amended) and are the primary tool for identification and mitiation of negative environmental impacts. The types and level of development that require SEPA review are established in state statute and adopted and administered by local governments.	Y	Y	Y	2	Y
NEPA	While not a local government requirement, NEPA is required when federal funding is used in most projects (e.g. sewer treatment upgrades, road reconstruction, replacement bridges, food banks, etc…) and often times local government is the applicant.	Y	Y	Y	2	Y

The next step in the review process was to determine the relative status of local government efforts to comply with state and federal requirements related to land use planning, regulation, management, compliance and environmental review. Tables 2, 3, 4 and 5 provide a summary of this exercise for the three counties, tribes and PUDs.

The first part of the review and analysis was to determine the status of comprehensive planning and implementation tools. Each jurisdiction was contacted and a determination made whether the various comprehensive planning and implementing documents were: adopted and compliant with current/pending requirements (e.g. comprehensive plan and critical areas regulations amended to include best available science, utility plans adopted within 6 year window); adopted but not in compliance with current/pending requirements (e.g. comprehensive plan and critical areas regulations have not been reviewed and revised based on best available science, utility plans adoption date outside of 6 year window); does not exist (e.g. no adopted plan or regulation exists); or the particular plan is not applicable (e.g. incorporated communities do not normally include a rural areas element). The date of the most recent amendments to the Comprehensive Plan was also determined and is included in the following tables.

It is important to note that Chelan and Douglas Counties and the incorporated municipalities within them are subject to Growth Management Act (GMA), which provides greater state oversight of planning activities within these counties. In general, nearly all of the local governments in the region are either in compliance with the requirements of the Growth Management Act or are presently working in that direction. The State has established a 2007 deadline for all local governments (including those in Okanogan County) to review and revise their Comprehensive Plans and Critical Areas regulations to ensure that the best available science is used to establish the goals, policies and regulations for protection of critical areas (fish and wildlife habitat, aquifer recharge areas, frequently flooded areas, geologically hazardous areas and wetlands).

The review and analysis found that none of the local governments in the region has a shoreline master program that complies with new State Shoreline Management Act (SMA) requirements. However, adoption of the new Shoreline Master Programs at the local level is not required until 2014. Okanogan and Douglas Counties have been awarded grant funds for the preparation of new compliant Shoreline Master Programs to be adopted in 2007. These new programs will be regional in scope and are intended to address shoreline protection, restoration and enhancement issues for each county and the municipalities within the counties.

In addition to GMA and SMA plans, programs and regulations, local governments also operate utilities (water, sewer and stormwater) and transportation and recreation systems (roads, parks, trails) that may affect listed species. The review and analysis found that with few exceptions, local governments in the region are compliant with Federal and State water and sewer planning and permitting. However, storm drainage has only recently become an important issue and therefore few local governments have adopted stormwater management plans. This is in large measure due to the lack, until recently, of adopted Eastern Washington Stormwater Management guidelines, which are considered inadequate.

Management of transportation systems is another area where local governments are just beginning to develop and adopt best management practices and road abandonment plans. As a result only a few of the local governments in the region have adopted plans or programs recommended by the County Arterial Road Board (CRAB).

The review and analysis found that in general, most local governments (the exception being the vary small communities in Okanogan County) have a wide range of ordinances and regulations that require review and permitting of developments that may potentially impact listed species. The most significant omission in regards to VSP parameters and ESA Threat Criteria is the lack of specific clearing and grading regulations. While most jurisdictions have adopted the International Building Code, very few have adopted the appendices related to clearing and grading.

Another aspect of local government plans, programs and regulations included in the analysis was a review of permitting processes. The review was very simple in that it identified whether a process existed or not and did not include a qualitative analysis of the adequacy of the existing program. In general nearly all local governments in the region have a wide array of processes that most development must go through prior to construction.

A fourth area included in the review was a determination of whether jurisdictions have a mechanism in place for code compliance and enforcement. The review found that very few local governments have a specific land use code compliance/enforcement position. Most jurisdictions either have the duties and responsibilities spread among planners and building officials or do not have such a position clearly delineated.

The final piece of the local government review was a determination of local environmental review processes. All local governments have some lead agency responsibilities under SEPA and use NEPA as required for specific projects. In general most jurisdictions have SEPA rules that are in need of updating.

Another aspect of local government plans, programs and regulations not included in the review was budget, personnel and expertise. The struggling economy in the region and general lack of public support for such programs means that funding for many planning and regulatory functions is driven by the availability of state and/or federal grant funding. The enforcement, compliance and monitoring of development related permits requires not only personnel, but a budget for legal action, scientific review, and the political will to implement the wide range of plans, programs and regulations under the jurisdiction of local governments.

A related issue is the availability of technical assistance, project review and comments and enforcement support from state and federal agencies resource agencies. Since most local governments in the region do not have the budget to support a science staff, there is a significant reliance on state and federal resource agencies to review and provide comments on plans, programs and regulations as there are developed, implemented and enforced. Unfortunately, the focus of many of the agencies is on planning rather than working closely with local government's on implementation and enforcement.

Table 2 needs to be printed on 11" X 17" paper

Table 2 Status of Chelan County efforts to comply with state and federal requirements related to land use planning, regulation, management, compliance and environmental review

Policy/Program/Regulation	CURRENT STATUS					
	Y - adopted and compliant with current/pending requirements		X - adopted but not compliant with current/pending requirements			blank - does not exist
	Chelan County (municipalities on waters with listed species are in italics)					
		Chelan	*Entiat*	*Wenatchee*	*Cashmere*	*Leavenworth*
Land Use Comprehensive Plans (Elements):	**2004**	**1998**	**2004**	**2004**	**2004**	**1997**
Land Use Element	Y, subject to annual update	X, 1998, amended 2000, update required for Critical Areas in 2006		X, subject to annual update and critical areas update 2007	Y	X, critical areas/ BAS adopted 2003
Capital Facilities Element	Y, subject to annual update	"		Y, subject to annual update	Y	X
Utilities Element	n/a, does not have traditional utilities	"		Y, subject to annual update	Y	X
Rural Areas Element	Y, subject to annual update	n/a	n/a	n/a	n/a	n/a
Transportation Element	Y, subject to annual update	"		Y, subject to annual update	Y	X
Urban Growth Area Element	Y, subject to annual update			Y, subject to annual update		X
Lands for Public Purpose and Open Space Corridors Element	Y, subject to annual update	n/a		Y, subject to annual update	Part of zoning code related to some residential developments 2004	n/a
Economic Development Element	Y, subject to annual update	2003		Y, subject to annual update	Y	draft element
Parks and Recreation Element	Y, subject to annual update	2003		Y, subject to annual update	Y	Y, separate plan
Water Comp Plan	n/a, does not have traditional utilities	1999 presently being updated	2003	Y, 2004	Y May 2003	Y 2001
Wastewater Comp Plan	n/a, does not have traditional utilities	Permit 2004	2004	No current plan, under order to have plan by 2007	Y 2005	Y
Stormwater Management Plan	planned adoption 2005	none, within development standards	none, within development standards	have unadopted plan that is being implemented, need to update and adopt		Y, Adopted EW Stormwater manual 2005

Policy/Program/Regulation	CURRENT STATUS					
	Y - adopted and compliant with current/pending requirements		X - adopted but not compliant with current/pending requirements			blank - does not exist
	Chelan County (municipalities on waters with listed species are in italics)					
		Chelan	*Entiat*	*Wenatchee*	*Cashmere*	*Leavenworth*
Land Use Comprehensive Plans (Elements):	**2004**	**1998**	**2004**	**2004**	**2004**	**1997**
Solid Waste Management Plan	DATE?	County Plan	County Plan	County Plan	County Plan	County Plan
Road Management and Abandonment Plan RCW 76.09.410 and 76.09.420	procedures	n/a	n/a	n/a	n/a	n/a
Watershed Plans	Chelan County has three WRIA's (40A, 45 and 46) involved in Watershed Planning.	Lake Chelan Water Quality Committee	2005, part of Entiat River Planning Unit	Part of Wenatchee Watershed effort	Part of Wenatchee Watershed effort	Part of Wenatchee Watershed effort
Implementing Regulations						
Zoning	Y, annual review	Y, 1962 with periodic amendments	Y, 2004	Y, updated consistent with comp plan amendments, other amendments as needed	2004	Y
Subdivision/Platting	Y, annual review	X mid 70's		Y, updated as needed	2002	Y
Development Standards	for roads only, rest in individual codes	X 1998	part of subdivision and zoning	integrated into zoning, subdivision and utilities plans	Part of the zoning code adopted 2004	Y
Planned Development	Y, annual review	part of zoning	part of zoning	Y, part of zoning regulation	Part of the zoning code adopted 2004	Y
Critical Areas	X, 2000, reviewing geohazards 2005, ca in 2006	1998, update by 2006	Y, 2004	X, update by 2007	Y 2002	Y
Flood Damage	Y, 2004	N FEMA model 1980's?	n/a	Y, 2004	Y, 2004	Y, 2003 Updated
Clearing and Grading	UBC only	Use standards in International Building Code	Use standards in International Building Code	Use standards in International Building Code	UBC, 1996	2004
International Building Code	IBC	adopted International Building Code 7/04	adopted International Building Code 7/04	adopted International Building Code 7/04	adopted International Building Code 2005	International Building Code 2004

Policy/Program/Regulation	CURRENT STATUS					
	Y - adopted and compliant with current/pending requirements		X - adopted but not compliant with current/pending requirements			blank - does not exist
	Chelan County (municipalities on waters with listed species are in italics)					
		Chelan	*Entiat*	*Wenatchee*	*Cashmere*	*Leavenworth*
Land Use Comprehensive Plans (Elements):	**2004**	**1998**	**2004**	**2004**	**2004**	**1997**
Shoreline Master Program	X, late 70's	X, mid 70's, no updates, update required by 2014	X, mid 90's, update required by 2014	X, early 70's update required by 2014	X,1975	X, 1975, update required by 2014
Administrative Procedures	Y, 2000	1998		Y,integrated into zoning, subdivision	2000	Y
Resource/Rural Lands	Y, 2000 annual; review	n/a	N/a	n/a	n/a	n/a
Permit Processes	**X - denotes that permit process exists, no assumption made on compliance**					
Conditional Uses	X	X	X	X	X	X
Variances	X	X	X	X	X	X
Exemptions	X	X	X	X	X	X
Substantial Development	X	X	X	X	X	X
Approach/Access	X	X	X	X	X	X
Septic	X	X	X	X	X	X
Subdivision/Platting/Planned Development/Binding Site Plans	X	X	X	X	X	X
Utility Connections	X	X	X	X	X	X
R-O-W permits	X	X	X	X	X	X
Hydraulics Permits*	JARPA	JARPA	JARPA	JARPA	JARPA	JARPA
Water Quality Modification*	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits
Corps Permits*	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits
Water Rights*	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits

Policy/Program/Regulation	**CURRENT STATUS**					
	Y - adopted and compliant with current/pending requirements		**X - adopted but not compliant with current/pending requirements**			**blank - does not exist**
	Chelan County (municipalities on waters with listed species are in italics)					
		Chelan	***Entiat***	***Wenatchee***	***Cashmere***	***Leavenworth***
Land Use Comprehensive Plans (Elements):	**2004**	**1998**	**2004**	**2004**	**2004**	**1997**
* - state or federal permit, local government may be initial point of contact or need review/action by state or federal agency prior to issuance of local government approvals.						
Compliance Program	**Y - position with clear land use authority exists, X - position exists, no clear land use authority, blank - no position**					
Code Enforcement/Compliance Position		Y	X Building Inspector/Planner	Y	Y public works coordinator	Y Code Administrator
Environmental Review						
SEPA	X, mid 80's	X - mid 70's	Y, 2003	Y, 2002	1999	as required SEPA ORD DATE
NEPA	as required	as required	as required	as required	as required	as required

Table 3 needs to be printed on 11" X 17" paper

Table 3 Status of Douglas County efforts to comply with state and federal requirements related to land use planning, regulation, management, compliance and environmental review

Policy/Program/Regulation	CURRENT STATUS					
	Y - adopted and compliant with current/pending requirements		X - adopted but not compliant with current/pending requirements		blank - does not exist	
	Douglas County (municipalities on waters with listed species are in italics)					
		E.Wenatchee	Waterville	Mansfield	*Rock Island*	*Bridgeport*
	1995	1998	2003	2003	2004	2004
Land Use Comprehensive Plans (Elements):						
Land Use Element	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update
Capital Facilities Element	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update
Utilities Element	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update
Rural Areas Element	Y, subject to annual update	n/a	n/a	n/a	Y	n/a
Transportation Element	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update
Urban Growth Area Element (gma?)	Y, subject to annual update	Y, subject to annual update		Y, subject to annual update	Y, subject to annual update	Y, subject to annual update
Lands for Public Purpose and Open Space Corridors Element	n/a	Y, subject to annual update				
Economic Development Element	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update	Y, subject to annual update		Y, subject to annual update
Parks and Recreation Element	Y, subject to annual update. Also Park and Rec District with separate plans	Open space and Recreation Element, also Park and Rec District with separate plans	Y	Y		Y
Water Comp Plan	East Wenatchee Water District	East Wenatchee Water District			X, most recent plan circa 1997	2000
Wastewater Comp Plan	Douglas Co. Sewer Dist.	Douglas Co. Sewer Dist.	Permit 2004			2001
Stormwater Management Plan	Y, Adopted EW Stormwater manual 2005	Y, Adopted Do. Co Flood Hazard Mgmt Plan, currently under way to include stormwater				1991
Solid Waste Management Plan	Y, 2002	Do Co Solid Waste Plan	Do Co Solid Waste Plan	Do Co Solid Waste Plan	Do Co Solid Waste Plan	Do Co Solid Waste Plan
Road Management and Abandonment Plan	X, one page	n/a				

Policy/Program/Regulation	CURRENT STATUS					
	Y - adopted and compliant with current/pending requirements		X - adopted but not compliant with current/pending requirements		blank - does not exist	
	Douglas County (municipalities on waters with listed species are in italics)					
		E.Wenatchee	**Waterville**	**Mansfield**	***Rock Island***	***Bridgeport***
Watershed Plans	Y, WRIA 44 and 50 plans adopted in 2004	n/a	Y	n/a	n/a	2004
Implementing Regulations						
Zoning	Y	Y	Y, 2003	Y, 2003	Y, 2004	Y, 2001
Subdivision/Platting	Y	Y	Y, 2001	Y, 2001	Y, 2001	Y, 2005
Development Standards	integrated into zoning, subdivision and utilities plans	in process of adopting a revised set of street standards; also developing stormwater standards	Y, 2001	Y, 2001	Y, 2001	
Planned Development	Y, part of zoning regulation	Y, currently revising	part of the zoning code adopted 2003			
Critical Areas	X, 2002, update required by 2007	Y, needs work	Y, 2003			Y, 2002
Flood Damage Prevention	Have a Hazard Mitigation Plan that includes flood measures	Y, DATE				X, 1987
International Building Code	International Building Code 2004	International Building Code 2004	International Building Code 2005			1997
Shoreline Master Program	X, 1973 update required by 2014, has applied for funding to adopt 2007	Do Co Shoreline Master Program				X, 1991
Administrative Procedures	Y, some stand alone, others integrated into zoning, subdivision	Y	1998	2000	1999	1996
Resource/Rural Lands	Y	n/a				
Permit Processes	**X - denotes that permit process exists, no assumption made on compliance**					
Conditional Uses	X	X	X	X	X	X
Variances	X	X	X	X	X	X
Exemptions	X	X	X	X	X	X
Substantial Development	X	X	n/a	n/a	X	X

Policy/Program/Regulation	CURRENT STATUS					
	Y - adopted and compliant with current/pending requirements		X - adopted but not compliant with current/pending requirements		blank - does not exist	
	Douglas County (municipalities on waters with listed species are in italics)					
		E.Wenatchee	Waterville	Mansfield	*Rock Island*	*Bridgeport*
Approach/Access	X	X	X	X	X	X
Septic	Chelan/Douglas Health District	X	X	X	X	X
Subdivision/Platting/Planned Development/Binding Site Plans	X	X	X	X	X	X
Utility Connections	n/a	n/a	X	X	X	X
R-O-W permits	X	X	X	X	X	X
Hydraulics Permits*	JARPA	JARPA	JARPA	JARPA	JARPA	JARPA
Water Quality Modification*	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits
Corps Permits*	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits
Water Rights*	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits
* - state or federal permit, local government may be initial point of contact or need review/action by state or federal agency prior to issuance of local government approvals.						
Compliance Program	**Y - position with clear land use authority exists, X - position exists, no clear land use authority, blank - no position**					
Code Enforcement/Compliance Position	Y, code compliance officer	Y, code compliance officer	Y	?	X, Clerk/Treasurer along with Alliance Consulting	Y, zoning administrator
Environmental Review						
SEPA	Y, DATE	Y, DATE	2001		1999	1999
NEPA	as required	as required	as required	as required	as required	as required

Table 4 needs to be printed on 11" X 17" paper

Table 4 Status of Okanogan County efforts to comply with state and federal requirements related to land use planning, regulation, management, compliance and environmental review

Policy/Program/Regulation	CURRENT STATUS													
	Y - adopted and compliant with current/pending requirements				X - adopted but not compliant with current requirements				blank - does not exist					
	Okanogan County (municipalities on waters with listed species are in italics)													
		Oroville	*Tonasket*	*Riverside*	Conconully	*Omak*	*Okanogan*	*Brewster*	*Pateros*	*Twisp*	*Winthrop*	Nespelem	Elmer City	Coulee Dam
	1964	1995	1995	None	2000	2004	1995	1995	1992	1991	1996	1994		2000
Land Use Comprehensive Plan (Elements):														
Land Use Element	X, Okanogan County is currently updating the Comp Plan and various elements on a sub area basis. Plans in the Methow Valley have been updated in 1979, the mid 1980's and the Mazama Area in 2000	X, adopted 1995, in need of review and revision	X, adopted 1995, in need of review and revision	Riverside does not have a comp plan	X, The Town has adopted a "Community" Plan	Y, updated 2004 including critical areas	X, adopted in 1995 currently being reviewed for update	X, presently being updated	Y 2003 update	X, adopted 1991	X, adopted in 1996	X		X, needs to be updated
Capital Facilities Element	Y 2004 interim	Y, 2004	X, adopted 1995, in need of review and revision		X, original early 1990's plan needs to be updated	Y, Under review, updated CFP adopted in 2004	X, adopted in 1995 currently being reviewed for update	Y, Under review, updated CFP adopted in 2005	X, Under review, CFP presently being updated	CFP year?	X, adopted in 1996			X, needs to be updated
Utilities Element	X, 1964 Comp Plan	X, adopted 1995, in need of review and revision	X, adopted 1995, in need of review and revision		X, needs to be updated	Under review	X, adopted in 1995 currently being reviewed for update	X, presently being updated	Y	X, adopted 1991	X, adopted in 1996	x		X, needs to be updated
Rural Areas Element	X, no rural element in existing plans	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Policy/Program/Regulation	**CURRENT STATUS**													
	Y - adopted and compliant with current/pending requirements					**X - adopted but not compliant with current requirements**			**blank - does not exist**					
	Okanogan County (municipalities on waters with listed species are in italics)													
		Oroville	***Tonasket***	***Riverside***	**Conconully**	***Omak***	***Okanogan***	***Brewster***	***Pateros***	***Twisp***	***Winthrop***	**Nespelem**	**Elmer City**	**Coulee Dam**
	1964	**1995**	**1995**	**None**	**2000**	**2004**	**1995**	**1995**	**1992**	**1991**	**1996**	**1994**		**2000**
Transportation Element	X, 1995, Central Okanogan Valley being updated, Corridor Management Plan being prepared for SR 97 Scenic Byway		X, adopted 1995, in need of review and revision		X, needs to be updated	X, Updated 2004	X, adopted in 1995 currently being reviewed for update	X, presently being updated	Y	X, adopted 1991	X, adopted in 1996	x		X, needs to be updated
Urban Growth Area Element (gma?)	Current plans do not address UGAs	X, adopted 1995, in need of review and revision	X, adopted 1995, in need of review and revision			Updated 2004	X, adopted in 1995 currently being reviewed for update	X, presently being updated	Y		X, adopted in 1996			X, needs to be updated
Lands for Public Purpose and Open Space Corridors Element	X, current plans do not specifically address	n/a	n/a	n/a	X, Community Plan does address to a small extent			X, presently being updated	Y					X, needs to be updated
Economic Development Element	Y, County adopts Economic Alliance Strategy Plan as economic development element	X, adopted 1995, in need of review and revision	X, adopted 1995, in need of review and revision		X, needs to be updated	Under review	X, adopted in 1995 currently being reviewed for update	X, presently being updated	Y, presently being updated	n/a	X, adopted in 1996	X		X, needs to be updated
Parks and Recreation Element	Y, Outdoor Rec Plan adopted in 2004	2004, current plan	2004, current plan		X, needs to be updated	Under review	X, adopted in 1995 currently being reviewed for update	X, presently being updated	Y	X, adopted 1991	X, adopted in 1996			X, needs to be updated

Policy/Program/Regulation	CURRENT STATUS													
	Y - adopted and compliant with current/pending requirements				X - adopted but not compliant with current requirements				blank - does not exist					
	Okanogan County (municipalities on waters with listed species are in italics)													
		Oroville	*Tonasket*	*Riverside*	Conconully	*Omak*	*Okanogan*	*Brewster*	*Pateros*	*Twisp*	*Winthrop*	Nespelem	Elmer City	Coulee Dam
	1964	1995	1995	None	2000	2004	1995	1995	1992	1991	1996	1994		2000
Water Comp Plan	N/a	Y, 2001	Y, 2003	N, 2000-01?, needs updated	n/a - no public water system, it is being developed	X, updated 2004	Y, updated 2004	Y		X, needs updated	X, adopted in 1996	N	N	N
Wastewater Comp Plan	N/a	X, 1978 wastewater plan with update under way, NPDES Permit 2003	Y, 1998, needs update, NPDES permit to be renewed	n/a	Permit 2004	Permit 2003, plant upgraded in 2000	Permit 2003, plant upgraded in 2001	Permit 2004, plant upgrade to be completed in 2005	Permit 2004, plant rebuilt in 2002	Permit 2004, plant upgraded in 1999	Y			
Stormwater Management Plan		comp plan policies and BMPs used to regulate, no stand alone plan	comp plan policies and BMPs used to regulate, no stand alone plan			Y, needs to be updated	Y, needs to be updated							
Solid Waste Management Plan	1993 currently updating	Ok. Co. Solid Waste Plan	Ok. Co. Solid Waste Plan	Ok. Co. Solid Waste Plan	Ok. Co. Solid Waste Plan	Ok. Co. Solid Waste Plan	Ok. Co. Solid Waste Plan	Ok. Co. Solid Waste Plan	Ok. Co. Solid Waste Plan	n/a Ok. Co. Solid Waste Plan	Ok. Co. Solid Waste Plan	X, Tribe 1997	X, Tribe 1997	X, Tribe 1997
Road Management and Abandonment Plan		n/a	n/a	n/a	n/a	n/a	n/a						n/a	n/a
Watershed Plans	Planning Unit formed for Okanogan Basin in 2004, work will focus on quantity, then habitat. Water quality plan prepared for Okanogan in 2003, completed but not approved by Ecology. Methow Basin Planning Unit has prepared plan approved by the Okanogan County Commissioners on ______________.											Not part of any active watershed planning effort		
Implementing Regulations										n/a				
Zoning	Y, 1994 most recent update	Y, 1995 most recent update	X, 1994 working on full update			X	Y	Y	Y	Y	Y	Land use regulations implemented by CCT		Y

Policy/Program/Regulation	**CURRENT STATUS**													
	Y - adopted and compliant with current/pending requirements				**X - adopted but not compliant with current requirements**				**blank - does not exist**					
	Okanogan County (municipalities on waters with listed species are in italics)													
		Oroville	***Tonasket***	***Riverside***	**Conconully**	***Omak***	***Okanogan***	***Brewster***	***Pateros***	***Twisp***	***Winthrop***	**Nespelem**	**Elmer City**	**Coulee Dam**
	1964	**1995**	**1995**	**None**	**2000**	**2004**	**1995**	**1995**	**1992**	**1991**	**1996**	**1994**		**2000**
Subdivision/Platting	Y, adopted early 1970;s minor revisions in 1980's	Y, 1996	X, 1987		X	X	Y			Y	Y			Y
Development Standards	integrated into other ordinances, state statute	integrated into other ordinances, state statute	integrated into other ordinances, state statute			no stand alone development standards	no stand alone development standards, currently under review			to some degree part of zoning and subdiv PD	to some degree, part of zoning and subdiv PD			Y
Planned Development	Y, adopted in 1980's	Within zoning code				X	Y		Y	to some degree part of zoning and subdiv PD	Y			Y
Critical Areas	X, 1994, update required by 2007	X, update required by 2007	X, update required by 2007			Y, adopted 2005	X, adopted as element of 1995 comp plan, update required by 2007	Y, 2004	Y, 2004	In Comp Plan, currently to DOE for update	Y			Y
Flood Damage Prevention *RCW 86.12.200 Comprehensive flood control management plan -- Elements. The county legislative authority of any county may adopt a comprehensive flood control management plan for any drainage basin that is located wholly or partially within the county.*	X, 1987 update needed to reflect recent statutory changes	X, 1991	X, 1996	use FEMA 100 yr.	X, needs to be updated	Y	Y			Y, updated 2004	Y			

Policy/Program/Regulation	CURRENT STATUS													
	Y - adopted and compliant with current/pending requirements				X - adopted but not compliant with current requirements				blank - does not exist					
	Okanogan County (municipalities on waters with listed species are in italics)													
		Oroville	*Tonasket*	*Riverside*	Conconull y	*Omak*	*Okanogan*	*Brewster*	*Pateros*	*Twisp*	*Winthrop*	Nespelem	Elmer City	Coulee Dam
	1964	1995	1995	None	2000	2004	1995	1995	1992	1991	1996	1994		2000
Clearing and Grading			Has adopted section of IBC				U				N, but need it			
International Building Code	International Building Code 2004	Uniform Building Code, expect to adopt IBC 2005	International Building Code 2004	City of Omak code	?	International Building Code 2004	International Building Code 2004	International Building Code 2004	International Building Code 2004	International Building Code 2004	International Building Code 2004	Building Code enforced by CCT		Y
Shoreline Master Program	X, needs to be updated by 2014, County has applied for funding to update program by 2007	X, needs to be updated by 2014	X, needs to be updated by 2014		Okanogan County	X, needs to be updated by 2014, City has applied for funding to update program by 2007	X, needs to be updated by 2014, City has applied for funding to update program by 2007	X, needs to be updated by 2014, City has applied for funding to update program by 2007	X, needs to be updated by 2014, City has applied for funding to update program by 2007	X, 1991 needs to be updated	Y 1991			N
Administrative Procedures	Y,integrated into zoning, subdivision	Y, 1999 integrated into zoning, subdivision	Y,integrated into zoning, subdivision			Y,integrated into zoning, subdivision	Y,integrated into zoning, subdivision	Y, stand alone ordinance	Y, stand alone ordinance	Y, stand alone ordinance	Y, stand alone ordinance			
Resource/Rural Lands		n/a	n/a			n/a	n/a				N, but need it			n/a
Permit Processes	**X - denotes that permit process exists, no assumption made on compliance**													
Conditional Uses	X	X	X	n/a	X	X	X	X	X	X	X	X	X	X
Variances	X	X	X		X	X	X	X	X	X	X	X	X	X
Exemptions	X	X	X		X	X	X	X	X	X	X	X	X	X
Substantial Development	X	X	X			X	X	X	X	X	X	n/a	n/a	n/a
Approach/Access	X	X	X			X	X	X	X	X	X	X	X	X

Policy/Program/Regulation	CURRENT STATUS													
	Y - adopted and compliant with current/pending requirements				X - adopted but not compliant with current requirements				blank - does not exist					
	Okanogan County (municipalities on waters with listed species are in italics)													
		Oroville	*Tonasket*	*Riverside*	Conconully	*Omak*	*Okanogan*	*Brewster*	*Pateros*	*Twisp*	*Winthrop*	Nespelem	Elmer City	Coulee Dam
	1964	1995	1995	None	2000	2004	1995	1995	1992	1991	1996	1994		2000
Septic	Okanogan County Health District	If permitted - approval by Okanogan County Health District	X	If permitted - approval by Okanogan County Health District	If permitted - approval by Okanogan County Health District	If permitted - approval by Okanogan County Health District	If permitted - approval by Okanogan County Health District	If permitted - approval by Okanogan County Health District	If permitted - approval by Okanogan County Health District	If permitted - approval by Okanogan County Health District	If permitted - approval by Okanogan County Health District	X	X	X
Subdivision/Platting/Planned Development/Binding Site Plans	X	X	If permitted - approval by Okanogan County Health District		X	X	X	X	X	X	X			X
Utility Connections		X	X	X	X	X	X	X	X	X	X	X	X	X
R-O-W permits	X	X	X											
Hydraulics Permits*	JARPA	JARPA	JARPA		?	JARPA	JARPA	JARPA	JARPA	JARPA	JARPA			
Water Quality Modification*	As per comments on permits	As per comments on permits	As per comments on permits			As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits			
Corps Permits*	As per comments on permits	As per comments on permits	As per comments on permits	?		As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits			
Water Rights*	As per comments on permits	As per comments on permits	As per comments on permits	?		As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits	As per comments on permits			
* - state or federal permit, local government may be initial point of contact or need review/action by state or federal agency prior to issuance of local government approvals.														
Compliance Program	**Y - position with clear land use authority exists, X - position exists, no clear land use authority, blank - no position**													

Policy/Program/Regulation	CURRENT STATUS													
	Y - adopted and compliant with current/pending requirements				X - adopted but not compliant with current requirements				blank - does not exist					
	Okanogan County (municipalities on waters with listed species are in italics)													
		Oroville	*Tonasket*	*Riverside*	Conconully	*Omak*	*Okanogan*	*Brewster*	*Pateros*	*Twisp*	*Winthrop*	Nespelem	Elmer City	Coulee Dam
	1964	1995	1995	None	2000	2004	1995	1995	1992	1991	1996	1994		2000
Code Enforcement/Compliance Position		Y Building Official/permit admin	Y Building Official/permit admin	N	X Town Superintentent	Y Building Inspector	X Building Inspector	Y Building Inspector	Y Building Inspector	X Planning dept/Sheriff	X Planning dept/police	?	?	X Building Dept./Planner
			Y Building Official/permit admin											
Environmental Review														
SEPA	X, 1995	Y, 2001	X, 1985	?		?	Updated in ordinance 2001							
NEPA	as required	as required	as required	as required	as required	as required	as required	as required	as required	as required	as required	as required	as required	as required

The review and analysis also included a limited review of the Colville Tribes and PUD's in the region. These entities also having plans, programs and regulations that closely relate to those of the other local governments in the region. Table 5 provides a summary of the review.

Table 5 Status of the Colville Tribe's and PUD's efforts to comply with state and federal requirements related to land use planning, regulation, management, compliance and environmental review

Policy/Program/Regulation	**Entity/Status**			
	Colville Tribes	**Douglas PUD**	**Chelan PUD**	**Okanogan PUD**
	The Confederated Tribes of the Colville Reservation are not subject to the same planning requirements as the local governments in the Upper Columbia Region. As a sovereign nation, the CCT have developed policies, programs and regulations, based in part on federal law.	**While PUDs are not required to prepare comprehensive plans in the same manner as other units of local government, all three utilities engage in forms of planning similar to those listed below. Chelan and Douglas PUDs have more developed comprehensive planning programs due to Federal Energy Regulatory Commission licenses and re-licensing processes and the Mid-Columbia Habitat Conversation Plan.**		
Land Use Comprehensive Plan (Elements):				
Land Use Element	The Tribes are presently working on a strategy to develop comprehensive plans for each of the four Business Council Districts. The first District subject to the planning process will be the Omak District. A team of Eastern Washington University Students conducted background research several years ago.	n/a*	n/a*	n/a*
Capital Facilities Element		n/a*	n/a*	n/a*
Utilities Element		n/a*	n/a*	n/a*
Rural Areas Element		n/a	n/a	n/a
Transportation Element		n/a	n/a	n/a
Urban Growth Area Element (gma?)	n/a	n/a*	n/a*	n/a*
Lands for Public Purpose and Open Space Corridors Element	n/a	n/a*	n/a*	n/a*
Economic Development Element	The Tribes have a Comprehensive Economic Development Strategy (CEDS) document that Is updated annually	n/a*	n/a*	n/a*

Policy/Program/Regulation	Entity/Status			
	Colville Tribes	**Douglas PUD**	**Chelan PUD**	**Okanogan PUD**
Parks and Recreation Element		n/a*	n/a*	n/a*
Water Comp Plan	n/a	?	?	n/a
Wastewater Comp Plan	n/a	?	?	n/a
Stormwater Management Plan	n/a	n/a	n/a	n/a
Solid Waste Management Plan	n/a	n/a	n/a	n/a
Road Management and Abandonment Plan	n/a	n/a	n/a	n/a
Watershed Plans	The CCT has an array of management plans for timber, wildlife, ater resources etc… which together provide policy and management strategies for lands within the reservation	n/a	n/a	n/a
Implementing Regulations				
Zoning	The CCT has a land use code adopted in 1993	n/a	n/a	n/a
Subdivision/Platting		n/a	n/a	n/a
Development Standards		n/a*	n/a*	n/a*
Planned Development		n/a	n/a	n/a
Critical Areas	The CCT is not subject to requirements of RCW 36.70A regarding classification, designation and protection of critical areas.	n/a	n/a	n/a

Policy/Program/Regulation	Entity/Status			
	Colville Tribes	Douglas PUD	Chelan PUD	Okanogan PUD
Flood Damage Prevention		n/a	n/a	n/a
Clearing and Grading		n/a	n/a	n/a
International Building Code	Y, Adopted 2004	n/a	n/a	n/a
Shoreline Master Program	The CCT adopted a Shoreline Management Plan in 199_. The Plan is modeled after the State Shoreline Management Act but includes all rivers, lakes and streams on the Reservation.	n/a	n/a	n/a
Administrative Procedures	Y	n/a*	n/a*	n/a*
Resource/Rural Lands		n/a	n/a	n/a
Permit Processes				
Conditional Uses	The Tribes have a provision for Special Property Uses that is similar to Conditional uses as well as a variety of other permit processes that closely mirror those found in off-reservation jurisdictions.	n/a	n/a	n/a
Variances		n/a	n/a	n/a
Exemptions		n/a	n/a	n/a
Substantial Development		n/a	n/a	n/a
Approach/Access		n/a	n/a	n/a
Septic		n/a	n/a	n/a
Subdivision/Platting/Planned Development/Binding Site Plans		n/a	n/a	n/a

Policy/Program/Regulation	Entity/Status			
	Colville Tribes	Douglas PUD	Chelan PUD	Okanogan PUD
Utility Connections		X	X	X
R-O-W permits				
Hydraulics Permits*	The Tribes have their own hydraulics, water quantity and water quality programs.	n/a	n/a	n/a
Water Quality Modification*		n/a	n/a	n/a
Corps Permits*		n/a	n/a	n/a
Water Rights*				
* - state or federal permit, local government may be initial point of contact or need review/action by state or federal agency prior to issuance of local government approvals.				
Compliance Program				
Code Enforcement/Compliance Position	Y	n/a	n/a	n/a
Environmental Review				
SEPA	The Tribes have their own environmental review process modeled after NEPA	As required	As required	As required
NEPA		As required	As required	As required

Recommendations:

Table 6 A summary of the recommendations resulting from this review

Policy/Program/Regulation		
	General Actions	**General Timelines**
Land Use Comprehensive Plans (Elements):	The Growth Management Act (36.70A.130 as amended) requires Comprehensive Plans to be reviewed and revised every 10 Years. Otherwise, amendments to the Plan are limited to once each year and are subject to a proscribed process and potential appeal to the Eastern Washington Growth Management Hearings Board (except Okanogan County and communities which are not required to fully plan under GMA).	
Land Use Element	Review and revise goals, policies and planned land uses as appropriate to be compliant with applicable State and/or Federal statutes	These Elements are subject to annual review.
Capital Facilities Element	Review and revise goals and policies for construction of capital facilities as appropriate to ensure protection of identified critical areas	
Utilities Element	Review and revise goals and policies for construction of utilities as appropriate to ensure protection of identified critical areas	
Rural Areas Element	Review and revise goals, policies for rural development as appropriate to ensure protection of identified critical areas	
Transportation Element	Review and revise goals, policies and planned transportation projects as appropriate to ensure protection of identified critical areas	
Urban Growth Area Element (gma?)	Review and revise goals, policies and planned growth areas as appropriate to ensure protection of identified critical areas	
Lands for Public Purpose and Open Space Corridors Element	Review and revise goals, policies and planned public and open space lands as appropriate to ensure protection, restoration or enhancement of identified critical areas	
Economic Development Element	Review and revise goals, policies and planned economic development efforts as appropriate to ensure protection of identified critical areas	

Policy/Program/Regulation		
	General Actions	**General Timelines**
Parks and Recreation Element	Review and revise goals, policies and planned recreation facilities as appropriate to ensure protection of identified critical areas	
Water Comp Plan	Review and revise goals, policies and system operations to be compliant with applicable State and/or Federal statutes	Water Comprehensive Plans are required to updated every 6 years (RCW 70.119A RCW) for systems with over 1,000 service connections, or in conformance with the cycle of updates required by the state Department of Health or Department of Ecology, whichever is sooner.
Wastewater Comp Plan	Review and revise goals, policies and system operations as appropriate to be compliant with NPDES permit and other applicable State and/or Federal statutes	Wastewater Comprehensive Plans are required to updated every 6 years - RCW 90.48
Stormwater Management Plan	Review and revise goals, policies and system operations as appropriate to be compliant with applicable State and/or Federal statutes	Stormwater Management Plans are required to updated every 6 years - RCW 90.48.40
Solid Waste Management Plan	Review and revise goals, policies and system operations as appropriate to be compliant with applicable State and/or Federal statutes	Solid Waste Management Plans are required to updated every 5 years - RCW 70.95 .110
Road Management and Abandonment Plan	Counties should consider development of local plans as well as implementation of best management practices in their road maintenance operations	Local Governments may review and revise or prepare new regulations at any time.

Policy/Program/Regulation		
	General Actions	**General Timelines**
Watershed Plans	Each Water Resource Inventory Area has the option of pursuing preparation of a Watershed Plan. The Wenatchee, Entiat, Methow and Okanogan watersheds are all involved with Watershed planning and all but the Okanogan (initiated in 2004) are well along in the plannning process.	Preparation of Watershed Plans under state statute involves a four phase process that can consume up to a half dozen years or longer. Since the process is locally driven with timelines established through grant contracts, and the differences in approach result in no firm timeline for plans within the Upper Columbia Region.
Implementing Regulations		
Zoning	Review and revise regulations as appropriate to ensure protection of identified critical areas	Local Governments may review and revise local land use regulations as required to address citizen petitions for amendments or as directed by resolution of elected bodies or appointed planning commissions.
Subdivision/Platting	Review and revise regulations as appropriate to ensure protection of identified critical areas	
Development Standards	Review and revise regulations as appropriate to ensure protection of identified critical areas	
Planned Development	Review and revise regulations as appropriate to ensure protection of identified critical areas	
Critical Areas	Review and revise regulations as appropriate to be compliant with applicable State and/or Federal statutes - State law requires critical areas regulations to be reviewed and revised using best available science by September 2006.	Local Governments have until 2007 to rev iew and revise Critical Areas regulations to include Best Available Science
Flood Damage Prevention	Review and revise regulations as appropriate to be compliant with applicable State and/or Federal statutes	Changes to Federal and State flood hazard statutes over the past few years has resulted in the need for local governments to update their programs to reflect such changes.

Policy/Program/Regulation		
	General Actions	**General Timelines**
Clearing and Grading	Review and revise, adopt regulations to ensure protection of identified critical areas	Local Governments may initiate public review and adoption procedures for establishing stand alone clearing and grading regulations or adopt appropriate sections of the IBC at anytime.
International Building Code	Review and revise regulations as appropriate to be compliant with applicable State and/or Federal statutes	Most local governments in the region have adopted the IBC.
Shoreline Master Program	Review and revise regulations as appropriate to be compliant with applicable State and/or Federal statutes	All local governments with shoreline areas within their jurisdiction are required to update their Shoreline Master Program to reflect new state requirements by 2014. Okanogan and Douglas Counties have been approved for funding to create regional programs in cooperation with incorporated municipalities. These new programs will be completed in 2007.
Administrative Procedures	Review and revise regulations as appropriate to be compliant with applicable State and/or Federal statutes and to ensure all developments are reviewed for potential impacts to critical areas	Local Governments may initiate public review and adoption of administrative procedures at anytime.
Resource/Rural Lands	Review and revise regulations to ensure protection of identified critical areas	Subject to annual review
Permit Processes		
Conditional Uses	Review and revise regulations as appropriate to be compliant with applicable State and/or Federal statutes and to ensure all developments are reviewed for potential impacts to critical areas	Local governments generally conduct an annual review of ordinances timelines and n umber of hearings set by State statute, local governments may amend local codes as often as needed.and codes that provide a basis for permit processes. Beyond limitations on
Variances		
Exemptions		
Substantial Development		
Approach/Access		
Septic		

Policy/Program/Regulation		
	General Actions	**General Timelines**
Subdivision/Platting/Planned Development/Binding Site Plans		
Utility Connections		
R-O-W permits		
Hydraulics Permits*	Review and revise application review procedures as appropriate to ensure that WDFW is notified and their concerns addressed for projects that require work near or below the ordinary-high-water-mark	State process, subject to legislative action and agency rule-making.
Water Quality Modification*	Review and revise application and review procedures as appropriate to ensure that Ecology is notified and their concerns addressed for projects that require work near or below the ordinary-high-water-mark	
Corps Permits*	Review and revise application and review procedures as appropriate to ensure that the Corps is notified and their concerns addressed for projects that require work near or below the ordinary-high-water-mark	Federal process, subject to congressional action and agency rule-making.
Water Rights*		State process, subject to legislative action and agency rule-making.
* - state or federal permit, local government may be initial point of contact or need review/action by state or federal agency prior to issuance of local government approvals.		
Compliance Program		
Code Enforcement/Compliance Position	If no such position and budget exists or if position exists, seek long term funding to ensure ongoing enforcement of existing plans, regulations and codes.	Local governments can create such a position at anytime, however the primary issue is budgetary. A code enforcement/compliance program not only requires staff to function as code enforcement/compliance officiers, but also budget for prosecution of cases if necessary.
Environmental Review		
SEPA	Review and revise regulations as appropriate to be compliant with	Local governments may amend their SEPA regulations

Policy/Program/Regulation		
	General Actions	**General Timelines**
	applicable State statutes	at any time.
NEPA	NEPA is a federal statute that local government must follow depending on the project and funding source. No local government action needed.	n/a

Appendix E

Inventory of Management Programs

Table 1 Inventory of management programs, sponsors or agencies, area affected by the programs, goal of the programs, and a determination whether the program affects the viability of spring Chinook, steelhead, and bull trout in the Upper Columbia River basin (inventory is from Golder Associates 2004). Threats were determined by assessing if the programs affect the biology of the fish or their environment

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Water Management Program	Bonneville Power Administration	Upper Columbia Basin	Establish prescriptions that apply to watershed mitigation projects	Supports—Should improve aquatic and riparian habitats
Pollution Prevention and Abatement Program	Bonneville Power Administration	Upper Columbia Basin	Coordinate the management and disposal of wastes generated as a result of BPA work practices	Supports—Prevents pollutants and wastes from entering aquatic habitats.
Natural Resources Program	Chelan and Okanogan Counties	Upper Columbia Basin	Administer watershed planning and salmon recovery efforts in the basin.	Supports—Improves watershed condition and supports recovery of listed species.
Conservation Easement Program	Chelan County	Wenatchee and Entiat Subbasins	Implement conservation easements to protect riparian habitat and long-term agricultural leases.	Supports—Improves and protects riparian areas along salmon bearing streams.
Growth Management Habitat Protection Plan	Chelan County	Wenatchee and Entiat Subbasins	Adopt a comprehensive plan and regulations that protect riparian areas, wetland, floodplains, hazardous areas, aquifer recharge zones, and fish and wildlife habitat	Supports—Protects aquatic habitat for fish.
Water Conservation Loan Program	Chelan County and Okanogan Conservation District	Wenatchee and Entiat Subbasins	Provide incentives to install water-efficient irrigation systems.	Supports—Improves instream flow conditions for fish.
Conservation Reserve Program	NRCS	Agricultural croplands and farms in Douglas County	Reduce soil erosion on upland habitats through establishment of perennial vegetation on cropland	Benign—Should have little to no effect on habitat conditions in streams.
Conservation Innovation Grants	Douglas County	Agricultural croplands and farms in Douglas County	Voluntary program intended to stimulate the development and adoption of conservation approaches and technologies in environmental enhancement and protection	Benign—Should have little to no effect on habitat conditions in streams.

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Environmental Quality Incentives Program	NRCS	Agricultural croplands and farms in Douglas County	Provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and natural resource concerns.	Benign—Should have little to no effect on habitat conditions in streams.
Conservation Securities Program	NRCS	All agricultural operations on private croplands, rangeland, pasture land, and orchards in Douglas County	Voluntary program providing financial reward to eligible agricultural operations for stewardship and enhancement practices and activities	Benign—Should have little to no effect on habitat conditions in streams.
Watershed Management Act (2514)	Chelan, Douglas, and Okanogan Counties and Conservation Districts	WRIAs 40a, 44, 45, 46, 48, 49, and 50	Enables the development of planning units that conduct watershed planning and recommend management strategies.	Supports—Should improve aquatic habitat conditions for fish.
Critical Areas Ordinances (CAO)-Wetlands Chapter 19.18B	Chelan, Douglas, and Okanogan Counties	County building and development but not agricultural practices	Prevent cumulative adverse environmental effects on water quantity and quality, groundwater, wetlands, and rivers and streams.	Supports—Should protect aquatic habitat conditions for fish.
CAO-Fish and Wildlife Conservation Chapter 19.18B	Chelan, Douglas, and Okanogan Counties	County building and development but not agricultural practices	Protect unique, fragile, and valuable elements of the environment.	Supports—Should protect aquatic habitat conditions for fish.
CAO-Frequently Flooded Areas Chapter 15.48B	Chelan, Douglas, and Okanogan Counties	County building and development but not agricultural practices	Promotes public health, safety, and welfare by minimizing public and private losses due to flood conditions.	Benign/Threaten—May reduce habitat diversity by reducing off-channel habitat and floodplain conditions.
CAO-Geohazards Chapter 19.18D	Chelan, Douglas, and Okanogan Counties	County building and development but not agricultural practices	Protects the general public and resources from flooding, landslides, or steep-slopes failure.	Benign/Threaten—May reduce habitat diversity by reducing off-channel habitat and floodplain conditions.
Shoreline Master Plan	Chelan, Douglas, and Okanogan Counties and Cities	All shoreline lands within the counties	New program designed to conserve and enhance anadromous fish resources.	Supports—Should protect and enhance the aquatic habitat of fish.
Road Maintenance Program	Douglas County	All county roads (excluding state and private roads) in Douglas County	Minimize erosion and sediment delivery by implementing various methods.	Benign—Should prevent increase in sediment recruitment to streams.

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Stormwater Program Chapter 19.40	Chelan and Douglas Counties	Currently applies only to a portion of East Wenatchee as a utility program in Douglas County	Establish a comprehensive approach to surface and storm-water management that protects property, water quality, aquifers, fish, and increase public education, and preserve natural drainage systems.	Supports—Should improve water quality and habitat conditions for fish.
Subdivision Title 17.04.020	Chelan, Douglas, and Okanogan Counties	Rural Counties	Establishes an exemption level of administrative review of property at 20 acres.	Benign/Threaten—At the 20 acre exemption level, no environmental review occurs. Also may lead to clustering and dividing into smaller lots along shorelines (near urban-scale density development in rural areas).
Six Year Transportation Plan	Chelan, Douglas, and Okanogan Counties	Stormwater drainage and management	Review transportation programs for consistency with the Counties Comprehensive Plans.	Supports—Should protect aquatic habitat for fish.
Douglas County Agricultural HCP	Douglas County	Agricultural croplands, farms, and ranches in Douglas County	Minimize and mitigate the incidental take of threatened and endangered species as a result of typical agricultural activities.	Supports—Should improve aquatic habitat for fish.
Upper Columbia Regional Fisheries Enhancement Group (RCW 77.95)	Chelan, Douglas, and Okanogan Counties	Upper Columbia Basin	Enhance salmon and steelhead resources, maximize volunteer efforts, assist the state with achieving their fisheries goals, and help develop project designs	Supports—Should improve habitat conditions and fish abundance in the Upper Columbia Basin
Upper Columbia Salmon Recovery Board	Chelan, Douglas, and Okanogan Counties and Colville Tribes and Yakama Nation	Upper Columbia Basin	Create an ESU-level recovery plan for ESA-listed species in the Upper Columbia Basin	Supports—Reduces threats to the abundance, productivity, spatial structure, and diversity of listed species in the Upper Columbia Basin
Salmon Recovery Planning Act (Lead Entity- 2496)	Chelan, Douglas, and Okanogan Counties, and Foster Creek Conservation District, and Colville Tribes	Upper Columbia Basin	Provides a framework for identifying limiting factors, developing, and funding restoration projects.	Supports—Should improve habitat conditions for ESA-listed species in the Upper Columbia River
Habitat Conservation Plans	Chelan and Douglas County Public Utility Districts	Upper Columbia Basin (upstream from Rock Island Dam)	Achieve “no net impact” on anadromous salmonids	Supports—Should improve survival for migrating salmonids and improve watershed conditions

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Wolf Creek HCP	Wolf Creek Reclamation District	Wolf Creek drainage	Minimize impacts to spring Chinook, steelhead, and bull trout	Supports—Should improve habitat conditions for ESA-listed species.
Chewuch River HCP	Skyline Ditch Company	Chewuch River	Minimize impacts to spring Chinook, steelhead, and bull trout	Supports—Should improve habitat conditions for ESA-listed species.
Northern Pikeminnow Population Reduction Program	Chelan, Douglas, and Grant Public Utility Districts	Mainstem Columbia River	Reduce Pikeminnow predation on smolts	Supports—Reduces loss of juveniles and smolts migrating downstream through the Columbia River
Bird Harassment Program	Chelan, Douglas, and Grant Public Utility Districts	Mainstem Columbia River	Reduce bird predation on juveniles and smolts	Supports—Reduces loss of juveniles and smolts migrating downstream through the Columbia River
Colville Hatchery Program	Colville Confederated Tribes	Upper Basin	Mitigate for fish migration blockage created by Chief Joseph Dam.	Benign/Threaten—Depending on where rainbow and brook trout are planted, they may affect the survival and viability of chinook and steelhead (and bull trout).
Omak Creek Acclimation Pond	Colville Confederated Tribes	Okanogan Subbasin	Used to acclimate summer steelhead smolts from local broodstock	Supports—Should increase numbers of summer steelhead in the Okanogan Subbasin.
Wells Hydroelectric Project Wildlife Mitigation Program	Douglas County PUD	Upper Basin	Secure, protect, and restore wildlife habitat.	Supports—Protects and restores riparian habitat.
Federal Columbia River Power System Program	NOAA Fisheries	Upper Columbia Basin	Provide biological, hydrological, and engineering expertise for review and approval of dam and reservoir operations.	Supports—Intended to improve passage success and survival of fish passing through hydro projects.
Cumulative Risk Initiative	NOAA Fisheries	Upper Columbia Basin	Provide scientifically rigorous support for salmonid conservation and recovery planning.	Supports—Intended to improve life-stage survival of fish through examination of all-Hs
Ecotoxicology and Environmental Fish Health Program and Environmental Assessment Program	NOAA Fisheries	Upper Columbia Basin	Assess the effects of human activities on the health of wild fish.	Supports—Improves understanding of contaminants of fish.

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Fish Passage Program	NOAA Fisheries	Upper Columbia Basin	Assess the effects and influences of the Columbia River hydropower system on the long-term viability of fish stocks.	Supports—Improves understanding of dam operations on survival of fish stocks.
Genetics and Evolution Program	NOAA Fisheries	Upper Columbia Basin	Evaluate how genetic processes contribute to species viability and develops genetic tools for resource management	Supports—Improves understanding of genetics and effects of actions on genetics of different fish stocks.
Salmon Harvest Program	NOAA Fisheries	Upper Columbia Basin	Provide technical expertise and develop tools for management of fish harvest	Supports—Improves understanding of harvest management.
Full Utilization Program	NOAA Fisheries	Upper Columbia Basin	Develop methods to improve fish processing.	Supports—Reduces waste released into aquatic habitats.
Integrative Fish Biology Program	NOAA Fisheries	Upper Columbia Basin	Research fish development, growth, reproduction, smolt quality, fish health, and disease	Supports—Improves understanding of the biology of fish stocks.
Mathematical Biology and Systems Monitoring Program	NOAA Fisheries	Upper Columbia Basin	Research methods to effectively monitor populations that are part of large scale environments.	Supports—Improves understanding of the status and trends of populations.
Migration Behavior Program	NOAA Fisheries	Upper Columbia Basin	Assess the effects and influences of the Columbia River hydropower system on the long-term viability of fish stocks.	Supports—Improves understanding of migration behavior of fish passing dams.
Northwest Salmon Recovery Planning Program	NOAA Fisheries	Upper Columbia Basin	Implement and plan salmon and steelhead recovery	Supports—Increases the long-term viability of listed fish stocks
Population Biology Program	NOAA Fisheries	Upper Columbia Basin	Develop the foundation for conservation and recovery efforts of listed stocks.	Supports—Implements conservation and recovery efforts for listed stocks.
Riverine Survival Program	NOAA Fisheries	Upper Columbia Basin	Assess the effects and influences of the Columbia River hydropower system on the long-term viability of fish stocks.	Supports—Increases understanding of hydropower effects on survival of fish stocks.
Salmon Enhancement Program	NOAA Fisheries	Upper Columbia Basin	Develop hatchery and cultural programs to rebuild endangered or depleted fish stocks.	Supports—Increases population abundance through the use of appropriate hatchery and cultural techniques.

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Watershed Program	NOAA Fisheries	Upper Columbia Basin	Conduct research on physical and biological processes that affect aquatic ecosystems.	Supports—Increases understanding of watershed processes.
Conservation Securities Program	Natural Resource Conservation Service	Upper Columbia Basin	Reward landowners who demonstrate good land stewardship	Supports—Should improve riparian condition and stream flows.
Conservation Technical Assistance Program	Natural Resource Conservation Service	Upper Columbia Basin	Provide conservation technical assistance to landowners and agencies on planning and natural resource conservation.	Supports—Should improve riparian condition and stream flows through conservation of resources.
Emergency Watershed Protection Program	Natural Resource Conservation Service	Upper Columbia Basin	Undertake emergency measures to protect life and property from floods, drought, and products of erosion.	Benign/Threaten—Could decrease riparian conditions and result in loss of channel complexity.
Environmental Quality Incentive Program	Natural Resource Conservation Service	Upper Columbia Basin	Provide conservation programs for farmers and ranchers.	Supports—Should improve environmental quality on farms and ranches thereby reducing negative effects to streams.
Farm and Rangeland Protection Program	Natural Resource Conservation Service	Upper Columbia Basin	Protect farm and rangeland and create an easement	Supports—Should protect riparian corridors from development
Forestry Incentives Program	Natural Resource Conservation Service	Upper Columbia Basin	Support good forest management practices on private lands	Supports—Should protect riparian habitats from timber harvest
Grassland Reserve Program	Natural Resource Conservation Service	Upper Columbia Basin	Protect range and pasture lands from development (subdivision)	Supports—Should protect riparian habitats from development
Grazing Lands Conservation Initiative	Natural Resource Conservation Service	Upper Columbia Basin	Maintain and improve management, productivity, and health of privately-owned grazing lands	Supports—Should reduce soil erosion and recruitment of fine sediments to streams.
Resource Conservation and Development Program	Natural Resource Conservation Service	Upper Columbia Basin	Accelerate resource conservation and development	Supports—Should enhance the environment, including stream and riparian habitat.
Soil Survey Program	Natural Resource Conservation Service	Upper Columbia Basin	Provide soil survey information necessary for understanding, managing, conserving, and sustaining soil resources	Supports—Should reduce soil erosion and recruitment of fine sediments to streams.

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Soil and Water Conservation Assistance Program	Natural Resource Conservation Service	Upper Columbia Basin	Provide cost share and incentive payments to farmers and ranchers to address threats to soil, water, and natural resources	Supports—Should reduce agricultural impacts to stream and riparian habitats
Snow Survey and Water Supply Forecasting Program	Natural Resource Conservation Service	Upper Columbia Basin	Provide information on future water supply.	Supports—Should provide information needed to maintain suitable stream flows
Stewardship Incentive Program	Natural Resource Conservation Service	Upper Columbia Basin	Provide technical and financial assistance to private forest landowners to keep lands and natural resources productive and healthy	Supports—Should improve riparian conditions on private lands.
Watershed Protection, Watershed Surveys, and Flood Prevention Program	Natural Resource Conservation Service	Upper Columbia Basin	Assist agencies and participants to protect and restore watersheds from erosion, floodwater, and sediments.	Benign/Threatens—Could decrease riparian conditions and result in loss of channel complexity.
Wetlands Reserve Program	Natural Resource Conservation Service	Upper Columbia Basin	Offers landowners opportunities to protect, restore, and enhance wetlands on their properties.	Supports—Should improve water quantity and quality
Wildlife Habitat Incentives Program	Natural Resource Conservation Service	Upper Columbia Basin	Provide incentives to develop and improve wildlife habitat on private lands.	Supports—Should improve riparian habitat
Conservation Loan Program	Okanogan County	Okanogan and Methow Subbasins	Promote the use of energy-efficient products and services.	Benign—Energy conservation measures for buildings should have no effect on fish and their habitats
Appliance Rebate Program	Okanogan County	Okanogan and Methow Subbasins	Provide rebates for customers that purchase energy efficient appliances	Benign—Rebates should have no effect on fish and their habitats
Abandoned Mine Land Program	Bureau of Land Management	Upper Columbia Basin	Identify and clean-up abandoned mines	Supports—Should reduce historic mining effects on fish and their habitats
Environmental Education Information	Bureau of Land Management	Upper Columbia Basin	Educate the public on environmental issues	Supports—Should improve and protect aquatic habitats through public understanding of healthy and productive ecosystems.
Federal Recreation Pass Program	Bureau of Land Management	Upper Columbia Basin	Require recreation fees in some parks, forests, wildlife refuges, and recreation areas.	Benign—Requiring fees should not harm fish and their habitats.

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Interior Columbia Basin Ecosystem Management Project	Bureau of Land Management and U.S. Forest Service	Upper Columbia Basin	Develop a scientifically sound and ecosystem-based strategy for management of forests.	Supports—Should lead to protected and improved habitat conditions for fish.
Integrated Weed Management Program	Bureau of Land Management	Upper Columbia Basin	Inventory and complete ecological assessments for noxious weeds.	Benign—Inventory and EA for weeds should not negatively affect fish and their habitats.
Land Exchange Program	Bureau of Land Management	Upper Columbia Basin	Provide for acquisition, use, disposal, and adjustment of land resources.	Supports—Should place lands supporting important fish species in public ownership.
Leave No Trace Program	Bureau of Land Management	Upper Columbia Basin	Promote responsible use of public lands to recreationists participating in human-powered activities	Supports—Should lead to activities that protect riparian habitat
Watchable Wildlife Initiative	Bureau of Land Management	Upper Columbia Basin	Provide wildlife viewing opportunities	Benign—Providing wildlife viewing opportunities should not effect fish and their habitat
Chief Joseph Dam Project	U.S. Bureau of Reclamation	Upper Columbia Basin	Provide present and future irrigation development	Benign/Threaten—Has the potential to reduce stream flows below minimum flows needed for rearing and spawning.
Okanogan Project	U.S. Bureau of Reclamation	Okanogan Subbasin	Provide present and future irrigation development	Benign/Threaten—Has the potential to reduce stream flows below minimum flows needed for rearing and spawning.
Federal Columbia River Power System Program BiOp Habitat Mitigation Program	U.S. Bureau of Reclamation	Upper Columbia Basin	Improve stream flows, channel complexity, fish passage at diversion dams, and screen diversion intakes	Supports—Should improve stream flows, habitat conditions, fish passage, and prevent loss of fish in diversions.
Research, Monitoring, and Evaluation Program	U.S. Bureau of Reclamation	Upper Columbia Basin	Develop and implement a monitoring program to assess status, trend, and effectiveness of management actions.	Supports—Provides information on the status and trend of populations and their habitats, and assesses effects of management actions.
Farm Service Agency Conservation Reserve Program	U.S. Department of Agriculture	Upper Columbia Basin	Help agricultural producers to protect environmentally sensitive lands.	Supports—Should prevent erosion and protect riparian areas.

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Advanced Hydropower Turbine Systems Program	U.S. Department of Energy	Upper Columbia Basin	Develop technology to maximize the use of hydropower resources while minimizing adverse environmental effects	Supports—Should improve survival of fish passing through turbines
Environmental Monitoring and Assessment Program	U.S. Environmental Protection Agency	Upper Columbia Basin	Assess the condition of ecological resources	Supports—Increases understanding of status and trends of populations and aquatic habitats.
Total Maximum Daily Load Program	U.S. Environmental Protection Agency	Upper Columbia Basin	Specify the maximum amount of a pollutant that a water body can receive and still meet water quality standards.	Supports—Improves and maintains water quality
Fish and Wildlife Assistance Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Restore and maintain the health of fish and wildlife resources	Supports—Should improve habitat conditions and population health
Partners for Fish and Wildlife Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Assist private landowners restore wetlands and other important fish and wildlife habitats	Supports—Should improve habitat conditions and population health
Fishery Resource Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Provide policy guidance, budget, planning, oversight, and coordination of diverse activities.	Supports—Should help improve habitat conditions
Entiat National Fish Hatchery Program	U.S. Fish and Wildlife Service	Entiat Subbasin	Produce and release spring chinook and coho salmon into the Entiat River	Threaten—Depending on the stock of chinook released, the program can threaten the viability of wild spring chinook (see Factors for Decline)
Winthrop National Fish Hatchery Program	U.S. Fish and Wildlife Service	Methow Subbasin	Produce and release spring chinook, summer steelhead, and coho salmon into the Methow River	Supports/Threatens—Supports abundance but may threaten diversity.
Leavenworth National Fish Hatchery Program	U.S. Fish and Wildlife Service	Wenatchee Subbasin	Produce and release spring chinook and coho salmon into the Wenatchee River	Threatens—Depending on the stock of chinook released, the program can threaten the viability of wild spring chinook (see Factors for Decline)
Hatchery Assessment Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Conduct production planning, marking, monitoring, and post-stocking evaluations for National Fish Hatcheries	Supports—Increases understanding of status and trends of hatchery fish

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Native American Tribal Assistance Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Work with tribes to conserve and manage fish and wildlife resources on Tribal lands and ceded territories	Supports—Should protect and improve aquatic habitat conditions on Tribal lands
Habitat and Population Evaluation Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Conduct surveys to describe fish populations and other aquatic organisms and their habitats	Supports—Increases understanding of fish populations and their habitats
Conservation Assessment Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Conduct analytical evaluations of stock assessments, extinction probabilities, and develop sound biological and technical recovery strategies	Supports—Should improve habitat conditions and population health
Water Management and Evaluation Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Coordinate and manage flow conditions in the Columbia Basin	Supports—Should improve habitat conditions by increasing stream flows
Fish and Wildlife Mitigation Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Advocate fish and wildlife habitat needs within the basin	Supports—Should protect and restore aquatic habitat conditions
Information, Education, and Outreach Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Promote public stewardship of fish and wildlife resources and foster support for conservation through outreach strategies.	Supports—Should protect and restore aquatic habitat conditions and lead to wise use of resources
Partners in Flight Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Manage and conserve neotropical birds	Benign—Managing neotropical birds should have no effect on fish and their habitats
Conservation Planning Program	U.S. Fish and Wildlife Service	Upper Columbia Basin	Work with private landowners, local and state governments, corporations and others to conserve and protect listed and unlisted species on non-Federal lands	Supports—Should protect and improve aquatic habitat conditions on non-Federal lands
PACFISH/INFISH Program	U.S. Forest Service	Upper Columbia Basin	Develop an ecosystem-based aquatic habitat and riparian-area management strategy	Supports—Should protect and improve stream and riparian habitat conditions
Pacific Northwest Fisheries Program	U.S. Forest Service	Upper Columbia Basin	Develop programs to protect riparian reserves, protect key watersheds, and to restore watershed health.	Supports—Should protect and improve stream and riparian habitat conditions
Respect the River Program	U.S. Forest Service	Upper Columbia Basin	Restore and preserve riparian and flood prone areas and balance those needs with public needs	Supports—Should protect and restore riparian areas

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Northwest Forest Plan	U.S. Forest Service	Upper Columbia Basin	Restore and maintain the ecological health of watersheds within the range of the northern spotted owl	Supports—Should improve aquatic and riparian habitat
National Streamflow Information Program	U.S. Geological Survey	Upper Columbia Basin	Provide long-term, accurate, and unbiased streamflow information	Supports—Monitoring streamflows will increase understanding of flow regimes
Lake Chelan National Recreation Area Forest Fuel Reduction/Firewood Management Plan	U.S. National Park Service	Chelan Subbasin	Reduce forest fuel accumulation in selected timber stands in the Stehekin Valley	Benign—Reducing fuel accumulation in the Stehekin Valley should have no effect on chinook and steelhead and their habitat in the Upper Columbia region
Lake Chelan NRA Management Plan	U.S. National Park Service	Chelan Subbasin	Manage visitor use, natural and cultural resources, development, and operation of the Lake Chelan Natural Recreation Area	Benign—Management of the Lake Chelan NRA should have no effect on chinook and steelhead and their habitat in the Upper Columbia region
Mountain Lake Fisheries Management Plan	U.S. National Park Service	Upper Columbia Basin	Develop and implement a conservation planning and environmental impact analysis process for mountain lake fisheries in the North Cascades National Park Service Complex	Benign—Conservation planning for mountain lake fisheries should have no effect on chinook and steelhead and their habitat in the Upper Columbia region
Columbia River Regional Initiative/Water Resource Program	Washington State Department of Ecology	Upper Columbia Basin	Develop an integrated state program for managing water resources--to allow access to new water withdrawals while providing support for salmon recovery	Benign/Supports—Should allow for water withdrawal without harming the survival of salmon and steelhead
Environmental Assessment Program	Washington State Department of Ecology	Upper Columbia Basin	Provide objective, reliable information about environmental conditions used to measure effectiveness of the program and to inform the public	Supports—Should increase understanding of status and trends of aquatic resources
Flood Control Assistance Program	Washington State Department of Ecology	Upper Columbia Basin	Work in partnership with communities to support healthy watersheds and promote environmental interests	Supports—Should preserve and improve aquatic habitat conditions

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Water Quality Program	Washington State Department of Ecology	Upper Columbia Basin	Protect, preserve, and restore water quality	Supports—Should improve habitat conditions by protecting and restoring water quality
Water Resource Program	Washington State Department of Ecology	Upper Columbia Basin	Manage watersheds, administer water rights, and restore and maintain stream flows.	Supports—Should improve aquatic and riparian habitat
Columbia River Instream Resource Protection Program	Washington State Department of Ecology	Upper Columbia Basin	Insure the future viability of instream resource values of the mainstem Columbia River, including fish, wildlife, aesthetics, navigation, and hydropower resource values	Supports—Should improve the habitat characteristics of the mainstem Columbia River
Trust Water Rights Program	Washington State Department of Ecology	Upper Columbia Basin	Develop and test means to facilitate the voluntary transfer of water and water rights, including conserved water, to provide water for presently unmet and emerging needs	Supports—If water is transferred back to streams with flows less than minimum levels for salmon and steelhead.
Water Acquisition Program	Washington State Department of Ecology	Upper Columbia Basin	Increase stream flows in watersheds with vulnerable salmon and trout populations	Supports—Increases stream flows in important watersheds
Aquatic Education Program	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Educate the public on environmental and salmon issues	Supports—Should help improve and protect fish and their habitats
Aquatic Habitat Guidelines Program	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Develop technical assistance guidance for those who want to protect and restore salmonid habitat	Supports—Should protect and restore aquatic and riparian habitats
WDFW Hatcheries Program	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Mitigate for chinook, steelhead, and sockeye salmon lost by the operations of Upper Columbia dams	Supports/Threatens—Supports abundance but may threaten diversity. Based on current operations and use of brood stock, this program should increase the production of chinook and steelhead in the Upper Columbia region (See Reasons for Decline)
Hydraulic Approval Program	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Regulate activities that affect the bed or flow of waters for the protection of fish life	Supports—Should protect aquatic habitat conditions

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Lead Entity Program	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Solicit, develop, prioritize, and submit habitat protection and restoration projects for funding to the Salmon Recovery Funding Board	Supports—Should protect and restore aquatic habitats
Nature Mapping Program	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Promote biodiversity studies through citizens and school-based data collection and research	Supports—Should preserve and protect fish and their habitats
Priority Habitats and Species Program	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Provide comprehensive information on important fish, wildlife, and habitat resources	Supports—Should increase understanding and proper management of fish and their habitats
Salmonid Stock Inventory Program	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Identify and monitor the status of salmonid fish stocks	Supports—Increases understanding of the status and health of salmonids
Salmon and Steelhead Habitat Inventory and Assessment Program	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Characterize freshwater and estuary habitat conditions and distributions of salmonid stocks	Supports—Increases understanding of the status and distribution of salmonids and their habitats
Watershed Recovery Inventory Project	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Develop a comprehensive inventory of watershed restoration projects and watershed information	Supports—Increases understanding of watershed processes and restoration projects
Wildlife Research	Washington State Department of Fish and Wildlife	Upper Columbia Basin	Conduct scientific investigations of priority wildlife species and habitats	Benign—Wildlife research should not effect salmon and steelhead in the Upper Columbia region
Aquatic Lands Enhancement Account	Washington State Department of Natural Resources	Upper Columbia Basin	Invest in projects that enhance and protect wildlife and fish habitat	Supports—Should improve aquatic and riparian habitat
Washington Natural Heritage Program	Washington State Department of Natural Resources	Upper Columbia Basin	Collect data and develop strategies for protection of native ecosystems and species most threatened	Supports—Should protect and restore aquatic and riparian habitats and threatened species
Washington State Natural Areas Program	Washington State Department of Natural Resources	Upper Columbia Basin	Protect the best remaining examples of many ecological communities and outstanding examples of native ecosystems, habitat for listed species, and scenic landscapes	Supports—Should protect important aquatic and riparian habitats from future development

Management Program	Sponsor/Lead Agency	Area affected by Program	Goal of the Program	Does the Program Support or Threaten ESA Species?
Agriculture, Fish and Water Program	Washington State Conservation Commission	Upper Columbia Basin	Negotiate changes to the existing Technical Guide and develop guidelines to be used to enhance, restore, and protect habitat for endangered fish and wildlife species	Supports—Should protect and restore aquatic and riparian habitats
Conservation Reserve Enhancement Program	Washington State Conservation Commission	Upper Columbia Basin	Provide incentives to restore and improve salmon and steelhead habitat on private lands	Supports—Should improve aquatic and riparian habitat on private lands
Salmon Habitat Limiting Factors	Washington State Conservation Commission	Upper Columbia Basin	Assess the habitat-based factors limiting the success of salmonids	Supports—Should increase understanding of limiting factors
Wetland and Fish and Wildlife Activities	Washington State Department of Transportation	Upper Columbia Basin	Maintain or implement activities that limit or reduce impacts to fish and wildlife and their habitats	Supports—Activities should improve connectivity and reduce sediment delivery to channels
State Parks Program	Washington State Parks and Recreation Commission	Upper Columbia Basin	Acquire, operate, manage, enhance, and protect a diverse system of recreational, cultural, historical, and natural sites	Supports—Should protect and enhance aquatic and riparian habitats
Coho Salmon Reintroduction Program	Yakama Indian Nation	Upper Columbia Basin	Assess the feasibility of re-establishing coho salmon in tributaries to the Upper Columbia River	Benign/Threatens—The reintroduction of coho should have little to no effect on production of chinook and steelhead (see Factors for Decline)

Appendix F1

Upper Columbia Salmon Recovery Plan

Analysis of Habitat Actions Using EDT

F.1 Wenatchee EDT Diagnosis
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EDT Model Input
Analysis of Model Output
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F.5 EDT Scenario Results and Comparison to VSP

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F.5.2 Entiat Spring Chinook

F.5.3 Methow Spring Chinook

F.5.4 Wenatchee Steelhead

F.5.5 Entiat Steelhead

F.5.6 Methow Steelhead

F.5.7 Okanogan Steelhead

F.6 EDT Sensitivity in the Wenatchee Subbasin

F.6.1 Contributions of Select Environmental Attributes to Fish Performance

F.6.2 Interactions of Environmental Attribute Ratings and Action Effectiveness

F.6.3 Action Class Effects to Scenario Results

F.1 Wenatchee EDT Diagnosis

F.1.1. Background

This section of Appendix F represents the "diagnosis" portion of EDT for the Wenatchee subbasin. The diagnosis portion of EDT was completed during subbasin planning in the Methow and Okanogan subbasins, but only a qualitative assessment had been completed in the Wenatchee (NPPC 2004). Both the diagnosis and treatment portions of EDT were completed in the Entiat (for spring and summer Chinook) as part of the watershed planning process (CCCD 2004). Therefore, the first step in using EDT as a habitat assessment tool for recovery planning in the Upper Columbia ESU was to complete the baseline environmental attribute ratings for the Wenatchee subbasin.

F.1.2 Methods

The Wenatchee Subbasin habitat was assessed using the Ecosystem Diagnosis and Treatment (EDT) method; EDT is an analytical model relating habitat features and biological performance to support conservation and recovery planning for salmonids (Lichatowich et al. 1995; Lestelle et al. 1996; Lestelle et al. 2004). EDT acts as an analytical framework that brings together information from empirical observation, local experts, and other models and analyses.

The Information Structure and associated data categories were defined at three levels of organization. Together, these can be thought of as an information pyramid in which each level builds on information from the lower level (**Figure F1**). As information in EDT moved up through the three levels, it took an increasingly organism-centered view of the ecosystem. Levels 1 and 2 together characterized the environment, or ecosystem, as it can be described by different types of data. This provides the characterization of the environment needed to analyze biological performance for a species. The Level 3 category is a characterization of that same environment from a different perspective: "through the eyes of the focal species" (Lestelle et al. 1996). This category describes biological performance in relation to the state of the ecosystem described by the Level 2 ecological attributes.

The organization and flow of information begins with a wide range of environmental data (Level 1 data) that describe a watershed, including all of the various types of empirically based data available. These data include reports and unpublished data. Level 1 data exist in a variety of forms and pedigrees. The Level 1 information is then summarized or synthesized into a standardized set of attributes (Level 2 ecological attributes) that refine the basic description of the watershed. The Level 2 attributes are descriptors that specify physical and biological characteristics about the environment relevant to the derivation of the survival and habitat capacity factors for the specific species in Level 3. Definitions for Level 2 and Level 3 attributes can be found along with a matrix showing associations between the two levels and various life stages (Lestelle et al. 2004).

The Level 2 attributes represent conclusions that characterize conditions in the watershed at specific locations, during a particular time of year (season or month), and for an

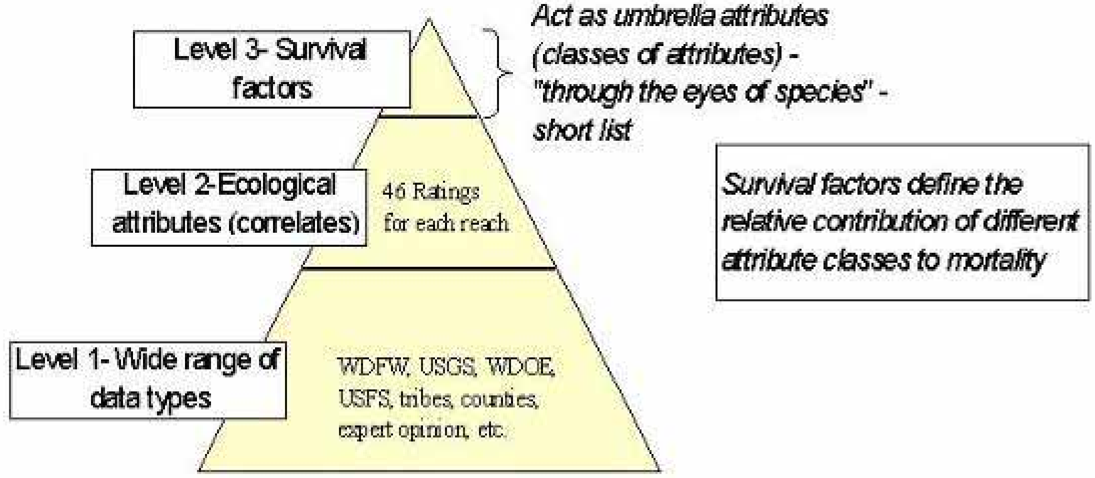


Figure F1. Data/information pyramid—information derived from supporting levels for use in the Ecosystem Diagnosis and Treatment model (Figure taken from Lestelle et al. 2004)

associated management scenario. Hence an attribute value is an assumed conclusion by site, time of year, and scenario. These assumptions become operating hypotheses for these attributes under specific scenarios. Where Level 1 data are sufficient, these Level 2 conclusions can be derived through simple rules. However, in many cases, experts were needed to provide knowledge about geographic areas and attributes where Level 1 data are incomplete. Regardless of the means whereby Level 2 information is obtained, the characterization it provides can be ground-truthed and monitored over time through an adaptive process.

The EDT model measured salmon/steelhead performance using 3 indicators; abundance, productivity, and life history diversity. Abundance (adults and smolts) was the equilibrium abundance based on the capacity of the watershed that was a measure of the habitat quantity. Productivity, or density-independent reproductive rate (returning adults per spawner), was a measure of the habitat quality. Life history diversity was the range of distributions and pathways that can be used successfully by a population. The life history diversity index in EDT output was reported as a percent of current life history trajectories that were successful, relative to the template potential (For more detail on EDT output parameters see documentation at www.mobrand.com).

EDT Model Input

To perform the assessment we first structured the entirety of the relevant geographic areas, including marine waters, into distinct habitat reaches. The Wenatchee drainage was subdivided into 119 stream segments (reaches) and 23 obstructions within the estimated historic range of each focal species. A stream reach was a segment of river in which environmental, anthropogenic, and biological attributes affecting the focal species were relatively constant. We identified reaches on the basis of similarity of habitat features, drainage connectivity, and land use patterns; some of the primary factors that influenced reach breaks included mainstem inundation, focal species bearing tributaries, obstructions to passage, changes in confinement (valley width), gradient, hydraulic roughness, dewatering reaches, thermal gradients, gross changes in riparian condition or channel form, urban-rural interface, and hatchery release points. Such a detailed reach structure, however, was counterproductive for displaying results and implementing a management plan. Therefore the reaches and obstructions were grouped into 18 larger geographic areas or assessment units (**Table F1**). In most cases, the assessment units corresponded to subwatersheds but were occasionally split into upper and lower portions of a watershed so that an AU strategy and plan could be easily described and implemented based on common problems and common solutions (**Table F1**). A set of standard habitat attributes and reach breaks developed by MBI were used for the mainstem Columbia River, estuarine, nearshore, and deep-water marine areas (www.mobrand.com). We then assembled baseline information on habitat and human-use factors and fish life history patterns for the watersheds of interest. This task required that all reaches be completely characterized by rating the 46 level 2 environmental attributes.

An obstruction was a structure (or multiple structures) that prevented fish passage in one or both directions (upstream or downstream). Obstruction complexes were designated when multiple culverts, diversions, or other barriers were in close proximity to avoid having excessive reach breaks in the model (**Table F2**). By lumping multiple barriers into complexes we were able to apply environmental attribute data at the appropriate scale and still capture the cumulative effects of the multiple barriers. Ten of the 23 obstructions were complexes with 2-28 barriers in each complex. The cumulative effect of the complex was applied at the lowest (downstream) obstruction.

Table F1 Reaches for EDT modeling based on historic (WDFW salmonscape) distribution of Wenatchee River steelhead and spring Chinook

Assessment Unit	Reach Codes	Location/Description
Lower Wenatchee Mainstem	Wen1-13	From Confluence with Columbia to Tumwater Canyon (RM 27)
Mission Ck	Miss1-7, Bren1-2, Sand1-3,LCam1-2, EFMiss1-2	Mission Creek to RM 16.3; Brender Ck to RM 2.8; Sand Ck to RM 3.1; Little Camas Creek to RM 1.7; East Fork of Mission Ck to RM 4.35
Lower Peshastin Ck	Pesh1-5, Mill1-2,Hans1	Peshastin Ck to RM 9.6; Mill Ck to RM 2.3; Hansel Ck to RM 0.25
Upper Peshastin Ck	Pesh6-9; Inga1-3;Ruby 1; Negro1; Tron1	Peshastin Ck to RM 9.6-16.3; Ingals Ck to RM 9.8; Ruby Ck to RM 1.5; Negro Ck to RM 2.9; Tronsen Ck to RM 1
Derby Ck	Derby1-2	Derby Ck to RM 3.2
Chumstick Ck	Chum1-3; Eagle1	Chumstick Ck to RM 5.9; Eagle Ck to RM 1
Lower Icicle Creek	Icic1-4	Icicle Creek to RM 5.6 (the boulder field)
Upper Icicle Creek	Icic5-11; Eightmile1, Jack1, French1	Icicle Ck from RM 5.6-24; Eightmile Creek to RM 0.39; Jack Ck to RM 1.2; French Ck to RM 0.66

Assessment Unit	Reach Codes	Location/Description
Tumwater Canyon	Wen14-16	Wenatchee River from the downstream end of Tumwater Canyon to the mouth of Chiwaukum Ck (RM 36)
Chiwaukum/Skinney Ck	Chiwaukum1-3; Skin1-2	Chiwaukum Creek to RM 4.3; Skinney Ck to RM 1.3
Upper Wenatchee Mainstem	Wen17-19	Wenatchee River from Chiwaukum Ck to Lake Wenatchee (RM 36-54)
Beaver Ck	Beav1-2	Beaver Ck to RM 2.5
Chiwawa River	Chiwawa1-9; Clear1-2; Bmeadow1; Twin1; Chik1; Rock1; Phel1	Chiwawa River to RM 35; Clear Ck to RM 1; Big Meadow Creek to RM 1.5; Twin Ck to RM 0.7; Chikamin Ck to RM 1; Rock Ck to RM 1.2; Phelps Ck to RM 0.5
Lower Nason Ck	Nas1-2; Coult1-3; Roar1	Nason Creek to Gaynor Falls (RM 17); Coulter Ck to RM 1.1; Roaring Ck to RM 0.75
Upper Nason Ck	Nas3-7	Gaynor Falls to Bygone Byway Falls (RM 17-21)
Lake Wenatchee	Wen20	Lake Wenatchee
Little Wenatchee	LitWen1-4	Little Wenatchee River to Falls at RM 7.8
White River	White1-4; Napee1, Panther1	White River to falls at RM 14.3; Napeequa River falls at RM 2.2; Panther Ck to RM 0.7

Table F2 Obstruction reaches for EDT modeling of Wenatchee steelhead and spring Chinook. Passage was estimated for each species and lifestage for both upstream and downstream orientation

Assessment Unit	Obstruction Codes	Location/Description
Lower Wenatchee Mainstem	None	None
Mission Ck	Bren1a	Obstruction Complex (18 structures) beginning with culvert at Kimber Rd. (rm 0.2)
	Miss3a	Miller Diversion Dam
	Miss4a	Triple Culvert just below Sand ck
	Sand1a	USFS culvert barriers at RM 1 and 1.29
	LCam1a	USFS barrier @ 0.8 mi
	EFMiss1a	7 culvert complex
Lower Peshastin Ck	Pesh1a	PID diversion @ RM 2.4
	Pesh2a	Tandy diversion
	Mill1a	Barrier complex including 2 diversion dams and 2 culverts
Upper Peshastin Ck	Ruby 1a	Culvert complex (3 culverts at rm 0.04, 0.64, and 1.48)
Derby Ck	Derby1a	Barrier complex (7 private fish blocking culverts then 4 USFS culverts)
Chumstick Ck	Chum1a	North Rd culvert
	Chum2a	Barrier complex (28 structures, culverts and diversions)

Assessment Unit	Obstruction Codes	Location/Description
Lower Icicle Creek	Icic1a	Leavenworth National Fish Hatchery
	Icic3a	Hatchery and Cascade Orchards Irr. Dist. Diversion
	Icic4a	Boulder field
	Icic4b	Icicle/Peshastin Irrigation diversion
Upper Icicle Creek	None	None
Tumwater Canyon	Wen14a	Tumwater Dam
Chiwaukum/Skinney Ck	Skin1a	Obstruction complex, beginning with FS Rd 7908 culvert (2 culverts and a mill pond)
Upper Wenatchee Mainstem	None	None
Beaver Ck	Beav1a	Barrier complex (6 culverts, starting at RM 0.3)
Chiwawa River	Clear1a	Culvert at RM 0.6
Lower Nason Ck	Coult1a	Complex: 2 obstructions at the mouth and 2 culverts at Rm 0.04
	Nas2a	Gaynor Falls at Rm 16.8
Upper Nason Ck	None	None
Lake Wenatchee	None	None
Little Wenatchee	None	None
White River	None	None

A habitat work group (Habitat Coordinating Committee; HCC) rated the Level 2 habitat attributes for the freshwater stream reaches within the Wenatchee subbasin and consisted of biologists from WDFW, USFWS, USFS, Yakama Nation, Chelan County, and several environmental consulting firms (Habitat Coordinating Committee). The work group drew upon published and unpublished data and information for the basin to complete the task. Expert knowledge about habitat identification, habitat processes, hydrology, water quality, and fish biology was incorporated into the process where data was not available. Protocol for rating attributes was taken from "Attribute Ratings Guidelines" (January 2003 revision) and "Attribute ratings Definitions" (January 2003); written and distributed by MBI (www.mobrand.com). In addition, MBI personnel were available for consultation and assistance with rating some attributes when local resources were not sufficient. The patient/current condition attribute ratings represent a variety of sources and levels of proof . Levels of proof (or confidence levels) assigned to ratings are directly from developed rating methods by MBI specifically for the EDT process. The attributes assigned to each reach are assigned a numerical value from 1 to 5 where: 1 is empirical observation; 2 is expansion of empirical observation; 3 is derived information; 4 is expert opinion; 5 is hypothetical. A brief description of the methods and the distribution of the confidence levels assigned to attributes are presented in **Table F3**. The template (reference) conditions were either a default, where level of proof was not applicable, or they were determined by expert opinion from within the HCC or other contributors to the EDT process that were solicited for participation by the HCC.

The estimate of template conditions represent an approximation of historic conditions that was intended to calibrate the model to the range of conditions that could naturally occur in the Wenatchee basin given the prevailing climatic, geologic, geographic, hydrologic, and biological characteristics. The objective of the diagnosis then became identifying the relative contributions of environmental factors to the reduction of focal species performance. The comparison of these scenarios (current and template) formed the basis for diagnostic conclusions about how the Wenatchee watershed and associated salmonid performance have been altered by human development. To accomplish this, we performed two types of analyses, the first to identify environmental attributes that were limiting the diversity, productivity and abundance of each species and the second to rank and prioritize the assessment units based on their importance for protection or restoration.

The final step in setting up the model was to define the life history characteristics of each population. Once the reaches and their habitat conditions were defined we needed to inform the model about the how, when, and where to move fish through the environment. The information that was used to accomplish this can be found in Tables F4 and F5.

Table F3 Environmental attributes, percent frequency in each Level of Proof category for 119 reaches, and a description of the data sources and abbreviated methods for EDT in the Wenatchee subbasin

Environmental Attribute	Level of Proof	Data Sources and Comments
Alkalinity	1) 3% 2) 26% 3) 71%	Data from WDOE watershed monitoring sites were used and extrapolated to reaches within a sub-watershed and the average was applied to other sub-watersheds without monitoring data and classified as derived.
Bed Scour	3) 100%	No empirical data existed for bed scour in the Wenatchee basin. EDT values for bed scour were derived using a multiple regression equation developed in the Yakima basin. Variables included gradient, hydroconfinement, LWD, % pools, fine sediment, high flow, and flow flashy with an r^2 of 0.77. Bed scour estimates were then adjusted to an index value of 2 in known core spawning areas of steelhead and spring Chinook and this correction factor was applied to all other bed scour estimates. Finally, bed scour was given an index score of 4 in all areas over 8% gradient.
Benthic Community Richness	1) 0% 2) 0% 3) 0% 4) 0% 5) 100%	Although WDOE collects the data that could provide B-IBI scores it was not available for inclusion in the model. We assumed that there was some impairment from nutrient reductions from small salmon runs and increased sediment. Benthic community richness was considered a critical data gap that needs more monitoring and research.
Channel Length	1) 100%	Channel length was measured in Terrain Navigator Pro and was considered empirical data for all reaches.
Channel Width Maximum	1) 76% 2) 5% 3) 0% 4) 18%	USFS habitat surveys on federal lands and WDFW surveys of mainstem Wenatchee River.

Environmental Attribute	Level of Proof	Data Sources and Comments
Channel Width Minimum	1) 74% 2) 4% 3) 0% 4) 21%	USFS habitat surveys on federal lands and WDFW surveys of mainstem Wenatchee River.
Confinement Man-Caused	3) 100%	Road encroachment on the floodplain was measured in Archview using the PBI road and transportation corridor layer and the riparian zone layer. Encroachment was measured in linear distance along the stream channel and this ratio was used to determine % hydroconfinement. We did not account for rip-rap and dikes, but those structures should be fairly well correlated with roads in the riparian corridor. In several relatively undisturbed watersheds (upper Icicle, Upper Nason, Chiwawa, White, and Little Wenatchee) we reduced the impact of road encroachment by 75% because road placement generally does not effect channel migration. However, the LFA (2000) report identified channelization and agriculture as contributing to loss of floodplain in the lower reaches of the White and Little Wenatchee Rivers. This report did not provide quantified estimates so we assumed that 50 % of the stream channel was confined.
Confinement Natural	1) 12% 2) 0% 3) 88%	Evaluated valley width using Terrain Navigator Pro and the Channel Migration Zone study for the mainstem and lower Nason Creek
Dissolved Oxygen	1) 4% 2) 25% 3) 0% 4) 71% 5) 0%	Used data from 5 WDOE watershed monitoring stations and USGS gauging stations. The data from these sites was expanded to other reaches within a subwatershed . We assumed that there was no DO problems in other areas since the subwatersheds with no monitoring are at higher elevations and generally contain cool clean water.
Embedded-ness	3) 100%	Used information from the USFS SMART database and summaries of USFS data reported in the LFA (2000).
% Fines	1) 6% 2) 5% 3) 4% 4) 85%	Used USFS SMART database for areas that had been surveyed and the LFA 2000 report that summarized some information at the sub-watershed scale. Information was generally lacking and not organized or presented in a way that would allow for much confidence in applying it to EDT. Given the effect of sediment on spawning and incubation this is a critical data gap that needs further analysis across the subbasin.
Fish Community Richness	3) 100%	Rated by local biologists and sources of information were not well documented. Future efforts should refine this attribute rating using USFS, USFWS, and WDFW fisheries survey data.
Pathogens	1) 0% 2) 4% 3) 66% 4) 30%	No studies exist for ambient pathogen levels. Derived via WDFW pathology reports, proximity to hatcheries, acclimation ponds, and release sites. Assumed historic stocking occurred in all drainages.
Fish Species Exotic	2) 100%	Rated by local biologists and sources of information were not well documented. Future efforts should refine this attribute rating using USFS, USFWS, and WDFW fisheries survey data.

Environmental Attribute	Level of Proof	Data Sources and Comments
Flow High	3) 100%	Gauging station data showed no trends, no high flow measurements are available for pre-development so we used road density (USFS data base) as an indicator to scale the EDT score between a 2 and 3. Confirmed with USFS hydrologists that this was the appropriate scale that road density would change runoff patterns.
Flow Low	1) 0% 2) 0% 3) 98% 4) 0%	Wenatchee Watershed Assessment, 2003. Some data derived from using acres of irrigated lands in relation to crop irrigation requirements.
Flow Diel Variation	1) 100%	Rock Island Pool effect in inundated reach. No other hydroelectric projects so this attribute is not applicable to the rest of the basin.
Flow Flashy	3) 100%	Gauging station data showed no trends, no high flow measurements are available for pre-development so we used road density (USFS data base) as an indicator to scale the EDT score between a 2 and 3. Confirmed with USFS hydrologists that this was the appropriate scale that road density would change flashy runoff patterns.
Gradient	1) 100%	Measured in Terrain Navigator Pro.
Habitat: Backwater-Pools; Large Cobble Riffles; Pool- Tailouts; Small Cobble-Riffles; Glides; Beaver Ponds; Primary-Pools;	1) 17% 2) 0% 3) 60% 4) 13% 5) 11%	**Wenatchee mainstem**: measurements for each habitat type (stream segment) were recorded with a laser rangefinder while floating the river on a raft. This method did not follow a standard protocol, however, no protocols were known for non-wadeable rivers. **Tributaries:** Pool and riffle data were generally available throughout much of the basin from USFS surveys in the last 10 years (SMART database). Survey data for pools and riffles were split into the 8 habitat categories based on Neiman classification available for all reaches from GIS layers from a classification analysis (PBI 2005). This transformation included assumptions about the composition of habitat segments in each Neiman class (see appendix X for details). In general, pools were split up into primary pools and pool tailouts in either (75:25) or (90:10) ratios. Likewise, riffles were split into small cobble/gravel riffles (0-40%), large cobble/boulder riffles (50-100%), glides (0-5%), and backwater pools (0-5%) based on Neiman classification and additional substrate information from USFS SMART database and Mullen et al. (1992).
Offchannel Habitat	3) 100%	Empirical assessments of offchannel habitat (oxbows, back swamps, riverine ponds, and connectivity channels) were not available for most areas in the Wenatchee basin. Therefore, we derived the proportion of offchannel habitat for current and historic conditions by applying a matrix of percentages of offchannel habitat that depended on the gradient and natural confinement within each.
Harassment	3) 100%	Used Terrain Navigator Pro to evaluate proximity to towns and roads.
Hatchery Fish Outplants	1) 70% 2) 0% 3) 0% 4) 30% 5) 0%	Stocking records and locations provided by WDFW, Yakama Nation, and USFWS
Hydrologic Regime Natural	1) 0% 2) 0% 3) 100%	In consultation with USFS hydrologist, reviewed the USFS subsection classification maps and the Hydrolic properties and responses map. Also evaluated flow patterns from USGS gauging stations.

Environmental Attribute	Level of Proof	Data Sources and Comments
Hydrologic Regime Regulated	1) 100%	This attribute was only applicable in reach Met1 (Rock Island Pool effect).
Icing	5) 100%	No data exists; we assumed that a min temp score < 3 = icing score of 1; Min temp 3-3.5 = Icing score 2; and Min temp score > 3.5 = icing score of 3. Winter temperatures, flows, and icing are an important data gap so we wanted to stress our uncertainty by categorizing the level of proof as "hypothetical" instead of "expert opinion".
Metals in Water Column	1) 0% 2) 0% 3) 100%	Derived or extrapolated from the WDOE website data or data collected by the CCCD.
Metals in Soils/ Sediment	4) 100%	Derived or extrapolated from the WDOE website data or data collected by the CCCD
Miscellaneous Toxins	1) 5% 2) 19% 3) 37% 4) 39%	Derived or extrapolated from the WDOE website data or data collected by the CCCD
Nutrients	3) 100%	Derived or extrapolated from the WDOE website data or data collected by the CCCD
Obstructions	NA	Obstructions were assessed individually and level of proof was not evaluated as it was for other attributes in standard reaches. Most of the obstructions had been surveyed but uncertainties still existed for some species/lifestages.
Predation Risk	3) 100%	Rated by local biologists and sources of information were not well documented. Future efforts should refine this attribute rating using USFS, USFWS, and WDFW fisheries survey data.
Riparian Function	3) 100%	Derived based on altered and unaltered riparian zone habitat types from PBI data layer 2004; see separate worksheet for details. C. Baldwin & M.Cookson. This method needs reviewed and cross referenced with recent studies (CMZ) and USFS stream surveys and biological assessments;
Salmon Carcasses	1) 0% 2) 56% 3) 44%	Wenatchee Hatchery Evaluation data, used average of 02 & 03 Used Mullen et al. (1992) for historic run re-creation. Some of the estimates did not make sense with very low numbers of carcasses, even historically. This attribute should be re-evaluated in conjunction with updating the benthic macro-invertebrate attribute with B-IBI scores. Then LOP scores for surveyed areas should be updated to 1 (empirical).
Temperature Maximum	1) 29% 2) 37% 3) 6% 4) 20% 5) 8%	USGS gauging stations (n=7); USFS temperature loggers (n=12); WDFW thermisters (n=5); expansions were made to adjacent reaches within a subwatershed and opinion was used to apply temperature patterns to other subwatersheds that were not monitored.
Temperature Minimum	1) 5% 2) 24% 3) 5% 4) 66% 5) 0%	USGS gauging stations (n=1), WDFW Thermisters n=5. These data were extrapolated to other reaches in the mainstem and within the subwatersheds. Most WDOE and USGS data sets were not helpful because they were not continuously logged.

Environmental Attribute	Level of Proof	Data Sources and Comments
Temperature Spatial Variation	1) 39% 2) 0% 3) 34% 4) 24% 5) 3%	FLIR analysis for the Wenatchee Mainstem, Chiwawa and Nason Ck. Other areas were estimated based on geomorphic change, IFIM video, and DNR aerial photos.
Turbidity	1) 0% 2) 33% 3) 0% 4) 67% 5) 0%	Used USGS gauging stations and WDOE monitoring sites to estimate the SEV and expanded to other subwatersheds based on opinion.
Withdrawals	3) 100%	WDOE GWIS data (2003). Not considered empirical because a comprehensive gravity and pump diversion inventory and assessment has not been completed. Most reaches were rated as a 1 or 2 (see attribute rating guidelines) but the results showed little or no effects.
Woody Debris	1) 0% 2) 0% 3) 83% 4) 17% 5) 0%	USFS habitat surveys (interpreted from the SMART database); WDFW surveys (mainstem). Although we had empirical estimates of pieces per mile in 83% of the reaches this information is not directly transferable into an EDT score. Also, high wood counts can be misleading if its small or isolated pieces that are not important to channel form or function or fish use. We had to generate categories of functioning conditions for wood in the Wenatchee based on wood levels in highly functional areas.

Table F4 Life history assumptions used to model spring Chinook in the Wenatchee River.

Stock Name:	Wenatchee River Spring Chinook
Race:	Spring
Geographic Area (spawning reaches):	Mission Ck (historic; RM 0-12); Peshastin Ck (RM 0-16); Ingals Ck; Icicle Ck (historic; RM 0-5); Chiwaukum Ck; Wenatchee R mainstem (RM 35-54), Chiwawa R. (RM 0-35), Nason Ck (0-17), Little Wenatchee River (RM 3-8), White River (RM 7-14).
River Entry Timing (Columbia R): Fish passage center	Bonneville Dam: March 1 – June 30 April 8: 10% April 24: 50% May 19: 90% Rock Island Dam: April 1 – July 15 April 30: 10% May 14: 50% June 2: 90%
River Entry Timing (Wenatchee): Tumwater Dam Video counts (1999-2003)	Tumwater Dam: May 9- August 22 June 23: 10% July 19: 50% August 14: 90%
Spawn Timing:	August 1- September 15 (peak August 31)

Stock Name:	**Wenatchee River Spring Chinook**	
Emergence Timing (dates):	February 15 to March 30	
Juvenile Life History:	Ocean type:	0%
	Stream type: Resident rearing: *Transient Rearing	100% 70% 30%
Stock Genetic Fitness:	85%	
Harvest (in basin):	0%	
Age Structure: (From scale analysis of carcass recoveries) WDFW data base	Age 3 (1.1) = 1.7% Age 4 (1.2) = 68.8% Age 5 (1.3) = 29.5%	
Fecundity:	Average = 4608 eggs/female	

*Transients move to the mainstem Wenatchee as subyearlings, residents remain in tributaries and migrate as yearlings. Subyearling fall migrants averaged 39% from the Chiwawa River (1993-2002; WDFW unpublished data). However, no data exists for other tributaries so to be conservative we modeled 30%.

Table F5 Life history assumptions used to model summer steelhead in the Wenatchee River.

Stock Name:	**Wenatchee River summer steelhead**
Geographic Area : (reaches with current and historic spawning):	Mission Ck (and tribs), Peshastin Ck. (and tribs), Derby Ck., Chumstick Ck, Eagle Ck, Icicle Ck (and tribs), Chiwaukum Ck (and Skinney Ck), Wenatchee R mainstem (RM 35-54), Beaver Ck, Chiwawa R (and tribs), Nason Ck. (including Coulter and Roaring), Little Wenatchee R., White R. (and tribs).
River Entry Timing (Columbia R.) : (Fish Passage Center website; however, we cannot use their numbers directly because they do not sample 100 % of the run timing)	Bonneville Dam: March-December June 30: 10% Aug. 15: 50% (peak, 40% of total pass in August) Oct. 1: 90% Rock Island Dam: April-February July 15: 10% Sept. 15: 50% (peak, 40% of total pass in September) Nov. 1: 90%
River Entry Timing (Wenatchee): (PUD radio telemetry; Tumwater Dam; Dryden Dam)	July to March; (peak October 15) 90% by November 30
Adult Holding: (PUD radio telemetry;	Columbia River: 50% Wenatchee R.: 50%
Spawn Timing:	Feb 15-June 15 (peak April 18)

Stock Name:	**Wenatchee River summer steelhead**	
Spawner Ages: Wild fish collected at Dryden and Tumwater Dams (1998-2003)	1-salt = 50.8% 2-salt = 48.8% 3-salt = 0.4%	
Emergence Timing :	May 28-August 6; mean July 2	
Smolt Ages: Wild fish collected at Dryden and Tumwater Dams (1998-2003)	age-1 = 3.8% age-2 = 69.5% age-3+ = 26.7%	
Juvenile Overwintering: No data exists	Columbia River:	25%
	Wenatchee Basin:	75%
Stock Genetic Fitness:	85%	
In-Basin Harvest:	0%	
Mean Fecundity: WDFW Broodstock	5913 eggs / female	

Analysis of Model Output

The first analysis considered conditions within individual stream reaches and identified the most important factors contributing to a loss in performance at specific life stages (1-12) corresponding to each reach. This analysis, called the Stream Reach Analysis, identified the survival factors (classes of Level 2 environmental attributes) that, if appropriately moderated or corrected, would produce the most significant improvements in overall fish population performance. The stream reach analysis identified the factors that should be considered in planning habitat restoration projects. Reach analysis tables (EDT consumer reports tables) were used to determine primary and secondary limiting factors within each Assessment Unit; this detailed information, specific to the Wenatchee basin analysis can be found at (www.mobrand.com/edt/NWPCC/index.htm).

We relied on the strategic priority summary, which was provided by the EDT software and integrated across the reaches and life stages within each AU to summarize limiting factors at the larger scale.

The second analysis was conducted across geographic areas (assessment units) relevant to populations, where each geographic area typically encompassed many reaches. This analysis, called the *Assessment Unit Analysis*, identified the relative importance of each area for either restoration or protection actions. In this case, we analyzed the effect of either restoring or further degrading of environmental conditions on population performance. These results were available in unscaled output. The unscaled output estimated the total potential for increase or decrease (due to restoration or protection actions) within an assessment unit, regardless of its length relative to other assessment units. Unscaled output showed us the critical areas for restoration and protection, regardless of size or efficiency of applying restoration action.

Priority Assessment Units

We evaluated the restoration and protection priorities separately for each species by categorizing the EDT output into 3 prioritization categories (Primary, Secondary, Tertiary). Although EDT provides quantitative output and ranks each assessment unit, we believed there was too much uncertainty in this first draft EDT assessment to rely on the absolute prioritization provided by the model. To establish the categories, we evaluated the fish performance increases (with restoration) or potential decreases (without protection) in two ways, 1) summing the percent increase or decrease across all three performance measures, 2) averaging the percent increase or decrease across all three performance measures and 3) averaging the ranks across all 3 performance measures. We presented and used all three summary methods because we did not believe that we had enough justification at this time to conclude that one method was the "right way" to analyze the results.

F.1.2. Results

Stream Reach Analysis

Wenatchee Spring Chinook.—When reach and life stage specific limiting factors were summed within the AU's, Habitat Diversity, Obstructions, Sediment Load, Temperature, Flow, and Key Habitat Quantity were primary limiting factors in one or more AU's (**Figure F2**). Secondary factors included competition with hatchery fish, channel stability, harassment, food, and predation. In several assessment units the interpretation was that there were no "primary" limiting factors because the habitat was in good condition and EDT confirmed that the degradations that were present were not having a "high" impact to fish survival. These assessment units included Tumwater Canyon, Upper Wenatchee Mainstem, Chiwaukum Ck, Chiwawa River, White River, and Little Wenatchee River (**Figure F2**). For a complete interpretation of the primary limiting factors and causal mechanism within each subwatershed refer to the recovery matrix (**Table 5.7**). A reach level assessment of each survival factors influence on 12 specific life stages can be downloaded from www.mobrand.com. An example of one of the 119 reach reports is shown in **Figure F3**. The first Peshastin Creek reach was selected to illustrate why flow (water quantity) was selected as a primary limiting factor even though it did not get a "high" rating on the strategic priority summary. The strategic summary report (**Figure F2**) indicated "low" impacts to spring Chinook in the lower Peshastin Creek assessment unit, however the reach report indicated that key habitat quantity was a limiting factor to 10 of the 12 life stages and that temperature was a limiting factor for spawning. Reduced key habitat quantity was caused by reduced flow decreasing minimum widths and artificial confinement simplifying the channel. Additionally, reduced flow was assumed to be a contributing factor to increased temperatures. Therefore, we concluded that water quantity in the Lower Peshastin Creek assessment unit should be classified was a primary limiting factor (**Table 5.7**).

Wenatchee steelhead.— When reach and life stage specific limiting factors were summed within the AU's, Flow, Habitat Diversity, Obstructions, Sediment Load, and Key Habitat Quantity were primary limiting factors in one or more AU's (**Figure F4**). Secondary factors included channel stability, competition with hatchery fish, food, harassment, predation, and temperature. In several assessment units the interpretation was that there were no "primary" limiting factors because the habitat was in good condition and EDT confirmed that the degradations that were present were not having a "high" impact to fish survival. These assessment units included Tumwater Canyon, Upper Wenatchee Mainstem, Chiwaukum Ck, Chiwawa River, White River, and Little Wenatchee River (**Figure F2**). For a complete interpretation of the primary limiting factors and causal mechanism within each subwatershed refer to the recovery matrix (**Table 5.7**). A reach level assessment of each survival factors influence on 12 specific life stages can be downloaded from www.mobrand.com.

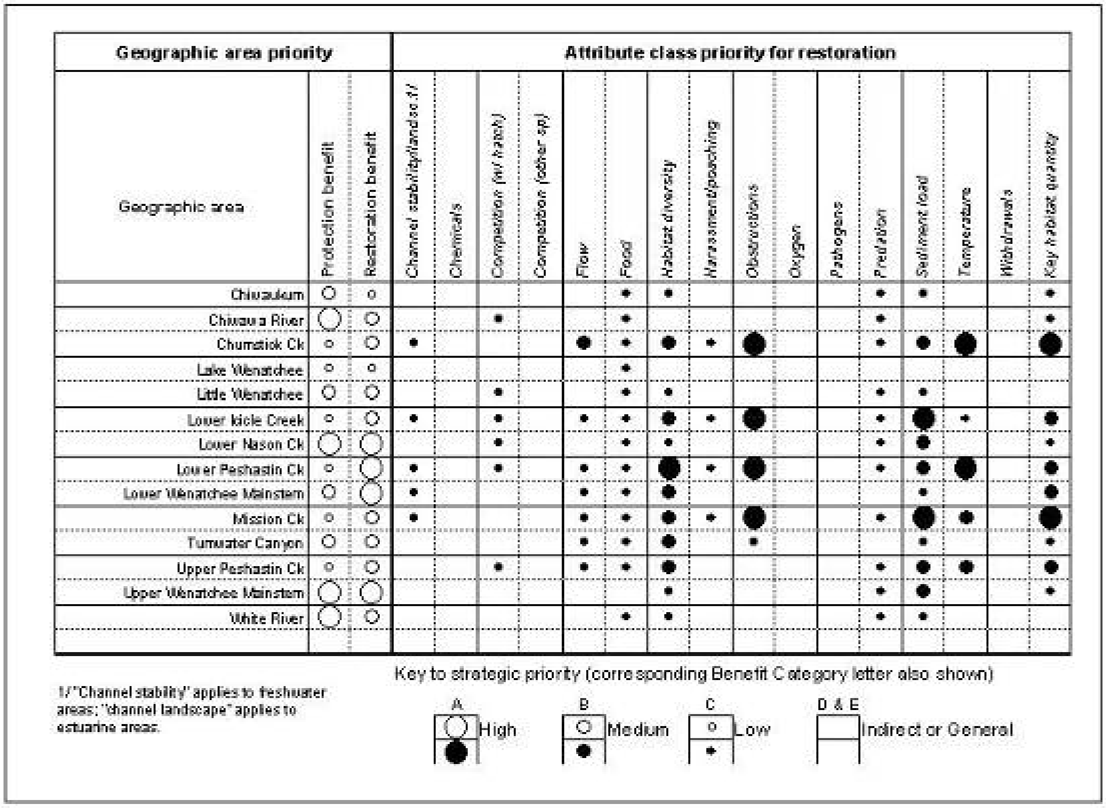


Figure F.2. EDT strategic priority summary for Wenatchee spring Chinook.

Species/Component:	Spring Chinook
Restoration Potential:	Current Conditions versus Historic Potential
Restoration Emphasis:	Restoration or maintenance/improvement of historic life histories

Wenatchee Spring Chinook May 2005 - Spring Chinook

Geographic Area:	Lower Peshastin Ck	Stream:	Peshastin Ck
Reach:	Peshastin Ck. Confluence to PID diversion @ RM 2.4	Reach Length (mi):	2.40
		Reach Code:	Pesh1

Restoration Benefit Category: 1/	A	Productivity Rank: 1/	9	Potential % change in productivity: 2/	0.0%
Overall Restoration Potential Rank: 1/	3	Average Abundance (Neq) Rank: 1/	3	Potential % change in Neq: 2/	17.0%
(lowest rank possible - with ties) 1/	11	Life History Diversity Rank: 1/	1	Potential % change in diversity: 2/	20.7%
Preservation Benefit Category: 1/	C	Productivity Rank: 1/	12	% loss in productivity with degradation: 2/	0.0%
Overall Preservation Rank: 1/	9	Average Abundance (Neq) Rank: 1/	12	% loss in Neq with degradation: 2/	-1.7%
(lowest rank possible - with ties) 1/	10	Life History Diversity Rank: 1/	10	% loss in diversity with degradation: 2/	-0.5%

Life stage	Relevant months	% of life history trajectories affected	Productivity change (%)	Life Stage Rank	Change in attribute impact on survival: Channel stability	Chemicals	Competition (w/ hatch)	Competition (other sp)	Flow	Food	Habitat diversity	Harassment/poaching	Obstructions	Oxygen	Pathogens	Predation	Sediment load	Temperature	Withdrawals	Key habitat quantity
Spawning	Sep	1.5%	-47.4%	3							●	•			·	●		⬤		●
Egg incubation	Sep-Apr	1.5%	-43.9%	5	•												●			●
Fry colonization	Mar-May	4.6%	-19.6%	2	•			·	•	•	●					·	·			●
0-age active rearing	Mar-Oct	6.2%	-12.7%	4	·		•			·	•				·	·		·		●
0-age migrant	Oct-Nov	2.4%	-2.5%	7							•					·				●
0-age inactive	Oct-Mar	0.5%	-35.6%	6	•				·	•	●						•	·		●
1-age active rearing	Mar-May	0.5%	-6.3%	8			·		·	·	•									●
1-age migrant	Mar-Jun	3.4%	-0.3%	9							•					·				●
1-age transient rearing																				
2+-age transient rearing																				
Prespawning migrant	Apr-Aug	12.6%	-0.1%	10							•	·								●
Prespawning holding	May-Sep	1.5%	-65.0%	1					•		●	·				•		•		●
All Stages Combined		12.6%																		

1/ Ranking based on effect over entire geographic area. 2/ Value shown is for overall population performance.

Notes: Changes in key habitat can be caused by either a change in percent key habitat or in stream width.
Potential % changes in performance measures for reaches upstream of dams were computed with full passage allowed at dams (though reservoir effects still in place).

KEY

NA = Not applicable

	Loss	Gain
None		
Small	·	°
Moderate	•	∘
High	●	○
Extreme	⬤	◯

Figure F.3. Reach report for one of the reaches (Pesh1) in the Lower Peshastin Creek assessment unit. For details and descriptions of the life stages and survival factors go to www.mobrand.com.

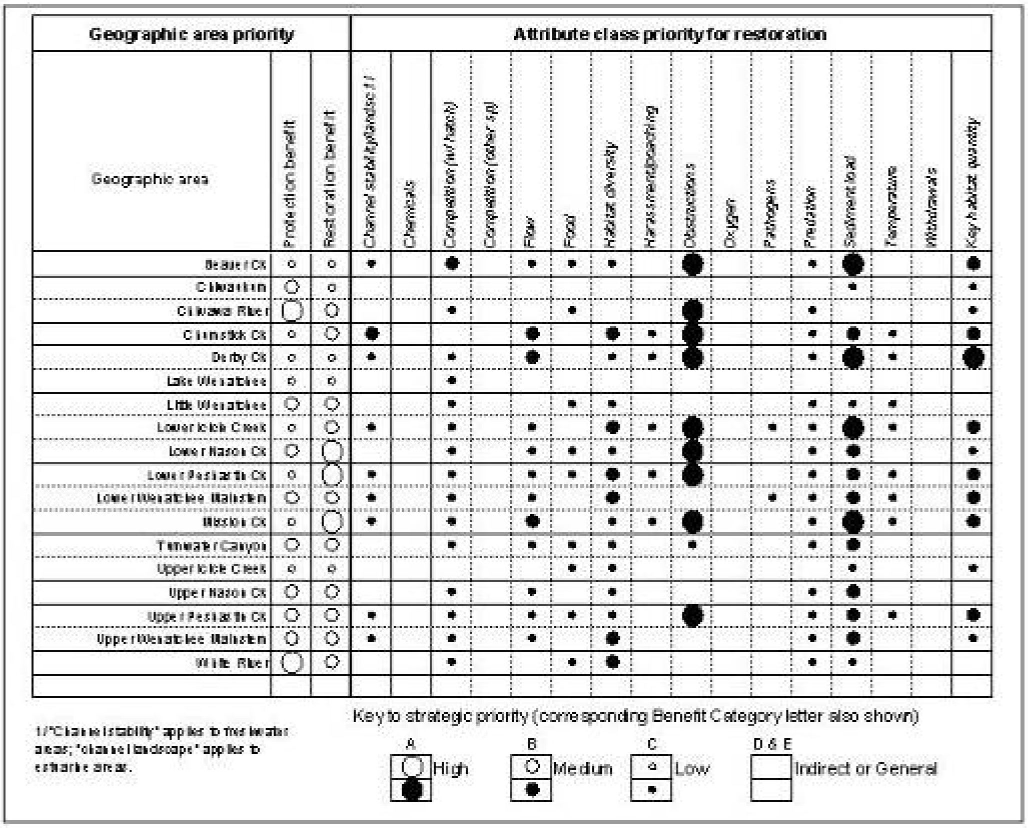


Figure F.4. EDT strategic priority summary for Wenatchee steelhead.

Priority Assessment Units

Spring Chinook.— The top assessment units for restoration benefits to spring Chinook were the Upper Wenatchee Mainstem, Lower Nason Creek, Lower Peshastin Creek, and the Lower Wenatchee Mainstem based on average rank and the sum of the restoration potential across the 3 performance measures (diversity index, productivity, and abundance)(**Table F6**). The high priority of the mainstem Wenatchee River AU's was primarily due to their contribution to abundance. We modeled a 50:50 resident:transient life history strategy which meant that 50% of the fry and parr left their natal streams and reared to smolt stages in the mainstem Wenatchee. This was consistent with empirical data that showed an average of 39% (range 17-74 %; 1993-2002) of the Chiwawa River smolts left the Chiwawa River as subyearling migrants (WDFW unpublished data). The inclusion of the Upper Wenatchee mainstem as a top restoration priority was somewhat unexpected since the strategic priority summary did not identify any primary limiting factors in this AU. We concluded that the quantity of habitat in this AU was so large compared to other AU's that the small restoration potential in individual environmental attributes was adding up to relatively large potential increases in performance. Similarly, the Chiwawa and White Rivers ranked relatively high for restoration benefit to productivity, even though they are thought to be in relatively pristine conditions. Again, we concluded that the small degradations to individual environmental attributes was adding up to relatively large potential increases because these areas had large quantities of critical spawning and rearing habitat. These conclusions were supported by the protection priorities because the Chiwawa and White Rivers and the Upper

Wenatchee Mainstem were 3 of the top 4 assessment units for protection (**Table F7**). Lower Nason Creek was also in the top benefit category for protection, in addition to being a high priority restoration AU. Other important AU's for protection included Tumwater Canyon, the Little Wenatchee River, and the Lower Wenatchee Mainstem.

Steelhead.— The top assessment units for restoration benefits to steelhead were Lower Peshastin Creek and Mission Creek, based on average rank and the sum of the restoration potential across the 3 performance measures (diversity index, productivity, and abundance)(**Table F.8**). However, 7 other assessment units were included in the benefit category A, based on summed restoration potentials over 40% (**Table F8**). It was unclear why the Upper Wenatchee Mainstem offered so much restoration potential for the diversity index (27%) and why the White River had so much restoration potential for productivity (19%). Both the White and Little Wenatchee Rivers were important for protection and restoration, though recent spawning ground surveys have revealed very little current steelhead use. No data existed to inform the model on when steelhead recruit to Lake Wenatchee, how long they stay in the lake, or what the mortality rates should be in the lake. All results and rankings relevant to the White and Little Wenatchee should be viewed tentatively until we know more about how steelhead are or should be dealt with in that lentic environment. Similar to spring Chinook, important AU's for protection for steelhead included the Chiwawa and White Rivers and Nason Creek (**Table F.9**).

Table F6. EDT model output for the assessment unit summary for Wenatchee spring Chinook. The restoration potential was the percent increase in each of the performance measures (diversity index, productivity, and abundance) by improving all environmental attributes in that assessment unit to template conditions. Benefit categories were derived by evaluating the mean rank and by finding breakpoints in the sum of the restoration benefits.

		Diversity Index		Productivity		Abundance				
Reach	**Benefit Category**	**Rank**	**Restoration Potential**	**Rank**	**Restoration Potential**	**Rank**	**Restoration Potential**	**Mean Rank**	**Mean % Restoration Potential**	**Sum of % Restoration Potential**
Upper Wenatchee Mainstem	A	4	9%	4	6%	2	23%	3	12%	37%
Lower Nason Ck	A	7	4%	1	23%	4	15%	4	14%	42%
Lower Peshastin Ck	A	1	21%	9	0%	3	17%	4	13%	38%
Lower Wenatchee Mainstem	A	6	5%	6	3%	1	29%	4	12%	37%
Lower Icicle Creek	B	3	9%	9	0%	6	8%	6	6%	17%
Chiwawa River	B	13	0%	2	20%	5	13%	7	11%	34%
Mission Ck	B	2	15%	9	0%	9	7%	7	7%	21%
White River	B	12	0%	3	19%	7	8%	7	9%	28%
Tumwater Canyon	B	8	3%	7	2%	8	7%	8	4%	12%
Chumstick Ck	B	5	6%	9	0%	11	3%	8	3%	9%
Little Wenatchee	B	10	1%	5	6%	10	4%	8	3%	10%
Upper Peshastin Ck	B	9	3%	9	0%	12	1%	10	1%	4%
Chiwaukum	C	11	1%	9	0%	13	0%	11	0%	1%
Lake Wenatchee	C	13	0%	8	0%	14	0%	12	0%	1%

Table F7. EDT model output for the assessment unit summary for Wenatchee spring Chinook. The potential loss from degradation was the percent decrease in each of the performance measures (diversity index, productivity, and abundance) by moving all environmental attributes in that assessment unit to a set of default extremely degraded conditions. Benefit categories were derived by evaluating the mean rank and by finding breakpoints in the sum of the losses from degradation.

		Diversity Index		Productivity		Abundance				
Reach	**Benefit Category**	**Rank**	**Potential Loss From Degradation**	**Rank**	**Potential Loss From Degradation**	**Rank**	**Potential Loss From Degradation**	**Mean Rank**	**Mean Potential Loss From Degradation**	**Sum of Potential Loss From Degradation**
Chiwawa River	A	1	-51%	1	-56%	1	-53%	1	-54%	-161%
White River	A	3	-14%	2	-23%	3	-19%	3	-19%	-57%
Lower Nason Ck	A	2	-17%	4	-9%	4	-19%	3	-15%	-45%
Upper Wenatchee Mainstem	A	5	-9%	3	-14%	2	-38%	3	-21%	-62%
Tumwater Canyon	B	4	-14%	5	-8%	6	-9%	5	-11%	-32%
Little Wenatchee	B	7	-6%	6	-8%	7	-8%	7	-7%	-22%
Lower Wenatchee Mainstem	B	8	-3%	7	-4%	5	-11%	7	-6%	-18%
Chiwaukum	C	6	-7%	9	-2%	8	-3%	8	-4%	-12%
Upper Peshastin Ck	C	9	-1%	10	0%	9	-2%	9	-1%	-3%
Lake Wenatchee	C	11	0%	8	-2%	11	-2%	10	-1%	-4%
Lower Icicle Creek	C	12	0%	12	0%	10	-2%	11	-1%	-2%
Lower Peshastin Ck	C	10	-1%	12	0%	12	-2%	11	-1%	-2%
Chumstick Ck	C	12	0%	11	0%	14	0%	12	0%	0%
Mission Ck	C	12	0%	12	0%	13	0%	12	0%	0%

Table F8. EDT model output for the assessment unit summary for Wenatchee steelhead. The restoration potential was the percent increase in each of the performance measures (diversity index, productivity, and abundance) by improving all environmental attributes in that assessment unit to template conditions. Benefit categories were derived by evaluating the mean rank and by finding breakpoints in the sum of the restoration benefits.

		Diversity Index		Productivity		Abundance				
Reach	**Benefit Category**	**Rank**	**Restoration Potential**	**Rank**	**Restoration Potential**	**Rank**	**Restoration Potential**	**Mean Rank**	**Mean % Restoration Potential**	**Sum of % Restoration Potential**
Lower Peshastin Ck	A	2	35%	3	20%	1	49%	2	35%	104%
Mission Ck	A	1	50%	6	13%	3	23%	3	29%	87%
Lower Nason Ck	A	7	12%	2	25%	4	20%	4	19%	58%
Lower Wenatchee Mainstem	A	5	20%	8	11%	5	19%	6	16%	49%
Upper Wenatchee Mainstem	A	3	27%	7	13%	10	10%	7	17%	51%
Chiwawa River	A	10	5%	5	16%	6	18%	7	13%	40%
Upper Nason Ck	A	13	3%	1	26%	7	17%	7	15%	45%
Lower Icicle Creek	A	4	22%	16	0%	2	28%	7	16%	49%
Tumwater Canyon	B	8	11%	10	2%	9	12%	9	9%	26%
White River	B	15	2%	4	19%	8	15%	9	12%	36%
Chumstick Ck	B	9	10%	11	1%	12	3%	11	5%	14%
Little Wenatchee	B	16	1%	9	9%	11	7%	12	5%	16%
Upper Peshastin Ck	B	6	19%	16	0%	14	1%	12	7%	20%
Beaver Ck	C	11	5%	13	1%	15	1%	13	2%	7%
Chiwaukum	C	14	2%	12	1%	13	2%	13	1%	4%
Derby Ck	C	12	4%	14	1%	16	1%	14	2%	6%
Lake Wenatchee	C	17	0%	15	0%	17	0%	16	0%	0%

		Diversity Index		Productivity		Abundance				
Reach	**Benefit Category**	**Rank**	**Restoration Potential**	**Rank**	**Restoration Potential**	**Rank**	**Restoration Potential**	**Mean Rank**	**Mean % Restoration Potential**	**Sum of % Restoration Potential**
Upper Icicle Creek	C	17	0%	16	0%	18	0%	17	0%	0%

Table F9. EDT model output for the assessment unit summary for Wenatchee steelhead. The potential loss from degradation was the percent decrease in each of the performance measures (diversity index, productivity, and abundance) by moving all environmental attributes in that assessment unit to a set of default extremely degraded conditions. Benefit categories were derived by evaluating the mean rank and by finding breakpoints in the sum of the losses from degradation

		Diversity Index		Productivity		Abundance				
Reach	**Benefit Category**	**Rank**	**Potential Loss From Degradation**	**Rank**	**Potential Loss From Degradation**	**Rank**	**Potential Loss From Degradation**	**Mean Rank**	**Mean Potential Loss From Degradation**	**Sum of Potential Loss From Degradation**
Chiwawa River	A	1	-39%	1	-38%	1	-51%	1	-43%	-128%
White River	A	3	-14%	2	-28%	2	-30%	2	-24%	-72%
Lower Nason Ck	A	2	-20%	4	-8%	4	-13%	3	-14%	-41%
Upper Nason Ck	A	4	-13%	3	-12%	3	-16%	3	-14%	-41%
Upper Wenatchee Mainstem	B	5	-11%	7	-5%	6	-10%	6	-9%	-26%
Chiwaukum	B	6	-7%	6	-6%	8	-8%	7	-7%	-21%
Tumwater Canyon	B	8	-6%	8	-4%	5	-13%	7	-8%	-23%
Little Wenatchee	B	7	-6%	5	-7%	10	-6%	7	-6%	-19%
Lower Wenatchee Mainstem	B	9	-3%	9	-3%	7	-9%	8	-5%	-15%
Upper Peshastin Ck	B	10	-1%	10	-1%	9	-7%	10	-3%	-9%
Lower Peshastin Ck	C	11	0%	12	0%	11	-2%	11	-1%	-2%
Mission Ck	C	12	0%	13	0%	12	-2%	12	-1%	-2%
Lake Wenatchee	C	12	0%	11	0%	15	0%	13	0%	-1%
Lower Icicle Creek	C	12	0%	15	0%	13	-1%	13	0%	-1%
Chumstick Ck	C	12	0%	15	0%	14	-1%	14	0%	-1%
Beaver Ck	C	12	0%	14	0%	17	0%	14	0%	0%

			Diversity Index			Productivity			Abundance					
Reach	Benefit Category		Rank	Potential Loss From Degradation		Rank	Potential Loss From Degradation		Rank	Potential Loss From Degradation		Mean Rank	Mean Potential Loss From Degradation	Sum of Potential Loss From Degradation
Derby Ck	C		12	0%		15	0%		16	0%		14	0%	0%
Upper Icicle Creek	C		12	0%		15	0%		18	0%		15	0%	0%

F.1.3 Data Availability and Quality

In general, adequate data sources were available to aid the habitat work group in rating the 46 environmental attributes for EDT. We evaluated 4641 current attribute rating levels of proof to determine the percent frequency of each level of proof (LOP) category (**Table F3**). Category one was used for attributes where data was available in a specific reach and was direct measure of the environmental attribute. Category two was used to expand empirical information to adjacent reaches, or to other reaches within the same sub-watershed, if appropriate. Category three was used when data was available to deduce the EDT score, but it was indirectly related to the EDT attribute or expanded from another sub-watershed where applicability was suspect. Category four was for expert opinion and was used for attributes where no data was available, so they had to be rated qualitatively. Category five was hypothetical, and was also based on opinion, but with less confidence and was sometimes used to highlight critical data gaps. Obviously, the more empirical data the better for population the EDT model with environmental attribute information. However, in many cases, the attributes could be adequately defined with derived information or expert opinion. In other cases, the analysis could benefit from refinement of the model input.

Overall, 76% of the data that populated the model for the Wenatchee Basin was empirical (21%), expanded from empirical (9%), or derived (46%) (**Figure F5**). Several of the attributes were designed to be rated qualitatively, according to the EDT attribute rating guidelines. For example, the attribute "harassment", is a relative measure of the proximity to population centers and the potential for disturbance and poaching on a fish population. Empirical data did not exist and will never exist for this attribute as it was defined in the attribute rating guidelines. It was included in EDT for watersheds that might have issues related to major population centers such as in the Puget Sound area. These attributes probably could have been categorized as expert opinion but we had some links to data that warranted a slightly better level of proof rating. Several other attributes that were rated qualitatively using derived information included pathogens and predation.

Several of the derived attributes need improvement and future efforts to use EDT should first focus on reviewing and improving critical model input.

Some key attributes with the majority of their LOP in the derived category that need to be revisited include artificial hydroconfinement, bed scour, salmon carcasses, and benthic macroinvertebrates. The cumulative effect of artificial confinement from all sources needs to be identified in each reach. We used the road and transportation layer generated by PBI then made some assumptions about what % of the confined linear distance actually severs the channel from its floodplain (**Table F3**). These assumptions need groundtruthed by field and aerial photo observations. Bed scour is the primary modifier for the survival factor "channel stability" that was rated as secondary or not a limiting factor for many of the assessment units, thereby decreasing the models sensitivity to this environmental attribute. Given the importance of bed scour related to egg incubation and productivity, we were not satisfied with the multiple regression using other attribute ratings to come up with EDT scores for bed scour.

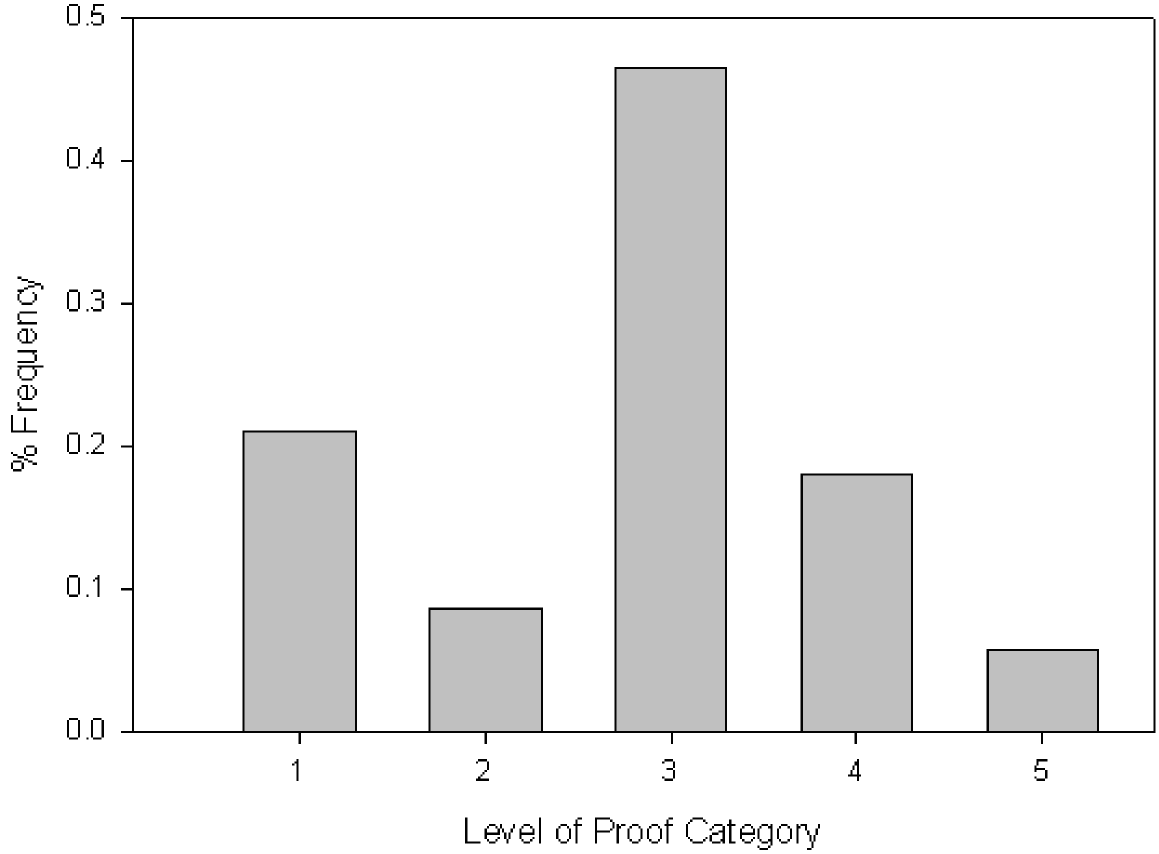


Figure F.5. Frequency distribution of each category of level of proof for the Wenatchee basin Ecosystem Diagnosis and Treatment model. Category 1= empirical data, 2=expansion of empirical data, 3=derived from relevant empirical information, 4=expert opinion, 5 = hypothetical.

Bed scour ratings generally came up very close to template conditions. However, until bed scour is measured using empirical studies at multiple locations throughout the watershed, we will have to rely on our initial indirect estimate. Salmon carcasses and benthic macroinvertebrates contributed to the limiting factor "food". There were relatively high average T-C ratings for both of these attribute, although the survival factor appeared to be a secondary limiting factor when examining the strategic priority summary. The need to re-visit these attributes was increased when the sensitivity analysis showed such a large potential to increase to improve abundance and productivity by addressing the survival factor "food" (section F.6). A result that seemed to conflict with our initial diagnosis that food was a secondary limiting factor. Since B-IBI data has been collected it should be relatively easy to update this metric, but those scores were not available when we were initially populating EDT with attribute scores.

Additional information regarding population performance and scenario modeling can be found in the subsequent sections of this appendix.

F.2 Model Setup for Scenarios

EDT was used to analyze the potential increases in salmon performance based on improved habitat conditions. A scenario consisted of multiple action classes that were targeted at addressing limiting factors identified in the recovery matrix (Tables 5.7-5.10). Action classes were groups or categories of restoration activities that could be implemented in a watershed to change the stream environment toward the normative or historical condition, such as removing passage barriers, restoring riparian condition, or floodplain connectivity (see **Table 5.6**). Action classes were grouped into scenarios to represent a coordinated approach to habitat restoration.

Scenarios resulted in a change in the environment from a set of combined actions. The total amount of change resulting from a scenario was bounded by the current condition and the normative or template condition. In other words, an attribute could not be improved beyond what was defined as its intrinsic condition in the template condition. The distance between the current and the template condition defined the ***restoration potential*** for each attribute. Construction of scenarios involved determining a percent change in the restoration potential for attributes as a result of the component actions (habitat action classes; see **Table 5.6**). Benefits of actions were not applied as absolute increases, but as a percent change to the difference between the current and template condition of a particular environmental attribute by the following formula:

$$N_i = C_i + [(T_i - C_i)*(E*I)]$$

Where N_i was the new score for a particular environmental attribute in a specific reach, T_i was the template value of the attribute in that reach, C_i was the current value for that attribute score for that reach, E was the effectiveness of the action at changing that attribute and I was the intensity of the action class application.

Its impossible to know the quantitative benefit to a species that will result from restoration scenarios because of the uncertainty regarding physical processes in streams, uncertainty in how fish may respond to environmental change and because of the compounding effect of many different factors inside and outside the subbasin that affect the abundance of salmon. For this reason, we created ***action class hypotheses*** that were the basis for analysis of the actions and scenarios in EDT. These hypotheses are based on scientific information and represent our best judgments regarding the effect of the scenarios. As hypotheses, they can and should be evaluated as they are implemented. Action class hypotheses were developed through a structured approach that incorporated published scientific knowledge and the judgments of local experts regarding the change in the environment that is likely to result from implementation of the actions (**Figure F6**). These action class hypotheses were grouped into scenarios that consisted of input changes to the EDT model. EDT was then re-run and the effect of the scenario was measured as the change in fish performance between the scenario and the baseline run.

The process used for developing action hypotheses and scenarios for EDT is shown in **Figure F6**. An action hypothesis describes a specific measure taken to affect the stream—planting trees, adding large wood, reconnecting floodplains and so on. The hypothesis for each action consisted of two elements: the ***effectiveness*** of the type of action to change one or more EDT environmental attributes (for example, temperature, flow, sediment) and the ***intensity*** of application of the action along the stream. Effectiveness is independent of intensity and represents a scientific conclusion regarding how the different types of actions affect the environment. Planting trees along a stream, for example, has an effectiveness that relates to the ecological role of riparian forests on the stream environment. Intensity, on the other hand, might refer to the proposed width of the riparian planting and the number or species of trees to be planted. The result of the action hypothesis is a statement regarding the percent change in one or more attributes in one or more reaches of the stream as a result of implementing the action. The percent changes for each action are combined to create scenarios that are analyzed in EDT.

Model

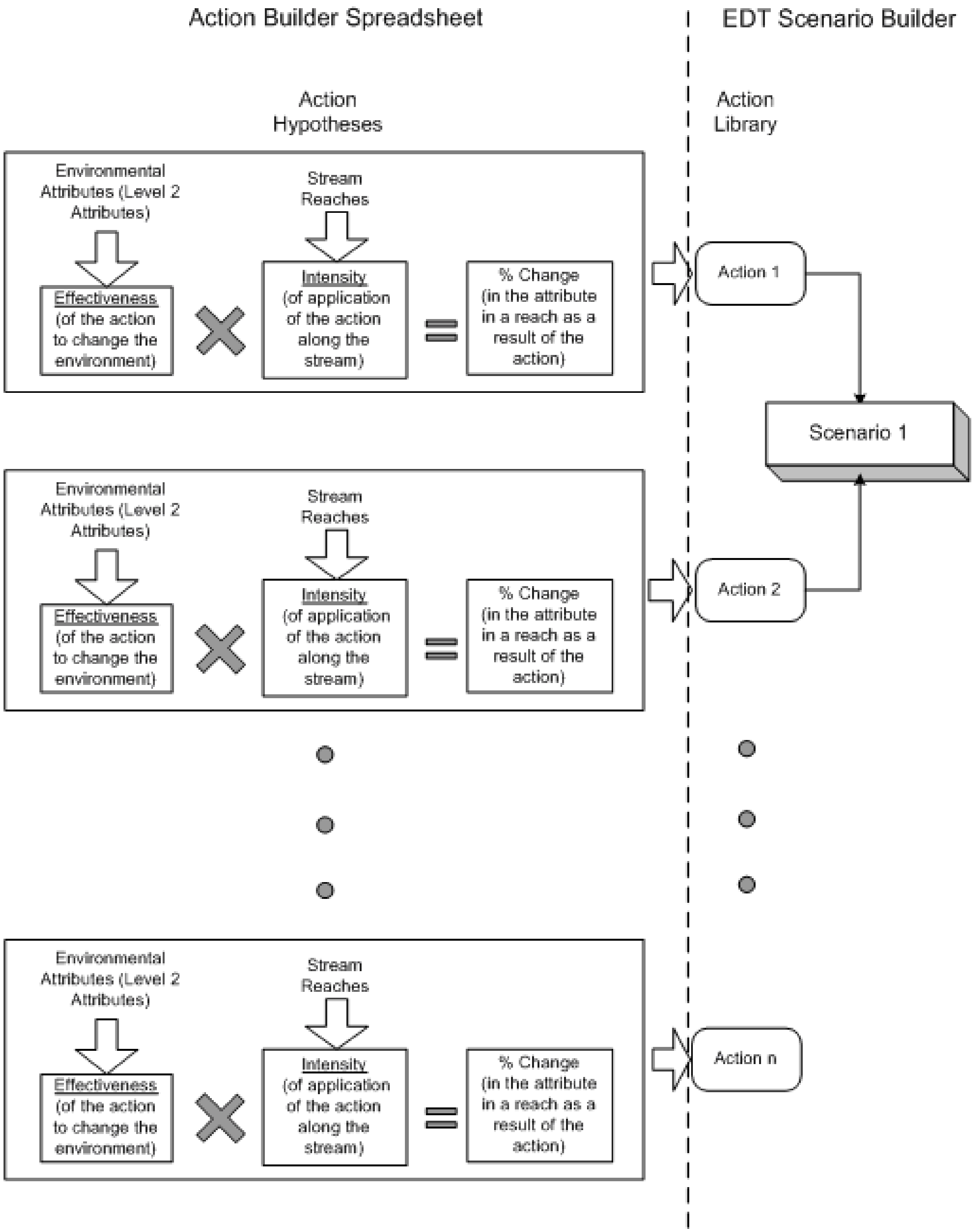


Figure F6. Development of scenarios for analysis within the Ecosystem Diagnosis and Treatment (EDT) model. An action builder spreadsheet was used to create an action hypothesis regarding the effectiveness of an action to change the environmental attributes and an intensity of application was selected to define the level of effort within each assessment unit. Actions were then brought together into a scenario that was evaluated

Scenarios were analyzed in two steps (**Figure F6**). First, recovery planners used an action builder spreadsheet to document assumptions regarding the effectiveness and intensity for each action class. This resulted in an estimate of the percent change in restoration potential that would result from the action class. Second, the estimated percent change in attributes in each affected reach was transferred to the EDT Scenario Builder where actions were combined into scenarios. Algorithms in the Scenario Builder combined the actions and ensured that the sum of all actions could not improve conditions beyond that described in the Template condition. Also in the scenario builder, the percent changes resulting from a scenario were applied to the EDT baseline environmental data set (developed in the Stream Reach Editor) to produce a modified environmental data set that was evaluated for its effectiveness at improving the status of salmon and steelhead performance measures including abundance, productivity, and life history diversity.

Effectiveness.— Effectiveness was used as a scientific hypothesis regarding how types of actions affect the environment, independent of the socioeconomic feasibility or intensity of application of a particular action. The intent of the effectiveness component was to develop a consistent scientific conclusion regarding each type of action that would be applied to address a limiting factor. The effectiveness hypotheses were developed by a group of scientists independently of the application of the action through the intensity multiplier. We estimated the effectiveness of each action class within 3 stream size categories (Strahler order) to capture the different levels of effectiveness in small (1-3 order) medium (4-5 order) and large (6^{th} order) stream sizes. The effectiveness hypothesis was created by considering how each type of action relates to one or more of the 46 physical and biological attributes in EDT. In most cases, there were one or more attributes for which the action had a primary impact and other secondary attributes that receive lesser benefits. Due to the uncertainty of how much an action class might change particular environmental attributes we formed 5 classes of effectiveness and then estimated the range and midpoint of each effectiveness rating (**Table F10**). We rarely assumed that an individual action class had a high capability of restoring normative conditions, but generally the sum of all action classes restored > 75% of normative conditions for most targeted attributes (**Table F11**). The gaps between the sum of the effectiveness and the template condition could be explained by other action classes that were not considered by recovery planners. For example, the action class “add large wood” was only rated to increase the large woody debris attribute by 0.3. We hypothesized that just adding wood to a dysfunctional stream channel would not be very effective at moving the attribute score towards the template condition (max = 0.30). However, when considered in combination with riparian restoration, floodplain reconnection, and road management the sum of the effectiveness to the large woody debris attribute was 1.05 (but if all actions were applied the model algorithms would cap the benefit at 1.0) indicating that template conditions could be achieved if all actions were implemented to their full intensity. As another example, the sum of effectiveness ratings for predation risk were only 0.15 for all stream sizes; however, we did not include specific actions to reduce predation, such as predator removal programs that would have moved the sum of the effectiveness towards 1.0. Additional discrepancies (variances from 1.0) could be explained by the uncertainty of the effectiveness assumptions and because we modeled the midpoints when the true value may have been closer to either end of the extremes.

Intensity.—Intensity described how much effort of each action class would be applied to specific assessment units of the subbasin. Because intensity directed specific actions at specific locations, managers referred to the EDT diagnosis and the recovery matrix (which included previous assessments as a guide to limiting factors). In determining the final effect of the action on the environmental attributes, intensity in each reach was multiplied by the effectiveness of the action (**Figure F6**). In the Action Builder Spreadsheet, intensity was set for each action in each assessment unit, so an intensity of 1.0 assumes that the action would be applied in every reach to its full effectiveness (limited to the midpoint of the effectiveness range). For example, we determined the effectiveness of adding large woody debris was 30% effective in medium and small streams so the overall effect with 1.0 intensity would be (1.0*0.3 = 0.3). Although this rating would take into account the biological and physical limitations of effectiveness of a particular action, it would not take into account social limitations or a cost benefit prioritization that would represent the feasibility of implementation. If an alternative scenario applied 0.33 intensity to the action class "add large woody debris" then the change to the attribute score would be (0.33*0.30 = 0.10). Again, this change (0.10) was not an absolute increase in the current score, rather it was applied to the difference between the current and template score. For example, if the attribute "large woody debris" was rated as a 3 for current and a 1 for historic (where a lower score means more wood; see attribute rating guidelines at www.mobrand.com) with an effectiveness of 0.3 and an intensity of 0.33 then, using the formula defined previously:

$$N_i = C_i + [(T_i – C_i)*(E*I)]$$

the new attribute score would be:

$$N_i = 3 + [(1-3)*(0.3*0.33)] = 2.8$$

Protection Action Classes.—A fundamental assumption of this plan was that existing high quality, functioning habitat needs to be protected. Much of the focus in the habitat section is on restoring or fixing impaired environmental function. That focus does not diminish the need to ensure that habitat remains functional or continues to recover from past land use/management practices where protection has already occurred. There were two forms of habitat protection considered in this plan, no-net-impact and passive restoration. First, in areas where development was likely to occur we applied no-net-impact protection that was designed to prevent degradation of riparian areas and stream channel function through mechanisms such as the Growth Management Act, Shorelines Management Act, Hydraulics Code and Clean Water Act. Second, in areas that were already protected by state and federal land ownership it is assumed that continued protection will occur and conditions will improve through passive restoration.

In the EDT modeling exercises, we assumed no-net-impact of development on the environmental attributes that affect fish survival in all assessment units. There are two ways to achieve this result. First, development will not be allowed in a manner that will impact the riparian area and stream channel. Second, if an impact does occur it must be mitigated by restoring and then protecting an area of the riparian and stream channel of "equal" value. This no-net-impact restoration will not be included with other restoration actions outlined to move the population towards recovery. It is simply compensating for new impacts and keeping conditions and species status from degrading. If species status is to improve then habitat conditions must improve and protection has to be applied to maintain functional conditions.

Within each watershed, areas already receiving some level of protection, primarily through state and federal ownership were noted (**Table F12**). These areas also generally represent the most pristine and functional habitats within each basin and it was assumed that continued protection of these habitats will lead to passive restoration, whereby conditions slowly improve without direct intervention. Our hypothesis was that habitat attributes associated with the riparian zone, stream channel, and water quality would improve through passive restoration at a rate of 0.25 over a 25 year time period. Additionally, we hypothesized that habitat attributes associated with or affected by roads would improve at a rate of 0.1 per 25 years. To see which of the 46 EDT environmental attributes these changes were applied to see (**Table F11**; action effectiveness table for hyperlink.xls). The improvement in habitat attribute scores were only applied to the difference between the current and template scores; therefore, no change occurred to a particular habitat attribute if it was rated the same for current and template. Passive restoration through protection was only applied in the relatively pristine sub-watersheds that were already in state and federal ownership, thereby leading to minor changes in attribute ratings and less sensitivity to our assumption that 0.25 and 0.10 were the correct rates for passive restoration. We also tested the models sensitivity to these passive restoration hypothesis by doubling and halving the multipliers (see section F.6 on model sensitivity).

The action class "add nutrients" (salmon carcasses or analogs) was also applied to the assessment units that were designated primarily for protection. Applying this action class makes sense when the majority of stream and riparian zone form and function are in place, but abundance and productivity are below carrying capacity. Although this action class was only applied at the generic scenario intensity levels, we believe that this action class should be prescribed on an annually, based on subwatershed level adult escapement objectives. This will ensure that nutrient levels are capable of supporting the juvenile production that is desired to achieve recovery levels.

Table F10. Effectiveness scores, ranges, and midpoints for modeling action classes in EDT and applied to the Upper Columbia salmon and steelhead populations in the Wenatchee, Methow and Okanogan. A score was assigned to each environmental attribute (1-46) and stream size category (small, medium, large) with the assumption that the true value was within the range of percentages. However, a single value was needed for modeling purposes so we chose to use the midpoint of the range as our hypothesis regarding how much each action class could effect the environment.

Score	Range	Mid Point (S1)
1	0-10%	5%
2	10%-20%	15%
3	20%-40%	30%
4	40%-80%	60%
5	80%-100%	90%

Table F11 Effectiveness assumptions for 3 size categories of streams in the Upper Columbia ESU. hyperlink file = action effectiveness table for hyperlink.xls)

Table F12 Assessment units in each subbasin where protection measures in at least some of the reaches were assumed to be adequate for passive restoration. Protection leading to passive restoration assumes that a greater level of protection is in place and habitat conditions will improve through time without the intervention of active restoration.

Subbasin	Assessment Unit	Protection leading to "passive restoration"
Wenatchee	Lower Wenatchee Mainstem	
Wenatchee	Mission Ck (upper reaches)	X
Wenatchee	Lower Peshastin Ck	
Wenatchee	Upper Peshastin Ck	X
Wenatchee	Derby Ck	
Wenatchee	Chumstick Ck	
Wenatchee	Lower Icicle Creek	
Wenatchee	Upper Icicle Creek	X
Wenatchee	Tumwater Canyon	X
Wenatchee	Chiwaukum	X
Wenatchee	Upper Wenatchee Mainstem	X
Wenatchee	Beaver Ck	
Wenatchee	Chiwawa River	X
Wenatchee	Lower Nason Ck	X
Wenatchee	Upper Nason Ck	X
Wenatchee	Lake Wenatchee	X
Wenatchee	Little Wenatchee	X
Wenatchee	White River	X
Methow	Lower Methow	
Methow	Middle Methow	
Methow	Upper Middle Methow	
Methow	Upper Methow/Early Winters/Lost River	X
Methow	Black Canyon/Squaw	

Subbasin	Assessment Unit	Protection leading to "passive restoration"
Methow	Libby/Gold	X
Methow	Beaver/Bear Creek	X
Methow	Lower Twisp	X
Methow	Upper Twisp	X
Methow	Lower Chewuch	X
Methow	Upper Chewuch	X
Methow	Goat Creek and Lower Boulder	X
Methow	Wolf Creek and Hancock Creek	X
Okanogan	Okanogan Lower	
Okanogan	Okanogan Middle	X
Okanogan	Okanogan Upper	X
Okanogan	Loup Loup Creek	
Okanogan	Lower Salmon	X
Okanogan	Upper Salmon	X
Okanogan	Omak Creek and Tributaries	X
Okanogan	Small Tributary Systems	
Okanogan	Similkameen	X
Okanogan	Osoyoos Lake South Central	
Okanogan	Osoyoos Lake North	
Okanogan	Inkaneep Creek	X
Okanogan	Canada Lower Mainstem	
Okanogan	Canada Middle Mainstem	
Okanogan	Vaseux-McIntire Creek	X
Okanogan	Vaseux Lake and Mainstem Reaches	
Okanogan	Skaha Lake	
Okanogan	Canadian Mainstem to Okanogan Lake	
Okanogan	Okanogan Lake	
Okanogan	Upper Okanogan Subbasin	
Entiat	Lower Entiat	
Entiat	Middle Entiat	X

Subbasin	Assessment Unit	Protection leading to "passive restoration"
Entiat	Upper Entiat	X
Entiat	Mad River	X

There were many assumptions that had to be made to conduct this predictive modeling exercise; however, we believe that the end result of the action effectiveness hypotheses were reasonable estimates of how the actions would change the environment. We used EDT because we could build on progress made during watershed planning and subbasin planning efforts and we knew of no other tool that would allow us to link restoration actions to habitat changes to fish performance changes in a quantitative assessment package. We evaluated 11 action classes for 3 stream size categories and 46 environmental attributes (that is 1518 decisions just for the effectiveness ratings). However, by laying out these decisions in a matrix format (**Table F11**) we could easily revise the model input to test alternative hypotheses. Eighty-five percent of the effectiveness ratings were "no effect" of the action on any of the environmental attributes. For the 232 times that we determined an action class would effect an attribute, we decided there would be very low (0.05) to low (0.15) effects on the environmental attribute 62% of the time (**Figure F7**). Again, those changes were for 100% intensity in the reach (or assessment unit) and they are only applied to the difference between current and template environmental attribute scores. Additionally, we did not model the downstream dispersal effect of action classes beyond the boundary of the assessment unit. However, we did capture the effect of upstream actions that benefit downstream AU's for actions such as road management that have downstream effects on survival factors such as sediment load. These assumptions should result in a fairly conservative model about how actions change the environment with respect to our scenarios, but we could not evaluate how the ratings were propagated through the EDT model and weather or not the results were likely an over or underestimate of salmon and steelhead performance. Assumptions and model sensitivity will be discussed further in section F.6.

F.3 Recovery Scenario Descriptions

Current without harvest.—This is the baseline EDT model run with current attribute ratings conducted during watershed planning for the Entiat (CCCD2004), subbasin planning for the Methow and Okanogan (NPPC 2004), and recovery planning for the Wenatchee (Section F.1 of this Appendix). The online EDT model only provided estimates without harvest; however, harvest was evaluated during integration of the four H's (section 5.6 of this plan) and the performance measures provided by EDT for each subsequent scenario were also without harvest so the results are compatible.

Scenario 1.—Recovery scenario 1 applied a full intensity of all restoration action classes to the limiting factors in each assessment unit, as identified in the recovery matrices (Tables 5.7-5.10). Scenario 1 was not grounded by the reality of socioeconomic feasibility. It was subject to the effectiveness limitations for each action class in each size category of stream (see effectiveness rating discussion above). It allowed us to evaluate how effective our action classes could be if applied to the in-basin limiting factors for each fish population. The cumulative change to each attribute from the implementation of all action classes in scenario 1 for the Wenatchee subbasin can be seen in **Table F13** (the same method and format was used in the Methow and Okanogan). The values in **Table F13** were obtained by summing the effectiveness ratings for action classes (**Table F11**) that addressed limiting factors in each assessment unit (Tables 5.7-5.10).

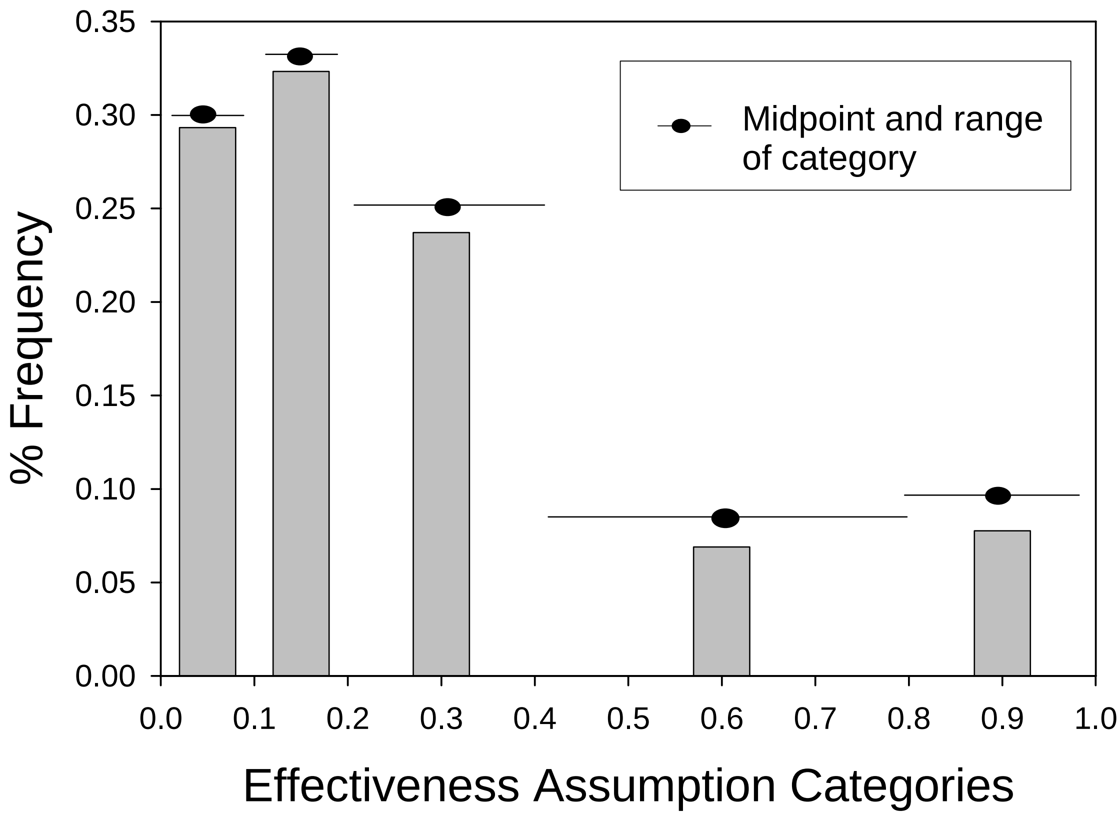


Figure F7. Distribution of effectiveness assumptions among the 5 categories of effectiveness for linking restoration actions to changes in habitat condition in EDT for the Upper Columbia ESU scenario modeling. This distribution only represents the actions and environmental attributes where a change to the current condition was applied and does not include the action-attribute combinations where "no effect" was assumed.

Table F13. The cumulative change to each EDT environmental attribute from the implementation of all action classes in scenario 1 for the Wenatchee subbasin. The values in were obtained by summing the effectiveness ratings for all recovery action classes that addressed limiting factors in each assessment unit

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Flow High	0.45	0.90	0.60	1.00	0.90	0.90	0.60	0.10	0.10	1.00	0.10	0.90	0.10	0.60	0.10	0.10	0.10	0.10
Flow Low	0.90	0.90	0.90	1.00	0.90	0.90	0.90	0.10	0.10	1.00	0.10	0.90	0.10	0.90	0.10	0.10	0.10	0.10
Flow Diel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flow Intra-Annual	0.15	0.60	0.30	0.70	0.60	0.60	0.30	0.10	0.10	0.70	0.10	0.60	0.10	0.30	0.10	0.10	0.10	0.10
Regime Natural	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Regime Regulated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Channel Length	0.30	0.15	0.30	0.40	0.15	0.15	0.30	0.25	0.25	0.40	0.25	0.15	0.25	0.30	0.25	0.25	0.25	0.25
Width Max	0.00	0.15	0.15	0.40	0.15	0.15	0.15	0.25	0.25	0.40	0.25	0.15	0.25	0.15	0.25	0.25	0.25	0.25
Width Min	0.75	0.75	0.75	1.00	0.75	0.75	0.75	0.25	0.25	1.00	0.25	0.75	0.25	0.75	0.25	0.25	0.25	0.25
Gradient	0.05	0.05	0.05	0.30	0.05	0.05	0.05	0.25	0.25	0.30	0.25	0.05	0.25	0.05	0.25	0.25	0.25	0.25
Natural Confinement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Confinement-Hydro	0.70	0.95	0.80	1.05	0.95	0.95	0.80	0.10	0.10	1.05	0.10	0.95	0.10	0.80	0.10	0.10	0.10	0.10
Habitat-backwater pools	0.15	0.05	0.15	0.30	0.05	0.05	0.15	0.25	0.25	0.30	0.25	0.05	0.25	0.15	0.25	0.25	0.25	0.25
Habitat-beaver ponds	0.00	0.05	0.05	0.30	0.05	0.05	0.05	0.25	0.25	0.30	0.25	0.05	0.25	0.05	0.25	0.25	0.25	0.25

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Habitat glides	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat-Large cobble	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat-Small cobble	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat Pool Tailouts	0.10	0.60	0.35	0.85	0.60	0.60	0.35	0.25	0.25	0.85	0.25	0.60	0.25	0.35	0.25	0.25	0.25	0.25
Habitat-Pools	0.10	0.75	0.45	1.00	0.75	0.75	0.45	0.25	0.25	1.00	0.25	0.75	0.25	0.45	0.25	0.25	0.25	0.25
Habitat-Off channel Habitat	0.35	0.20	0.30	0.45	0.20	0.20	0.30	0.25	0.25	0.45	0.25	0.20	0.25	0.30	0.25	0.25	0.25	0.25
Obstructions	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.00	0.90	0.00	0.90	0.00	0.00	0.00	0.00
Water Withdrawal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bed Scour	0.75	1.15	0.90	1.40	1.15	1.15	0.90	0.25	0.25	1.40	0.25	1.15	0.25	0.90	0.25	0.25	0.25	0.25
Icing	0.00	0.05	0.00	0.30	0.05	0.05	0.00	0.25	0.25	0.30	0.25	0.05	0.25	0.00	0.25	0.25	0.25	0.25
Riparian Functions	0.65	0.95	0.95	1.20	0.95	0.95	0.95	0.25	0.25	1.20	0.25	0.95	0.25	0.95	0.25	0.25	0.25	0.25
Wood	0.65	1.05	1.05	1.30	1.05	1.05	1.05	0.25	0.25	1.30	0.25	1.05	0.25	1.05	0.25	0.25	0.25	0.25
Embeddedness	0.50	1.00	0.80	1.10	1.00	1.00	0.80	0.10	0.10	1.10	0.10	1.00	0.10	0.80	0.10	0.10	0.10	0.10
Fine sediment	0.50	1.00	0.80	1.10	1.00	1.00	0.80	0.10	0.10	1.10	0.10	1.00	0.10	0.80	0.10	0.10	0.10	0.10
Turbidity	0.15	0.60	0.30	0.70	0.60	0.60	0.30	0.10	0.10	0.70	0.10	0.60	0.10	0.30	0.10	0.10	0.10	0.10
Alkalinity	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Dissolved O2	0.65	0.15	0.05	0.40	0.15	0.15	0.05	0.25	0.25	0.40	0.25	0.15	0.25	0.05	0.25	0.25	0.25	0.25
Metals Water Column	0.90	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Metal sediment	0.90	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Misc Toxic pollutants	1.05	0.15	0.15	0.40	0.15	0.15	0.15	0.25	0.25	0.40	0.25	0.15	0.25	0.15	0.25	0.25	0.25	0.25
Nutrient Enrichment	0.90	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Temp Max	0.55	0.95	0.60	1.20	0.95	0.95	0.60	0.25	0.25	1.20	0.25	0.95	0.25	0.60	0.25	0.25	0.25	0.25
Temp Min	0.15	0.30	0.15	0.55	0.30	0.30	0.15	0.25	0.25	0.55	0.25	0.30	0.25	0.15	0.25	0.25	0.25	0.25
Temp Spatial Variation	0.25	0.70	0.50	0.95	0.70	0.70	0.50	0.25	0.25	0.95	0.25	0.70	0.25	0.50	0.25	0.25	0.25	0.25
Fish Community Richness	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Fish Pathogens	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Fish Species Intro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harassment	0.90	0.90	0.90	1.00	0.90	0.90	0.90	0.10	0.10	1.00	0.10	0.90	0.10	0.90	0.10	0.10	0.10	0.10
Hatchery outplants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Predation Risk	0.15	0.15	0.15	0.40	0.15	0.15	0.15	0.25	0.25	0.40	0.25	0.15	0.25	0.15	0.25	0.25	0.25	0.25
Salmon Carcass	0.15	0.05	0.05	0.90	0.05	0.05	0.05	0.55	0.40	0.90	0.40	0.05	0.55	0.35	0.85	0.25	0.55	0.55
Benthic Comm Rich	0.65	0.70	0.55	1.05	0.70	0.70	0.55	0.35	0.35	1.10	0.30	0.70	0.30	0.60	0.40	0.25	0.30	0.30

Protection strategies for scenario 1 included no-net-impact of development throughout all assessment units and passive restoration through protection on lands already in public ownership, such as USFS. No-net-impact assumes that protection will occur (at least) to the level where there is no loss to current habitat function or associated fish survival. Additional restoration actions (see above) were then assigned to these assessment units in order to improve their condition and function. Protection leading to passive restoration assumed that a greater level of protection was in place and habitat conditions would improve through time (without the intervention of active restoration). Finally, nutrient supplementation was applied to the assessment units where protection was the primary action class.

Scenario 2.—Scenario 2 was not available in time for modeling purposes. Our vision was for scenario 2 to be the chosen mix and match of action classes and intensities that were feasible in each assessment unit, based on detailed local input regarding feasibility. We left an un-modeled scenario 2 in the report to emphasize the need for subwatershed specific prescriptions of each action class. The HCC assumed that Scenario 2 would fall somewhere in between scenarios 1 and 3.

Scenario 3.—Scenario 3 was designed to provide perspective on "what if" we only applied 1/3 intensity for each of the action classes. It seemed logical that feasibility of certain action classes would be constrained due to social or economic factors. However, we did not have a final list of intensities for each action class and assessment unit. Therefore, 1/3 of full intensity was selected to provide an alternative level of reduced effort for the habitat action plan, without making judgments about exactly where higher and lower intensities were feasible. Scenario 3, though not grounded in reality, provides insight to species performance measures given an alternative application of the action classes that address limiting factors in each of the assessment units. The only exceptions to the 1/3 intensity application were regarding obstructions and protection. We assumed that all artificial fish migration obstructions would be fixed and maintained, and that the same protection strategies and intensities as Scenario 1 would occur with Scenario 3.

The cumulative change to each attribute from the implementation of all action classes in scenario 1 can be seen in **Table F14**. The values in **Table F14** were obtained by multiplying the effectiveness ratings by 0.33 then summing all action classes (**Table F11**) that addressed limiting factors in each assessment unit (Tables 5.7-5.10).

PFC.—EDT Scenario Builder is hard-wired to provide Properly Functioning Conditions (PFC), which was initially based on many of the targets listed in the "matrix of pathways and indicators" for functional habitat conditions (NMFS 1996). PFC for EDT was further developed and applied in the Puget Sound Recovery Planning process. We did not review and edit PFC specifically for the Upper Columbia watersheds, so we do not have confidence that the values represent reasonable objectives for the watersheds of the Upper Columbia. However, we included a PFC run in our model output to be consistent with the use of EDT in other areas in Washington State and because we were interested in comparing the results of our scenarios to PFC and possibly evaluating the similarities and differences in attribute objectives in the future.

Table F14. The cumulative change to each EDT environmental attribute from the implementation of all action classes in scenario 3 for the Wenatchee subbasin. The values in were obtained by multiplying the effectiveness ratings by 0.33 then summing all action classes that addressed limiting factors in each assessment unit

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Flow High	0.15	0.30	0.20	0.40	0.30	0.30	0.20	0.10	0.10	0.40	0.10	0.30	0.10	0.20	0.10	0.10	0.10	0.10
Flow Low	0.30	0.30	0.30	0.20	0.30	0.30	0.30	0.10	0.10	0.40	0.10	0.30	0.10	0.30	0.10	0.10	0.10	0.10
Flow Diel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flow Intra-Annual	0.05	0.20	0.10	0.30	0.20	0.20	0.10	0.10	0.10	0.30	0.10	0.20	0.10	0.10	0.10	0.10	0.10	0.10
Regime Natural	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Regime Regulated	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Channel Length	0.10	0.05	0.10	0.30	0.05	0.05	0.10	0.25	0.25	0.30	0.25	0.05	0.25	0.10	0.25	0.25	0.25	0.25
Width Max	0.00	0.05	0.05	0.30	0.05	0.05	0.05	0.25	0.25	0.30	0.25	0.05	0.25	0.05	0.25	0.25	0.25	0.25
Width Min	0.25	0.25	0.25	0.40	0.25	0.25	0.25	0.25	0.25	0.50	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Gradient	0.02	0.02	0.02	0.27	0.02	0.02	0.02	0.25	0.25	0.27	0.25	0.02	0.25	0.02	0.25	0.25	0.25	0.25
Natural Confinement	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Confinement-Hydro	0.23	0.32	0.27	0.42	0.32	0.32	0.27	0.10	0.10	0.42	0.10	0.32	0.10	0.27	0.10	0.10	0.10	0.10
Habitat-backwater pools	0.05	0.02	0.05	0.27	0.02	0.02	0.05	0.25	0.25	0.27	0.25	0.02	0.25	0.05	0.25	0.25	0.25	0.25

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Habitat-beaver ponds	0.00	0.02	0.02	0.27	0.02	0.02	0.02	0.25	0.25	0.27	0.25	0.02	0.25	0.02	0.25	0.25	0.25	0.25
Habitat glides	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat-Large cobble	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat-Small cobble	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Habitat Pool Tailouts	0.03	0.20	0.12	0.45	0.20	0.20	0.12	0.25	0.25	0.45	0.25	0.20	0.25	0.12	0.25	0.25	0.25	0.25
Habitat-Pools	0.03	0.25	0.15	0.50	0.25	0.25	0.15	0.25	0.25	0.50	0.25	0.25	0.25	0.15	0.25	0.25	0.25	0.25
Habitat-Off channel Habitat	0.12	0.07	0.10	0.32	0.07	0.07	0.10	0.25	0.25	0.32	0.25	0.07	0.25	0.10	0.25	0.25	0.25	0.25
Obstructions	0.90	0.90	0.90	1.15	0.90	0.90	0.90	1.15	1.15	1.15	1.15	0.90	1.15	0.90	1.15	1.15	1.15	1.15
Water Withdrawal	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Bed Scour	0.25	0.38	0.30	0.63	0.38	0.38	0.30	0.25	0.25	0.63	0.25	0.38	0.25	0.30	0.25	0.25	0.25	0.25
Icing	0.00	0.02	0.00	0.27	0.02	0.02	0.00	0.25	0.25	0.27	0.25	0.02	0.25	0.00	0.25	0.25	0.25	0.25
Riparian Functions	0.22	0.32	0.32	0.57	0.32	0.32	0.32	0.25	0.25	0.57	0.25	0.32	0.25	0.32	0.25	0.25	0.25	0.25
Wood	0.22	0.35	0.35	0.60	0.35	0.35	0.35	0.25	0.25	0.60	0.25	0.35	0.25	0.35	0.25	0.25	0.25	0.25
Embeddedness	0.17	0.33	0.27	0.43	0.33	0.33	0.27	0.10	0.10	0.43	0.10	0.33	0.10	0.27	0.10	0.10	0.10	0.10
Fine sediment	0.17	0.33	0.27	0.43	0.33	0.33	0.27	0.10	0.10	0.43	0.10	0.33	0.10	0.27	0.10	0.10	0.10	0.10

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Turbidity	0.05	0.20	0.10	0.30	0.20	0.20	0.10	0.10	0.10	0.30	0.10	0.20	0.10	0.10	0.10	0.10	0.10	0.10
Alkalinity	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Dissolved O2	0.22	0.25	0.22	0.45	0.25	0.25	0.22	0.25	0.25	0.50	0.25	0.25	0.25	0.22	0.25	0.25	0.25	0.25
Metals Water Column	0.30	0.30	0.30	0.55	0.30	0.30	0.30	0.25	0.25	0.55	0.25	0.30	0.25	0.30	0.25	0.25	0.25	0.25
Metal sediment	0.30	0.30	0.30	0.55	0.30	0.30	0.30	0.25	0.25	0.55	0.25	0.30	0.25	0.30	0.25	0.25	0.25	0.25
Misc Toxic pollutants	0.35	0.35	0.35	0.60	0.35	0.35	0.35	0.25	0.25	0.60	0.25	0.35	0.25	0.35	0.25	0.25	0.25	0.25
Nutrient Enrichment	0.30	0.30	0.30	0.55	0.30	0.30	0.30	0.25	0.25	0.55	0.25	0.30	0.25	0.30	0.25	0.25	0.25	0.25
Temp Max	0.18	0.32	0.20	0.47	0.32	0.32	0.20	0.25	0.25	0.57	0.25	0.32	0.25	0.20	0.25	0.25	0.25	0.25
Temp Min	0.05	0.10	0.05	0.35	0.10	0.10	0.05	0.25	0.25	0.35	0.25	0.10	0.25	0.05	0.25	0.25	0.25	0.25
Temp Spatial Variation	0.08	0.23	0.17	0.48	0.23	0.23	0.17	0.25	0.25	0.48	0.25	0.23	0.25	0.17	0.25	0.25	0.25	0.25
Fish Community Richness	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Fish Pathogens	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00	0.25	0.00	0.25	0.25	0.25	0.25
Fish Species Intro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Harassment	0.30	0.30	0.30	0.40	0.30	0.30	0.30	0.10	0.10	0.40	0.10	0.30	0.10	0.30	0.10	0.10	0.10	0.10
Hatchery outplants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Environmental Attribute	Lower Wenatchee Mainstem	Mission Ck	Lower Peshastin Ck	Upper Peshastin Ck	Derby Ck	Chumstick Ck	Lower Icicle Creek	Upper Icicle Creek	Tumwater Canyon	Chiwaukum	Upper Wenatchee Mainstem	Beaver Ck	Chiwawa River	Lower Nason Ck	Upper Nason Ck	Lake Wenatchee	Little Wenatchee	White River
Predation Risk	0.05	0.05	0.05	0.30	0.05	0.05	0.05	0.25	0.25	0.30	0.25	0.05	0.25	0.05	0.25	0.25	0.25	0.25
Salmon Carcass	0.05	0.02	0.02	0.47	0.02	0.02	0.02	0.35	0.30	0.47	0.30	0.02	0.35	0.02	0.45	0.30	0.35	0.35
Benthic Comm Rich	0.27	0.32	0.23	0.60	0.32	0.32	0.23	0.32	0.32	0.62	0.32	0.32	0.32	0.23	0.35	0.32	0.32	0.32

Habitat Template.—This model run is currently referred to as "historical" in the online EDT model, however, it only represents estimated historical habitat conditions (template) and current Columbia River mainstem conditions. This is fundamentally different than a true template, which estimates salmon performance with historic habitat and historic Columbia River mainstem conditions (i.e. no hydropower system). The habitat template allows us to evaluate fish performance relevant to what can be accomplished in the tributaries, because out-of-subbasin-effects (OOSE) generally dominate the mortality factors that effect capacity, abundance, and productivity of fish populations (Methow Subbasin Plan, NPPC 2004).

True Template.—A true template model run (historic habitat, historic mainstem) allowed us to evaluate the effectiveness of habitat actions relevant to "whole life cycle" mortality. In conjunction with other methods, it was helpful in integrating across various mortality sectors of each fish population.

F.4 Model Output Analysis Methods

We will only attempt to describe the methods that we used to analyze the results that EDT provided. There are a number of documents, available on-line, that explain the basics of how EDT works as well as all the formulas that derive the relationships between habitat conditions and fish life stage survival (www.mobrand.com).

F.4.1 Percent Increase Relative to Current

It is not possible, at this time, to thoroughly explain all the methods and assumptions used to populate the EDT model for the Upper Columbia subbasins because they are each comprised of tens of thousands of data points compiled from various sources of empirical data and expert opinion. Reviews of the level of proof and quality of information for environmental attribute ratings can be found in CCCD (2004) for the Entiat, NPPC (2004) for the Methow and Okanogan, and section F.1 (of this Appendix) for the Wenatchee. See section F.6 for a more detailed discussion of assumptions and model sensitivity.

Because of these uncertainties, we avoided using the EDT output as a predictor of absolute change, but rather an indicator of the potential for change based on relative increases over the current condition and the proportion of in-basin potential that could be realized under different scenarios. The relative change (percent) compared to the current condition were calculated for each EDT performance measure (Diversity Index, Productivity, Capacity, Abundance) by the equation:

$$R_x = \frac{S_x - S_c}{S_c}$$

where R_x was the relative change in the performance measure (x), S_x was the scenario being evaluated, and S_c was our scenario for current conditions.

F.4.2 Proportion of In-basin Potential

We used the proportion of in-basin potential to isolate how effective the restoration and protection scenarios were at capturing the potential for each performance measure (abundance, productivity, and diversity index) just within the subbasin habitat. The proportion of in-basin potential that was realized by each scenario was calculated by the equation:

$$P_x = \frac{S_x}{S_t}$$

where Px was the proportion of in-basin potential realized for each performance measure (x), S_x was the scenario being evaluated, and S_t was the scenario for the habitat template.

Unfortunately, there were no recovery criteria or standards to compare these results to and come to a conclusion regarding "how much is enough?". We recognize that the future desired conditions, as a result of scenario implementation, will have to be compared to socioeconomic constraints to determine if the actions in the habitat have done all they could. For now, this measure should be viewed as general guidance regarding how effective the scenarios are at reaching the habitat's potential.

F.4.3 Comparison of EDT to VSP

Abundance.—Abundance was the only parameter that could be directly compared to the VSP criteria from the ICTRT. However, due to uncertainty regarding the accuracy of changes to abundance predicted by EDT, we compared percent increase predicted by EDT to the percent increase needed to achieve the ICTRT minimum abundance threshold. We also qualitatively considered the relationship between the EDT estimate of abundance and the empirical estimate of abundance, but did not apply the restoration benefits to the empirical estimates. These estimates were generally close to one another and we believed the conclusions would have been the same, considering the variance of the empirical estimates and the uncertainty of the EDT predictions. Therefore, the results should be viewed as a likely trajectory and monitoring efforts in the future will have to determine the empirical abundance as a measure of recovery.

An important factor in considering the results of the scenarios was the smolt-to-adult survival rates (SAR) used in EDT. The SAR back to the spawning grounds in EDT has a huge effect on abundance, and changes or inaccuracies in SAR will skew the observed benefits from habitat restoration actions. The smolt to adult return rates (SAR) in EDT were developed during the subbasin planning process and we did not attempt to validate or alter them (www.nwppc.org). We reported the SAR with each model output so that fish performance measures could be put into perspective relative to the SAR used to generate it. The one case where we had an empirical estimate of SAR for a wild stock (Chiwawa spring Chinook) suggested that EDT overestimated the SAR and therefore the EDT projections of abundance relative the ICTRT minimum threshold would be overly optimistic or only representative of periods with relatively high ocean survival. Another perspective was that the EDT prediction represents a future condition where SAR's have improved due to decreased mortality in the Columbia River Mainstem, Estuary, or Ocean.

Productivity.—The EDT performance measure "Productivity" could not be directly compared to productivity on the ICTRT viability curve because EDT reports the slope of the Beverton-Holt stock recruitment function at the y-intercept (theoretically = 2 spawners), whereas the ICTRT viability curve requires a prediction of the hockey stick stock recruitment function at generally low abundances (above the y-intercept). Therefore, we will only discuss the relative trends in productivity and qualitatively evaluate if the changes might be adequate to achieve VSP.

Additionally, it is useful to examine the relative changes observed between EDT scenarios and to evaluate how much additional improvement might be possible based on the proportion of in-basin potential.

Diversity Index.—The life history diversity index in EDT is not directly comparable to spatial structure and diversity in a VSP risk assessment. The EDT diversity index should correlate with several of the ICTRT metrics for evaluating spatial structure and diversity; however, it cannot be compared directly to any of them. EDT did not consider genetic variation and the possible genetic influences of hatchery fish on the spawning grounds. The EDT diversity index is a measure of the proportion of historic life history pathways that are available to the fish populations. Its generated by first testing all possible (productivity > 1.0) life history trajectories under template conditions. A trajectory is a life history pathway that starts in one of the spawning reaches and moves through time and space in the environment that was defined by the reach structure and environmental attribute ratings. Complete methods for how MBI created, rejected, and accepted trajectories were not available for the Upper Columbia watersheds.

We will only discuss general trends in the change to the EDT diversity index with the assumption that large changes in the index were indicators and high proportions of in-basin potential were indicators that the restoration actions were effective at providing an opportunity for spatial structure and diversity to be expressed. We recognize that empirical estimates of changes to distribution, genotype, phenotype, spawner composition, and selective pressures will have to be monitored to determine the effectiveness of the actions at improving spatial structure and diversity for a viable salmonid population.

F.5 EDT Scenario Results and Comparison to VSP

F.5.1 Wenatchee Spring Chinook

Abundance.—The accuracy of EDT for spring Chinook in the Wenatchee was difficult to evaluate. The model output for abundance was considerably higher (1604 adult spawners) than the 12-year geometric mean (444 adult spawners; 1992-2003; **Table 2.1**). Much of this difference was due to an SAR that was too high in the EDT model. EDT used an SAR (back to the spawning grounds) of 1.36%, whereas recent studies on the Chiwawa River have estimated an 8-year geometric mean of only (0.63%). This empirical estimate of SAR would have dropped the adult abundance in EDT to 741 fish. Additionally, the variance of the abundance estimate was high with a standard deviation of 1225 fish and a coefficient of variation of 2.76. Therefore, we concluded that the EDT estimate was within an acceptable error range to be used for planning purposes, when compared to recent abundance estimates. Additionally, there could be other factors, such as genetic fitness, that are not accounted for in the modeling estimates.

Scenarios 1 and 3 predicted 69% and 56% increases in abundance, respectively, suggesting that both scenarios would be effective at moving the population abundance in a positive direction (**Table F15**; **Figure F8**). Scenario 3 captured 59% of the proportion of in-basin potential, whereas Scenario 1 captured 64%. We conducted a series of additional model runs to test the EDT model’s sensitivity to our assumptions and help explain the magnitude of the changes from current conditions to future conditions under each scenario. Additionally, we wanted to be able to explain why the model predicted relatively small differences between S1 and S3. See section F.6 for the results of these test model runs. In general, the small difference between S3 and S1 was because the large quantities of relatively pristine habitat in the Upper Wenatchee Mainstem, Tumwater Canyon, Chiwawa, White, and Little Wenatchee Rivers were mostly unaffected by the restoration action classes. Conversely, the habitat below Tumwater Canyon were smaller, shorter, and of lower quality so when a higher intensity of action class was applied, there was a relatively small improvement at the population scale.

Additionally, the same intensity of protection and obstruction action classes were applied to each scenario. Additional gains in abundance could be achieved by increasing the habitat quality in the lower and middle mainstem (below Tumwater Canyon) and by addressing secondary limiting factors (see section F.6 for details).

Table F15 Performance measures of Wenatchee spring Chinook based on EDT modeling scenarios using an SAR of 1.36% back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat, historic mainstem conditions. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available for this analysis

		Adult Performance					Juvenile Performance		
Population	**Scenario**	**Diversity index**	**Productivity**	**Capacity**	**Abundance**	**Abundance with 0.63% SAR**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**
Wenatchee Spring Chinook	Current without harvest	48%	4.4	2071	1604	741	236	170,763	117,619
	Scenario 3	75%	5.0	3,114	2,496	1,085	271	231,024	172,176
	Scenario 2								
	Scenario 1	78%	5.1	3,372	2,714	1,209	288	254,307	191,831
	PFC	81%	4.9	4,432	3,534	1,620	287	344,491	257,222
	Habitat Template	87%	6.5	4,990	4,221	1,922	376	377,537	305,060
	True Template	97%	26.8	23,978	23,084				

		Increase relative to current					Increase relative to current		
Wenatchee Spring Chinook	Current without harvest	0%	0%	0%	0%	0%	0%	0%	0%
	Scenario 3	55%	14%	50%	56%	46%	15%	35%	46%

Scenario 2								
Scenario 1	60%	16%	63%	69%	63%	22%	49%	63%
PFC	67%	11%	114%	120%	119%	22%	102%	119%
Habitat Template	79%	46%	141%	163%	159%	60%	121%	159%
True Template	100%	504%	1058%	1339%				

		Proportion of In-basin Potential					Proportion of In-basin Potential		
	Current without harvest	56%	68%	42%	38%	39%	63%	45%	39%
	Scenario 3	86%	78%	62%	59%	56%	72%	61%	56%
	Scenario 2								
Wenatchee Spring Chinook	Scenario 1	89%	79%	68%	64%	63%	76%	67%	63%
	PFC	93%	76%	89%	84%	84%	76%	91%	84%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%	100%
	True Template								

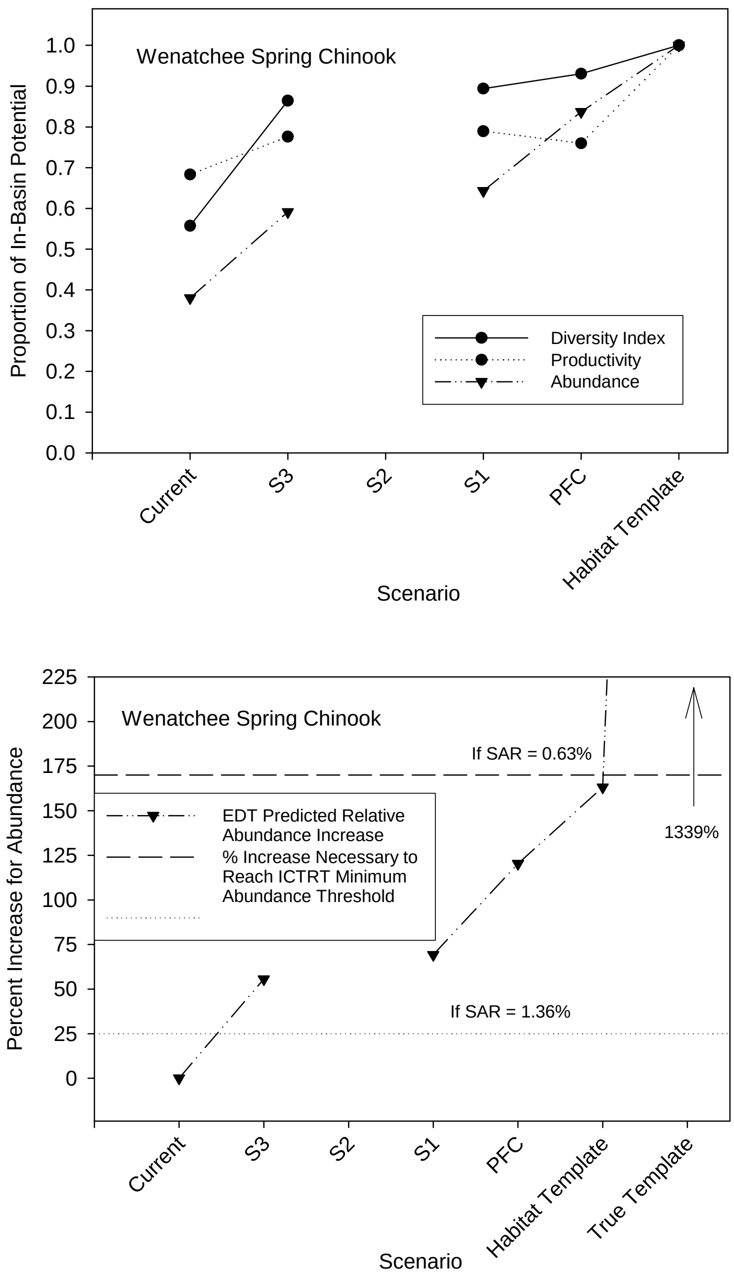


Figure F8. EDT model predictions for spring Chinook in the Wenatchee subbasin. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat and historic mainstem. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available at the time of this analysis. Alternative SAR values were based on those used in EDT (1.36%) and empirical estimates (0.63%).

The conclusions of our modeling scenarios stress the importance of protecting the intact habitat in the upper watershed, along with restoring the mainstem Wenatchee rearing areas for overwintering subyearling migrants. Although EDT predicted a relatively low benefit to abundance (and productivity) through restoration actions in the more degraded assessment units below Tumwater Canyon, these areas were determined to be important for spatial structure and diversity in the VSP risk assessment (particularly Peshastin Creek), so the value of restoring them should not be overlooked based on modeling results with respect to abundance.

The EDT model predicted that in-basin restoration and protection actions could achieve the ICTRT minimum threshold abundance (2000 spawners) for the Wenatchee spring Chinook population for scenarios 1 and 3 (**Figure F8**), assuming an SAR of 1.36%. However, with the empirically derived SAR from 1993-2000 (0.63%; WDFW unpublished data), both recovery scenarios and even the habitat template would not reach the minimum abundance threshold. Although the average of the five highest years SAR was 1.28% (1995-1999, 2001). These results stress the importance of integrating habitat-based productivity (smolts/redd) versus whole life cycle productivity (including SAR) to understand the mechanisms driving population performance related to recovery actions. Integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery abundance levels, especially when considered simultaneously with productivity using the viability curve.

Productivity.— The recovery actions increased the proportion of in-basin potential from 68% (Current) to 78% (S3) and 79% (S1). Additionally, the increase in productivity relevant to the current condition was 14% (S3) and 16% (S1), suggesting that both scenarios were effective at moving the population productivity in a positive direction but that neither had much room for improvement relevant to what is needed for recovery (**Table F15**). However, Wenatchee spring Chinook need to improve their productivity from 0.74 (12 yr geomean as of 1999) to 1.2 (viability curve minimum) which represents an increase of 62%. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Wenatchee subbasin, that would be adequate to achieve a viable population of spring Chinook with respect to productivity. Integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Increasing the restoration intensity (beyond S1) in the middle and lower mainstem did not improve productivity, as it did abundance. Additional gains in productivity were predicted with increased passive restoration in the upper watersheds and addressing secondary limiting factors such as competition, predation, and harassment (see section F.6).

Diversity Index.— The diversity index for spring Chinook in the Wenatchee basin improved from 48% to 75% for Scenario 3 and 78% for Scenario 1, indicating that the recovery scenarios effectively provided an opportunity for the expression of the majority of the life history pathways. All obstructions were made passable for both scenarios so the change in the diversity index from S3 to S1 was due to improved habitat quality in areas that affected survival of early or late migrating smolts or adults. Additional contributions to increased life history diversity came from increased survival of eggs and fry that were produced earlier or later than normal. See Appendix B to better understand the kinds of actions and improvements that would be needed to achieve low risk for spatial structure and diversity beyond the habitat related action classes that were modeled in EDT.

F.5.2 Entiat Spring Chinook

Action alternative 5 of the Entiat watershed plan represents Scenario 2 of this plan because it was the watershed group's mix and match of action classes and intensities. For consistency with the watershed plan, we will continue to refer to the recovery scenario for Entiat habitat as action alternative 5 (CCCD 2004). We could not analyze the Entiat with respect to the proportion of in-basin potential because there was not a habitat template model run in the watershed plan.

Abundance.—The EDT model predicted an abundance (138) of spring Chinook that was similar to empirical estimates (12-year geometric meant = 108 spawners; 1992-2003). Action alternative 5 increased the abundance of spring Chinook by 36% over current conditions but still fell short of the ICTRT minimum threshold by a considerable margin (262%).

Productivity.—The EDT model predicted a 5% increase in productivity for spring Chinook in the Entiat for scenario 5. To reach the ICTRT minimum abundance threshold the Entiat would need to improve its productivity from 0.76 to 1.4 (84%).

Diversity Index.—The EDT model predicted that the Entiat spring Chinook diversity index would increase from 35% (current) to 50% (action alternative 5).

F.5.3 Methow spring Chinook

Abundance.—The accuracy of EDT for spring Chinook in the Methow was difficult to evaluate due to the influence of hatchery fish. The EDT abundance (535) estimate was very close to the 12-year geometric mean abundance (480 spawners; 1988-1999). In recent years with higher abundance (2001 and 2002) there was 2200-8400 hatchery fish on the spawning grounds, making it impossible to determine if the natural population is responding to the capacity of the habitat.

Scenarios 1 and 3 predicted a 124% and 54% increase in abundance, respectively, suggesting that both scenarios were effective at moving the population abundance in a positive direction (**Table F16**; **Figure F9**). Scenario 3 only captured 36% of the in-basin potential, suggesting that there may be additional limiting factors that were not adequately addressed. This deficiency was probably not just a factor of intensity because Scenario 1 only utilized 53% of the in-basin potential with a relatively large gap between Scenario 1 and PFC (80%). Or, it could be that the effectiveness assumptions underestimated the effectiveness of the action classes. Future efforts should first determine the model input and processing mechanisms that lead to this discrepancy to determine if the difference makes sense with respect to ecological interactions or if the problem was with model application. To better understand the models sensitivity to our scenarios see the sensitivity analysis conducted on the Wenatchee populations.

The EDT model predicted that in-basin restoration and protection actions could not achieve the minimum threshold abundance (2000 spawners) for the Methow spring Chinook population under any scenario except Historic Template (**Figure F9**). This result was obtained with an SAR of 1.241% back to the spawning grounds, which was probably an overestimate because the 8-year (1993-2000) geometric mean SAR for wild Chiwawa River spring Chinook was only 0.63% and Chiwawa River fish have 2 fewer dams to negotiate. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Methow subbasin, that would be adequate to achieve a viable population of spring Chinook with respect to abundance. Integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Productivity.—The recovery actions increased the proportion of in-basin potential from 43% (Current) to 51% (S3) and 66% (S1). Additionally, the increase in productivity relevant to the current condition was 17% (S3) and 53% (S1), suggesting that both scenarios were effective at moving the population productivity in a positive direction (**Table F16**; **Figure F9**). However, Methow spring Chinook need to improve their productivity from 0.51 (12 yr geomean as of 1999) to 1.2 (viability curve minimum) which represents an increase of 135%. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Methow subbasin, that would be adequate to achieve a viable population of spring Chinook with respect to productivity. Integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Diversity Index.—The diversity index for spring Chinook in the Methow improved from 58% to 77% for Scenario 3 and 89% for Scenario 1 indicating that the modeling scenarios were effective at provided an opportunity for the expression of the majority of the life history pathways (**Table F16**). All obstructions were made passable for both scenarios so the change in the diversity index from S3 to S1 was due to improved habitat quality in areas that affected survival of early or late migrating smolts or adults. Additional contributions to increased life history diversity came from increased survival of eggs and fry that were produced earlier or later than normal. See Appendix B to better understand the kinds of actions

Table F16 Performance measures of Methow spring Chinook based on EDT modeling scenarios that used an SAR of 1.24 %, back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat, historic mainstem conditions. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available for this analysis

		Adult Performance				Juvenile Performance		
Population	Scenario	Diversity index	Productivity	Capacity	Abundance	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance
	Current without harvest	56%	1.9	1,116	535	122	84,045	36,802
	Scenario 3	77%	2.3	1,482	823	139	96,584	52,432
	Scenario 2							
Methow Spring Chinook	Scenario 1	89%	2.9	1,821	1,200	173	110,642	72,158
	PFC	91%	3.3	2,600	1,801	186	151,438	104,213
	Habitat Template	96%	4.4	2,922	2,263	249	168,097	129,483
	True Template	100%	22.9	10,874	10,400			
		% Increase relative to current				% Increase relative to current		
Methow Spring Chinook	Current without harvest	0%	0%	0%	0%	0%	0%	0%
	Scenario 3	39%	17%	33%	54%	14%	15%	42%
	Scenario 2							
	Scenario 1	60%	53%	63%	124%	41%	32%	96%

	PFC	64%	69%	133%	237%	52%	80%	183%
	Habitat Template	72%	131%	162%	323%	104%	100%	252%
	True Template	80%	1092%	875%	1844%			
		Proportion of In-basin Potential				**Proportion of In-basin Potential**		
	Current without harvest	58%	43%	38%	24%	49%	50%	28%
	Scenario 3	81%	51%	51%	36%	56%	57%	40%
	Scenario 2	NR	NR	NR	NR	NR	NR	NR
Methow Spring Chinook	Scenario 1	93%	66%	62%	53%	69%	66%	56%
	PFC	95%	73%	89%	80%	74%	90%	80%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%
	True Template	NA	NA	NA	NA	NA	NA	NA

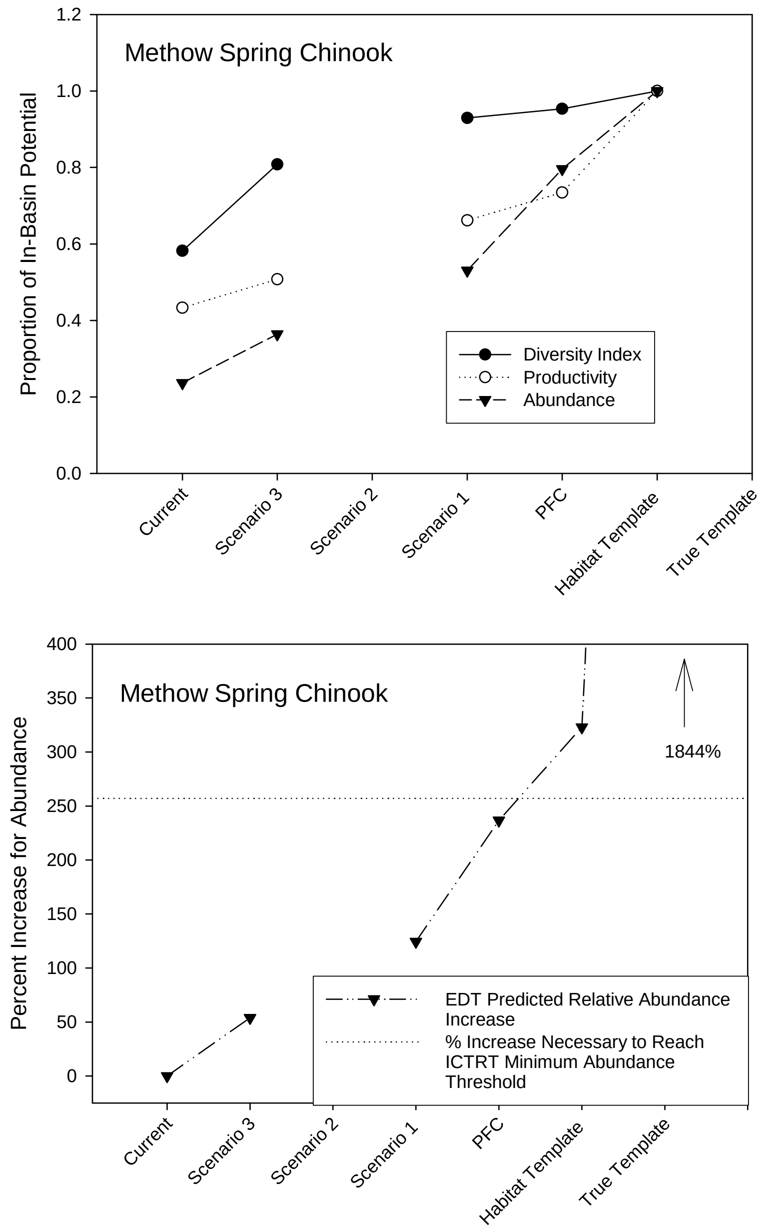


Figure F9. EDT model predictions for spring Chinook in the Methow subbasin, assuming an SAR of 1.24% back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat and historic mainstem. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available at the time of this analysis.

and improvements that would be needed to achieve low risk for spatial structure and diversity beyond the habitat related action classes that were modeled in EDT.

F.5.4 Wenatchee Steelhead

Abundance.— The accuracy of EDT and comparisons to empirical estimates for steelhead in the Wenatchee were difficult to evaluate due to the influence of hatchery fish and the uncertainty of actual spawners because redd counts were not available for a long enough time series. Regardless, the EDT abundance estimate (528) was fairly close to the 12-year geometric mean abundance of wild fish on the spawning grounds (716 spawners; 1992-2003; **Table 2.4**). Statistical tests would not be valid when comparing modeling results with unknown error bounds to empirical estimates; however, the empirical estimate has a standard deviation of 742 fish (not reported in **Table 2.4**). Therefore, given the high variance of the empirical estimate we assumed that the EDT model was an adequate representation of Wenatchee steelhead.

Scenarios 1 and 3 predicted a 102% and 89% increase in abundance, respectively, suggesting that both scenarios were effective at moving the population abundance in a positive direction (**Table F17**; **Figure F10**). A sensitivity model run revealed that the majority of the benefit to steelhead came from the obstruction removal (48%) and protection measures (11%)(section F.6). This would partially explain the relatively small difference between S1 and S3. S1 and S3 captured 66% and 62% of the in-basin potential, respectively, suggesting that there may be additional limiting factors that were not adequately addressed by the action classes that were applied to the limiting factors from the recovery matrix. See section F.5 for additional analysis of EDT attributes and model sensitivity for Wenatchee steelhead scenarios.

The EDT model predicted that in-basin restoration and protection actions would just barely achieve the minimum threshold abundance (1000 spawners) for the Wenatchee steelhead population for S3 and S1 (**Table F17**; **Figure F10**). This result was obtained with an SAR of 1.257% back to the spawning grounds, which was probably an overestimate of actual SAR (if the comparison of Chiwawa River spring Chinook SAR to EDT SAR correlates with steelhead). However, there are no data for empirical estimates of SAR for wild Wenatchee steelhead. Additionally, the model predicted changes that would not put abundance far enough past the minimum abundance threshold to achieve recovery with any certainty, particularly when incorporating the error bounds around the empirical estimate. Therefore, we conclude that the habitat recovery actions are not likely to achieve the VSP minimum abundance threshold suggested by the ICTRT and integration with the other 3 H's will be necessary to achieve recovery.

Productivity.—The recovery actions increased the proportion of in-basin potential from 65% (Current) to 70% (S3) and 72% (S1). We believe that achieving over 70% of the in-basin potential represents a very good level of achievement in the habitat, particularly considering that the PFC scenario resulted in 75% the in-basin potential and the PFC

Table F17 Performance measures of Wenatchee steelhead based on EDT modeling scenarios that used an SAR of 1.26%, back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat, historic mainstem conditions. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available for this analysis

		Adult Performance				Juvenile Performance		
Population	Scenario	Diversity index	Productivity	Capacity	Abundance	Juvenile Productivity	Juvenile Capacity	Juvenile Abundance
Wenatchee Steelhead	Current without harvest	25%	2.5	883	528	166	80,948	42,117
	Scenario 3	65%	2.7	1,590	1,000	171	119,590	70,344
	Scenario 2							
	Scenario 1	72%	2.8	1,668	1,068	176	124,419	74,812
	PFC	78%	2.9	2,021	1,321	182	149,971	92,397
	Habitat Template	85%	3.8	2,200	1,626	242	162,348	114,935
	True Template	91%	11.3	6,457	5,884			

		Increase relative to current				Increase relative to current		
Wenatchee Steelhead	Current without harvest	0%	0%	0%	0%	0%	0%	0%
	Scenario 3	164%	8%	80%		3%	48%	67%
	Scenario 2				89%			

	Scenario 1	192%	12%	89%	102%	6%	54%	78%
	PFC	218%	16%	129%	150%	10%	85%	119%
	Habitat Template	245%	54%	149%	208%	46%	101%	173%
	True Template	270%	354%	631%	1014%			

		Proportion of In-basin Potential				Proportion of In-basin Potential		
Wenatchee Steelhead	Current without harvest	29%	65%	40%	32%	69%	50%	37%
	Scenario 3	77%	70%	72%	62%	71%	74%	61%
	Scenario 2							
	Scenario 1	85%	72%	76%	66%	73%	77%	65%
	PFC	92%	75%	92%	81%	75%	92%	80%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%

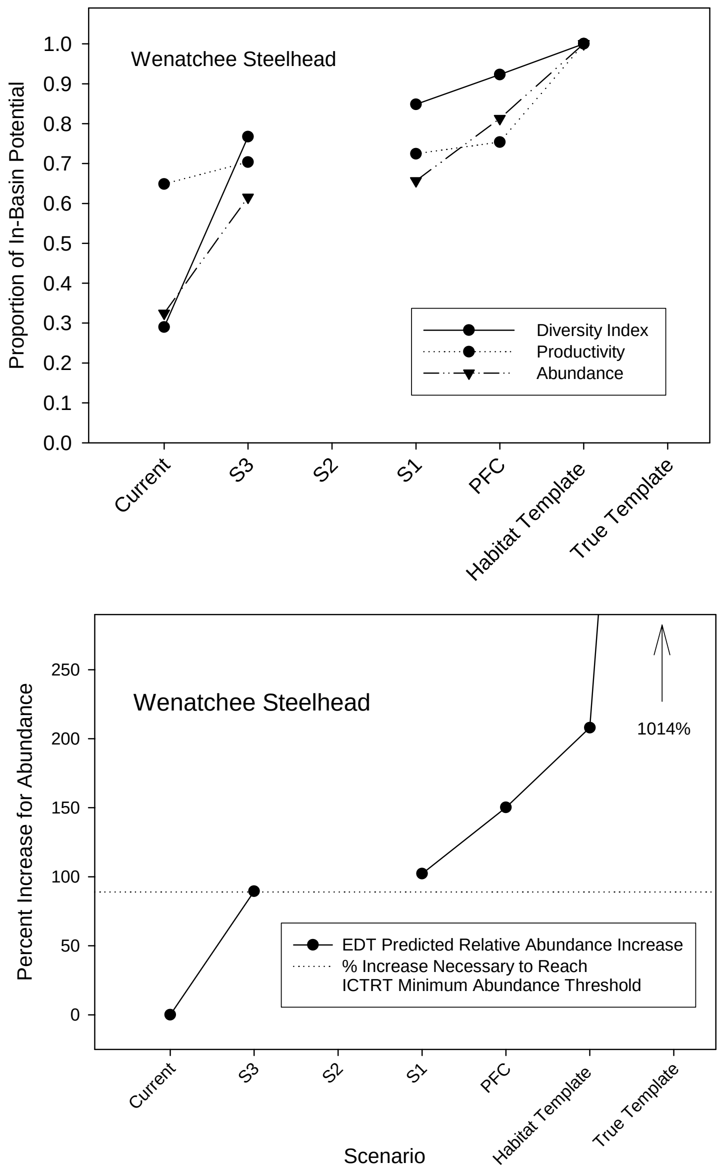


Figure F10. EDT model predictions for steelhead in the Wenatchee subbasin, assuming an SAR of 1.26% back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat and historic mainstem. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available at the time of this analysis. Alternative SAR values were based on those used in EDT (1.36%) and empirical estimates (0.63%).

attribute ratings were generally considered unrealistic based on societal constraints. The increase in productivity relevant to the current condition was 8% (S3) and 12% (S1), suggesting that both scenarios were effective at moving the population productivity in a positive direction (**Table F17**; **Figure F10**). However, Wenatchee steelhead need to improve their productivity from between 0.25 and 0.81 (depending on hatchery fish contribution (12 yr geomean as of 1999) to 1.2 (viability curve minimum threshold assuming adequate abundance) which represents an increase of between 48% and 380%. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Wenatchee subbasin, that would be adequate to achieve a viable population of steelhead with respect to productivity. Therefore, integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Diversity Index.—The diversity index for steelhead in the Wenatchee improved from 25% (current) to 65% for Scenario 3 and 72% for Scenario 1 indicating that the recovery scenarios effectively provided an opportunity for the expression of the majority of the life history pathways. All obstructions were made passable for both scenarios so the small change in the diversity index from S3 to S1 was due to improved habitat quality in areas that affected survival of early or late migrating smolts or adults. Additional contributions to increased life history diversity came from increased survival of eggs and fry that were produced earlier or later than normal. See Appendix B to better understand the kinds of actions and improvements that would be needed to achieve low risk for spatial structure and diversity beyond the habitat related action classes that were modeled in EDT.

F.5.5 Entiat Steelhead

Steelhead were not modeled in EDT as part of any previous planning process, although the 2514 watershed planning group did expand the Chinook reaches to cover areas accessible to steelhead. They also rated the environmental attributes in those reaches. We completed the life history assumptions and conducted baseline model runs for current, PFC, habitat template, and true template scenarios. However, we did not model the recovery scenarios (S1, S3) or the watershed plans action alternative 5. In general, we assume that the model would predict similar increases for steelhead as it did for spring Chinook, based on similar relative performance increases in the other Upper Columbia populations. We present a brief description of the results for the baseline and PFC model runs to serve as an indicator regarding the likelihood of achieving recovery by implementing restoration and protection actions in the habitat. This information is not published but is available online (www.mobrand.com)

The EDT model failed to produce enough viable trajectories to sustain a population of steelhead in the Entiat with a productivity greater than 1.0. Therefore, a current abundance estimate could not be generated. EDT predicted an abundance of 244 adult spawners using the default PFC habitat conditions and 321 fish with the habitat template conditions. These results were considered generally consistent with the observation that current abundance was less than 100 fish, based on the 12-year geometric mean and recent redd counts.

Therefore, based on the observation that our recovery scenarios always result in fewer fish than the PFC and habitat template conditions; we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Entiat subbasin, that would be adequate to achieve a viable population of steelhead with respect to abundance or productivity. Integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

F.5.6 Methow Steelhead

Abundance.— The accuracy of EDT and comparisons to empirical estimates for steelhead in the Methow were difficult to evaluate due to the influence of hatchery fish and the uncertainty of actual spawners because comprehensive redd counts were unavailable for a long time series. The EDT abundance estimate (724) was considerably higher than the 12-year geometric mean abundance (202 spawners; 1991-2002; **Table 2.4**). However, the EDT model used an SAR (back to the spawning grounds) of 1.032% which may have been an overestimate of actual SAR. Unfortunately, no empirical data exists for SAR of wild steelhead in the Methow. However, for Wenatchee spring Chinook the SAR used in EDT was more than twice that observed for wild fish. If the SAR in the model had been reduced in half (0.52%) then the current EDT abundance estimate would have been 363 fish. Therefore, considering the unknown influence of hatchery fish affecting capacity and productivity and the uncertainty of the correct SAR we assumed that the EDT model was an adequate representation of Methow steelhead.

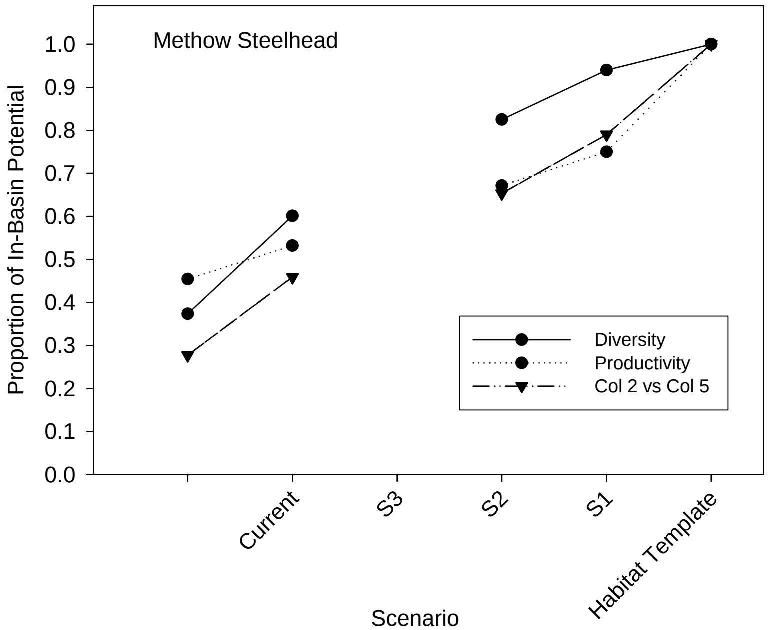
Scenarios 1 and 3 predicted a 136% and 65% increase in abundance, respectively, suggesting that both scenarios were effective at moving the population abundance in a positive direction (**Table F18**; **Figure F11**). Scenario modeling predicted the population would move from 28% (current) of the in-basin potential to 46% (S1) and 65% (S1) of the in-basin potential, respectively. Although this is a considerable change, the gap between S1 and PFC suggests that there may be additional limiting factors that were not adequately addressed by the restoration action classes used in this modeling effort. Or, it could be that the effectiveness assumptions underestimated the effectiveness of the action classes. Future efforts should first determine the model input and processing mechanisms that lead to this discrepancy to determine if the difference makes sense with respect to ecological interactions, or if the problem was with model application. To better understand the models sensitivity to our scenarios see the sensitivity analysis conducted on the Wenatchee populations (section F.6).

The EDT model predicted that in-basin restoration and protection actions could achieve the minimum threshold abundance (1000 spawners) for the Methow steelhead population for both Scenario 1 and Scenario 3, assuming the average SAR (back to the spawning grounds was at least 1.03% (**Figure F11**). However, S3 only exceeded the ICTRT minimum threshold by 12% and coefficient of variation (using 1 standard deviation) of the empirical estimate was 91%. This suggests that a restoration action plan with an intensity near or greater than S1 might be necessary to achieve an abundance that has a high probability of achieving the ICTRT minimum abundance threshold. Therefore,

Table F18. Performance measures of Methow steelhead based on EDT modeling scenarios that used an SAR of 1.03%, back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat, historic mainstem conditions. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available for this analysis

		Adult Performance				Juvenile Performance		
Population	**Scenario**	**Diversity index**	**Productivity**	**Capacity**	**Abundance**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**
	Current without harvest	33%	1.4	2,407	724	131	270,926	70,316
	Scenario 3	54%	1.7	2,971	1,198	150	303,973	112,886
	Scenario 2							
Methow Steelhead	Scenario 1	74%	2.1	3,236	1,706	187	326,336	161,326
	PFC	84%	2.4	3,578	2,060	205	356,010	192,991
	Habitat Template	89%	3.1	3,827	2,612	269	376,265	245,092
	True Template	94%	11.3	13630	12422	NR	NR	NR
		% Increase relative to current				**% Increase relative to current**		
Methow Steelhead	Current without harvest	0%	0%	0%	0%	0%	0%	0%
	Scenario 3	61%	17%	23%	65%	14%	12%	61%

	Scenario 2							
	Scenario 1	121%	48%	34%	136%	43%	20%	129%
	PFC	151%	65%	49%	185%	56%	31%	174%
	Habitat Template	168%	120%	59%	261%	105%	39%	249%
	True Template	181%	690%	466%	1615%	NR	NR	NR
		Proportion of In-basin Potential				**Proportion of In-basin Potential**		
Methow Steelhead	Current without harvest	37%	45%	63%	28%	49%	72%	29%
	Scenario 3	60%	53%	78%	46%	56%	81%	46%
	Scenario 2							
	Scenario 1	83%	67%	85%	65%	69%	87%	66%
	PFC	94%	75%	93%	79%	76%	95%	79%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%



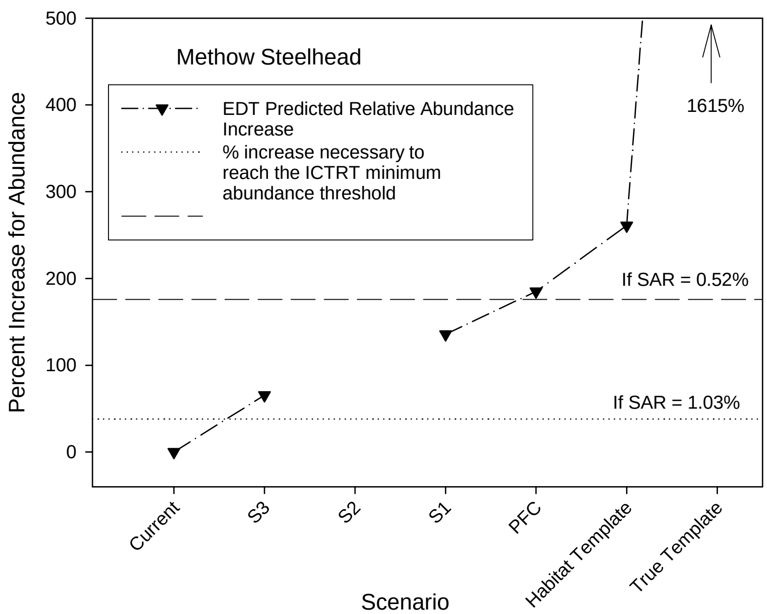


Figure F11. EDT model predictions for steelhead in the Methow subbasin, assuming 2 different SAR values. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat and historic mainstem. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available at the time of this analysis.

considering the variance of the empirical estimate and the uncertainty of the actual SAR for wild Methow steelhead we believe that integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Productivity.—The recovery actions increased the proportion of in-basin potential from 45% (current) to 53% (S3) and 67% (S1). We believe that achieving over 60% of the in-basin potential represents a very good level of achievement in the habitat, particularly considering that the PFC scenario resulted in 75% the in-basin potential and the PFC attribute ratings were generally considered unrealistic based on societal constraints. The increase in productivity relevant to the current condition was 17% (S3) and 48% (S1), suggesting that both scenarios were effective at moving the population productivity in a positive direction (**Table F18**; **Figure F11**). However, Methow steelhead need to improve their productivity from between 0.09 and 0.84 (depending on hatchery fish contribution (12 yr geomean as of 1996; **Table 2.6**) to 1.2 (viability curve minimum threshold for a basic population, assuming adequate abundance) which represents an increase of between 43% and 1233%. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Methow subbasin, that would be adequate to achieve a viable population of steelhead with respect to productivity. Therefore, integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Diversity Index. — The diversity index for steelhead in the Methow improved from 33% to 54% for Scenario 3 and 74% for Scenario 1 indicating that the recovery scenarios effectively provided an opportunity for the expression of the majority of the life history pathways. All obstructions were made passable for both scenarios so the change in the diversity index from S3 to S1 was due to improved habitat quality in areas that affected survival of early or late migrating smolts or adults. Additional contributions to increased life history diversity came from increased survival of eggs and fry that were produced earlier or later than normal. See Appendix B to better understand the kinds of actions and improvements that would be needed to achieve low risk for spatial structure and diversity beyond the habitat related action classes that were modeled in EDT.

Okanogan steelhead

Abundance.— The accuracy of EDT and comparisons to empirical estimates for steelhead in the Okanogan were difficult to evaluate due to the influence of hatchery fish and the uncertainty of actual spawners because redd counts were unavailable. Regardless, the EDT abundance estimate (61) was very close to the 12-year geometric mean abundance (53 spawners; 1991-2002; **Table 2.4**). Therefore, we assumed that the EDT model was an adequate representation of Okanogan steelhead.

Scenarios 1 and 3 predicted a 377% and 281% increase in abundance, respectively, suggesting that both scenarios were effective at moving the population abundance in a positive direction (**Table F19**; **Figure F12**). Scenario modeling predicted the population would move from 15% (current) of the in-basin potential to 72% (S1) and 57% (S3) of the in-basin potential. Although no test model runs were conducted, it is assumed that the vast majority of the increase in abundance was due to providing access to the blocked habitat in Salmon and Omak Creeks (based on 100% barrier removal with the S3 scenario).

The EDT model predicted that in-basin restoration and protection actions in the US portion of the Okanogan steelhead population would not achieve the minimum threshold abundance (500 spawners for US portion) (**Table F19**; **Figure F12**). This result was obtained with an SAR of 0.915% back to the spawning grounds, which was probably an overestimate of actual SAR (if the comparison of Chiwawa River spring Chinook SAR to EDT SAR correlates with Okanogan steelhead). However, there are no data for empirical estimates of SAR for wild Okanogan steelhead.

Productivity.—The recovery actions increased the proportion of in-basin potential from 46% (current) to 68% (S3) and 76% (S1). We believe that achieving over 60% of the in-basin potential represents a very good level of achievement in the habitat, particularly considering that the PFC scenario resulted in 75% the in-basin potential and the PFC attribute ratings were generally considered unrealistic based on societal constraints. The increase in productivity relevant to the current condition was 49% (S3) and 66% (S1), suggesting that both scenarios were effective at moving the population productivity in a positive direction (**Table F19**; **Figure F12**). However, Okanogan steelhead need to improve their productivity from between 0.09 and 0.84 (depending on hatchery fish contribution (12 yr geomean as of 1996; **Table 2.6**) to 1.4 (viability curve minimum threshold for a basic population, assuming adequate abundance) which represents an increase of between 67% and 1400%. Therefore, we conclude that there is no combination of restoration and protection actions to habitat conditions, within the Okanogan subbasin, that would be adequate to achieve a viable population of steelhead with respect to productivity. Therefore, integration of the habitat actions identified in this plan with the other 3 H's will be necessary to achieve recovery.

Diversity Index. —The diversity index for steelhead in the Okanogan improved from 1% (current) to 29% for Scenario 3 and 49% for Scenario 1 indicating that there was still considerable impediments to life history pathways for Okanogan steelhead, even under the improved habitat conditions. However, the improved habitat conditions represented 50% (S3) to 85% (S1) of the in-basin potential, indicating that out-of-subbasin factors were a strong driver in achieving a high diversity index score in EDT.

Table F19 Performance measures of Okanogan steelhead based on EDT modeling scenarios that used an SAR of 1.03%, back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat, historic mainstem conditions. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available for this analysis

		Adult Performance				Juvenile Performance		
Population	**Scenario**	**Diversity index**	**Productivity**	**Capacity**	**Abundance**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**
Okanogan Steelhead US and Canada	Current without harvest	1%	1.9	127	61	178	17,323	6,650
	Scenario 3	29%	2.9	355	231	247	38,124	22,851
	Scenario 2							
	Scenario 1	49%	3.2	422	290	277	44,740	28,717
	PFC	55%	3.1	492	335	272	51,375	32,846
	Habitat Template	58%	4.2	531	405	361	54,940	39,914
	True Template	60%	15.1	2,469	2,305			

		% Increase relative to current				**% Increase relative to current**		
Okanogan Steelhead US and Canada	Current without harvest	0%	0%	0%	0%	0%	0%	0%
	Scenario 3	3144%	49%	181%	281%	39%	120%	244%
	Scenario 2							

	Scenario 1	5379%	66%	234%	377%	56%	158%	332%
	PFC	6030%	64%	289%	453%	53%	197%	394%
	Habitat Template	6333%	118%	320%	567%	103%	217%	500%
	True Template	6570%	686%	1851%	3698%			
		Proportion of In-basin Potential				Proportion of In-basin Potential		
	Current without harvest	2%	46%	24%	15%	49%	32%	17%
	Scenario 3	50%	68%	67%	57%	68%	69%	57%
	Scenario 2							
Okanogan Steelhead US and Canada	Scenario 1	85%	76%	80%	72%	77%	81%	72%
	PFC	95%	75%	93%	83%	75%	94%	82%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%
	True Template							

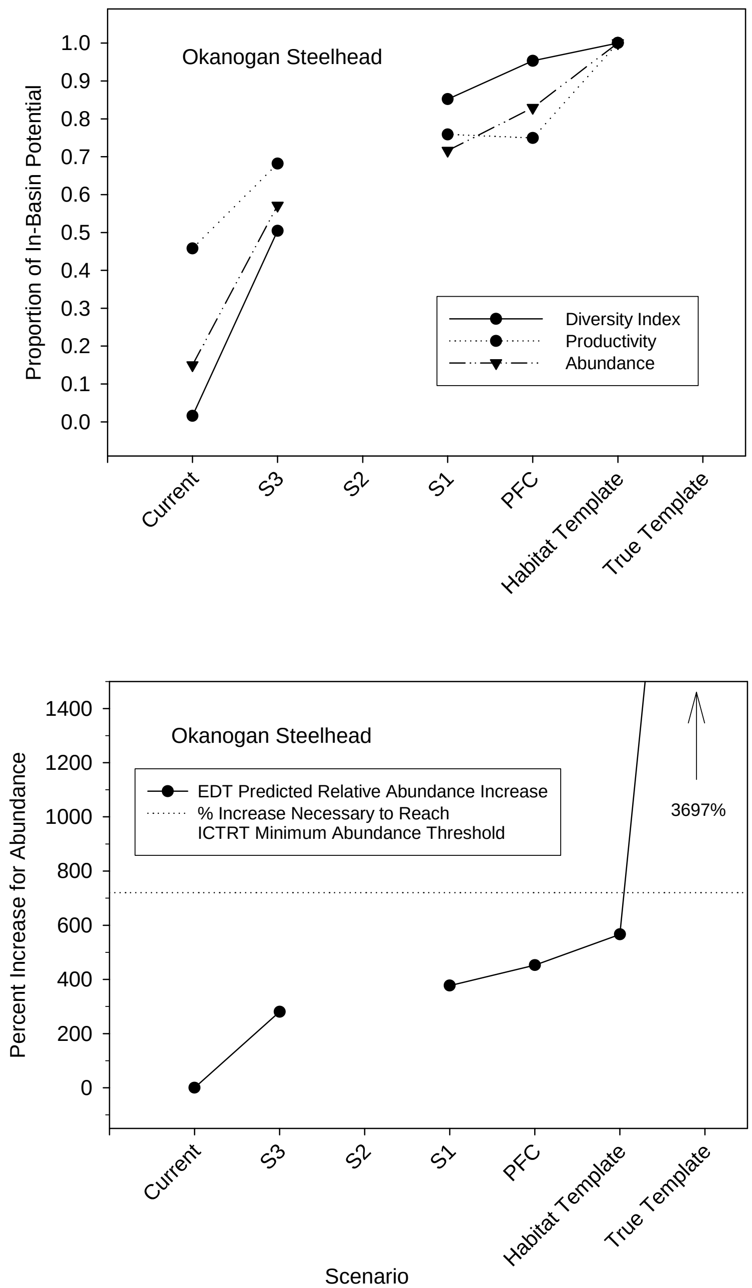


Figure F12. EDT model predictions for steelhead in the Okanogan subbasin, assuming an SAR of 0.92%, back to the spawning grounds. Scenario 1 (S1) applied the full effectiveness of the restoration action classes that addressed primary limiting factors within each assessment unit. Scenario 3 (S3) was 33% of the intensity of S1, with full effect of artificial barrier removal and protection. PFC was properly functioning conditions, the habitat template was historic pristine habitat with current mainstem conditions, and true template was historic habitat and historic mainstem. Scenario 2 (S2) (assessment unit specific intensities based on feasibility) was not available at the time of this analysis.

F.6 EDT Model Sensitivity in the Wenatchee Subbasin

We evaluated several aspects of model sensitivity in the Wenatchee Subbasin in relation to performance predictions for spring Chinook and steelhead. We did not attempt to test general EDT model sensitivity or validate the algorithms in EDT that link habitat conditions to life stage specific survival. The algorithms that link fish performance to habitat conditions can be found at www.mobrand.com. Our goal was to better understand what EDT did with the information we provided. Additionally, we did not attempt any statistical analysis so our conclusions are purely descriptive and to provide the opportunity for review, understanding, and improvement. We could only focus this analysis on one subbasin (2 populations) due to time constraints. Although it was possible that some of the general conclusions from this analysis would apply to the other subbasins, we highly recommend that each individual population has its own sensitivity analysis. This will provide local biologists, stakeholders, and planners the understanding of the strengths, weaknesses, and limitations of EDT as it applies to each watershed and population. We recognize that the information in this section is incomplete and we suggest that the entire Columbia Basin needs to establish a set of standardized analysis protocols and sensitivity tests for watershed level population modeling efforts for EDT and/or any other model that is used to predict changes in fish performance from implementation of actions in the habitat.

Our specific objectives were to evaluate…

1. Contributions of select environmental attributes to fish performance
2. Interactions of environmental attribute ratings and action effectiveness
3. Action class effects to scenario results

F.6.1 Contributions of Select Environmental Attributes to Fish Performance

We evaluated the contributions of select environmental attributes to fish performance to understand why the information we put into EDT led to the model results for the diagnosis portion of the assessment (section F.1 of this Appendix). We interpreted the output and categorized survival factors (groups of environmental attributes) as primary, secondary, or not limiting factors. This assessment was then considered in concert with other assessments (Subbasin Plan, Biological Strategy) to identify the limiting factors for each assessment unit in the Recovery Matrix (**Table 5.7**).

We first examined the attribute ratings that contributed to limiting factors in one or more assessment units. To do this we calculated the average difference between template and current (T-C) ratings for each attribute. This provided insight to how attributes were rated and how much change there was from template conditions. This assessment was conducted across all reaches, however, we recognize that conditions were generally degraded (or pristine) in certain subwatersheds so there was a pattern of T-C variance that we did not account for. Additionally, a change of 0.5, 1 or 2 is not the same for every attribute because each of differences in units and because the survival curves are not linear (**Table F15**).

The average T-C value was 0.58, however, this included many attributes that were not relevant for this analysis (natural hydrologic regime, natural confinement, gradient) or were considered not applicable in the Wenatchee (hydrologic regime-regulated) (**Table F20**). A subset of attributes that were generally thought to contribute to limiting factors averaged 0.76, indicating that an average change in the EDT score less than 1 could still have notable impacts to population performance (**Table F20**). Because the data for these results were non-normal, we also plotted the distribution of the average T-C variance for a subgroup of attributes (**Figure F13**). This simply points out that the majority of reaches were rated very similar (< 0.5) between current and template, with select reaches (or assessment units) where larger deviations from the template were applied. Finally, several attributes had an average T-C variance greater than 1, but were not generally considered a limiting factor. Defining all the relationships between attribute ratings, performance measures and the Strategic Priority Summary (consumer reports, big dot-little dot graphics) provided in the diagnosis were beyond the time and financial scope of this analysis.

Therefore, we conducted individual model runs on select attributes and changed the attribute score from current to template value in every reach. For each model run, all other attributes were left at their respective score for current conditions. The model was then re-run and the change to each performance measure was documented. This method did not identify the correlated and synergistic relationships between attributes that are part of the hard-wired model relationships; therefore, the sum of the individual performance increases could be greater than 100%. These results indicated that many of the attributes thought to be primary limiting factors from the diagnosis did result in larger opportunities for improvement of the 3 performance measures (**Table F21**). However, several attributes that were identified as limiting factors in certain assessment units showed negligible change at the population level. For example, temperature increases in Mission, Peshastin, and Chumstick Creeks were identified as limiting factors for these assessment units, but simply changing the temperature to template conditions (for the whole subbasin) did not improve performance of either species by more than 0.32% for any performance measure (**Table F21**). Conversely, several attributes that appeared to be secondary limiting factors in the Strategic Priority Summary (consumer reports, big dot-little dot graphics) had the potential to change the performance of the performance measures by greater than or equal to many of the primary limiting factors. For example, the attributes benthic diversity and production and salmon carcasses were rated relatively poorly (T-C > 1) but were considered secondary limiting factors because there were no “big hits” on the Strategic Priority Summary for the survival factor “food”. Additionally, nutrient limitations were not identified as a recommended management action in the Biological Strategy (RTT 2003). However, increasing benthic productivity and salmon carcasses to template conditions in all reaches resulted in the largest increases in population performance for abundance of both species and for productivity of spring Chinook. The final factor that must be taken into consideration is the certainty of the inputs for these environmental attributes. The level of proof analysis/description revealed that the majority of reaches were rated with derived information or expert opinion for both benthic macroinvertebrates and salmon carcasses, rather than empirical data (section F.1). Therefore, the coarse of action for addressing nutrient limitations depends on the risks associated with implementation based on a “false positive”. Finally, some attributes had a relatively high T-C variance but had little or no effect in individual assessment units or at the population scale. An example of this situation was the attribute “water withdrawals”. The average T-C variance (1.44) was among the highest of the 46 attributes but it had virtually no effect at the assessment unit or population scale. This result was a function of the EDT model not being sensitive to the attribute ratings in the range that we used, regardless of the magnitude of change between current and historic.

Table F20. The average difference between template (estimated historic) and current conditions for the 46 EDT environmental attributes from 119 reaches in the Wenatchee River subbasin. Habitat types and channel widths and lengths were not included in the averages because they were entered in % and ft, respectively, rather than a transformed EDT score. Definitions for EDT attribute scores can be found at www.mobrand.com)

Attribute #	EDT Environmental Attribute Name		Average (T-C)	Max (T-C)
1	Alkalinity		0.00	0.0
2	Bed scour	*	0.05	1.1
3	Benthos diversity and production	**	3.00	3.0
4	Channel length		0.0	0.0
5	Channel width - month maximum width (ft)		-1.2	-51.9
6	Channel width - month minimum width (ft)		2.2	25.0
7	Confinement – Hydromodifications	*	1.93	4.0
8	Confinement - natural		0.00	0.0
9	Dissolved oxygen		0.00	0.0
10	Embeddedness		0.90	1.5
11	Fine sediment	*	0.87	3.0
12	Fish community richness		0.02	1.0
13	Fish pathogens		0.62	2.0
14	Fish species introductions	**	1.02	2.0
15	Flow - change in average annual peak flow		0.26	0.6
16	Flow - change in average annual low flow	*	0.28	1.5

17	Flow - Intra daily (diel) variation		0.03	3.0
18	Flow - intra-annual flow pattern		0.26	0.6
19	Gradient		0.00	0.0
20	Habitat type - backwater pools		1%	5%
21	Habitat type - beaver ponds		1%	10%
22	Habitat type - glide		3%	-33%
23	Habitat type - large cobble/boulder riffles		15%	-48%
24	Habitat type - off-channel habitat factor		3%	25%
25	Habitat type - pool tailouts.		1%	6%
26	Habitat type - primary pools		10%	43%
27	Habitat type - small cobble/gravel riffles		5%	26%
28	Harassment	**	1.79	3.0
29	Hatchery fish outplants	**	1.77	4.0
30	Hydrologic regime - natural		0.00	0.0
31	Hydrologic regime - regulated		0.00	0.0
32	Icing		0.01	1.0
33	Metals - in water column		0.10	1.0
34	Metals/Pollutants - in sediments/soils		0.13	1.0
35	Miscellaneous toxic pollutants - water column		0.21	2.0
36	Nutrient enrichment		0.32	2.5
37	Obstructions to fish migration		NA	
38	Predation risk		0.55	2.0

39	Riparian function	*	0.89	3.5
40	Salmon Carcasses	**	1.01	3.0
41	Temperature - daily maximum (by month)	*	0.04	0.2
42	Temperature - daily minimum (by month)		0.11	2.0
43	Temperature - spatial variation	*	0.45	2.0
44	Turbidity		0.18	1.0
45	Water withdrawals	**	1.44	2.0
46	Wood	*	1.56	4.0
		Grand Mean =	0.58	
	*Attributes generally associated with limiting factors; mean =		0.76	

**Other attributes generally not classified as “primary" but with anaverage T-C > 1

Table F21. Percent change in population performance for three performance measures for spring Chinook and Steelhead in the Wenatchee River subbasin EDT model. Each attribute's (or attribute group) EDT score was increased to template conditions (estimate of historic/pristine) and the model was re-run with current conditions for all other attributes

		% Increase under Template Conditions					
		Wenatchee Spring Chinook			Wenatchee Steelhead		
	Attribute(s) name	Diversity Index	Productivity	Abundance	Diversity Index	Productivity	Abundance
Common EDT Attributes Contributing (or thought to contribute) to Primary Limiting Factors	Fine sediment & Embeddedness	14.9%	8.9%	9.0%	40.3%	8.9%	4.5%
	Obstructions to fish migration	9.5%	0.0%	10.4%	30.8%	-4.1%	41.4%
	Confinement – Hydromodifications	6.0%	7.0%	19.0%	23.0%	2.0%	7.0%
	Riparian function	5.0%	5.0%	18.0%	21.0%	2.0%	11.0%
	Wood	9.9%	3.8%	15.5%	19.6%	2.8%	7.9%
	Habitat type - primary pools	0.0%	-0.6%	8.7%	0.3%	0.1%	-0.2%
	Key habitat types (all 7 habitat types)	0.0%	-0.7%	7.7%	0.3%	0.1%	1.1%
	Temperature - spatial variation	0.00%	0.03%	0.26%	0.16%	-0.05%	0.18%
	Bed scour	0.00%	0.01%	0.02%	0.16%	0.01%	0.04%
	Low Flow	0.00%	0.00%	0.11%	0.08%	0.00%	0.08%
	Temperature - daily maximum (by month)	0.00%	0.00%	0.32%	0.08%	0.01%	0.15%

	Benthos diversity and production & Salmon Carcasses	1.7%	12.1%	22.8%	11.9%	8.6%	30.5%
	Hatchery Fish Outplants	1.5%	5.1%	4.7%	12.8%	3.3%	2.5%
	Predation risk	1.0%	2.5%	2.6%	2.3%	1.0%	1.1%
	Fish Species Introductions (exotics)	0.6%	1.6%	2.1%	4.6%	1.5%	1.2%
Select "other" EDT Attributes	Harassment	0.1%	0.2%	0.5%	1.3%	0.9%	2.5%
	Habitat type - pool tailouts.	0.00%	0.02%	0.01%	0.00%	0.00%	0.24%
	Minimum Width	0.0%	0.0%	2.1%	0.1%	-0.1%	3.5%
	Flow - change in average annual peak flow & Flashy Flow	0.00%	-0.02%	0.04%	0.24%	0.12%	0.12%
	Habitat type - off-channel habitat factor	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Water withdrawals (entrainment impingement)	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

*19 additional environmental attributes were not tested for sensitivity due to time constraints and because they were perceived as not being as important as the 27 attributes shown here. For a complete list go to www.mobrand.com.

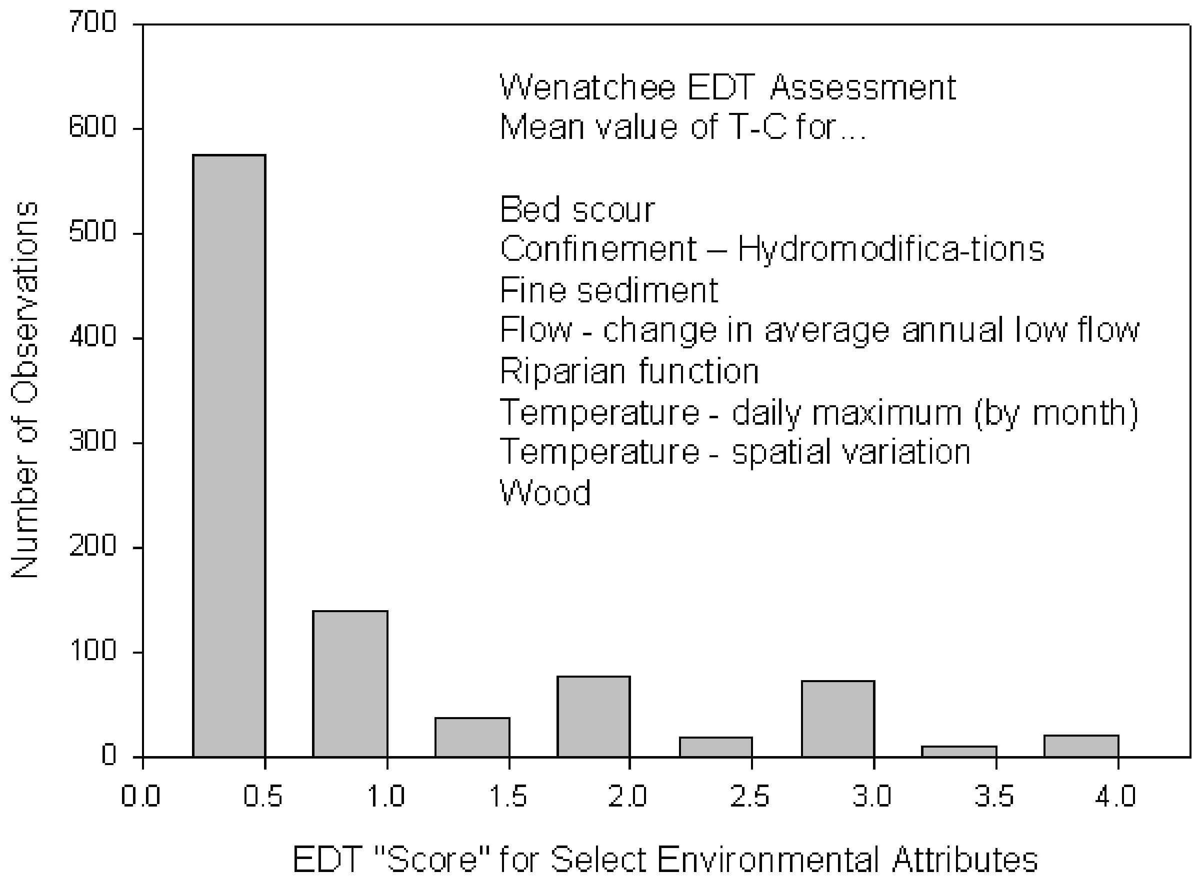


Figure F13. The difference between template (T) and current (C) attribute scores for select environmental attributes that contributed to habitat limiting factors during the "diagnosis" phase of Ecosystem Diagnosis and Treatment

F.6.2 Interactions of Environmental Attribute Ratings and Action Effectiveness

In section F.2 we described the process of defining effectiveness, using an intensity multiplier, and changing the current attribute score within the constraints of the template conditions. Sections F.3 and F.4 defined the scenarios that were modeled and the methods used to analyze and interpret the results of the model output. Finally, section F.5 provided the population specific results for the scenario modeling in all the Upper Columbia populations. In those results, there was a relatively small difference between the S1 and S3 scenarios, despite the fact that S3 had been defined as 33% of the intensity of S1. In this section we will describe how effectiveness and intensity are interacting with the restoration potential (T-C) for particular attributes in our EDT scenarios.

The greatest change to an attribute score occurs when;

1. The restoration (T-C) potential for the environmental attribute is high
2. The effectiveness of the action is high
3. The intensity of the application is high

Using the formula defined previously;

$$N_i = C_i + [(T_i - C_i)*(E*I)]$$

It is only possible to obtain a new attribute value (N_i) equal to the template score when both effectiveness and intensity are 1.0. Therefore, the greater the difference between template and current the greater the magnitude of change to the attribute score (**Table F22**). Likewise, when the intensity was held constant, then increasing effectiveness would increase the magnitude of change between current and template (**Figure F14**). Relatively small differences occurred to the attribute score when the effectiveness was less than 0.3 and when the restoration potential was low.

In the Wenatchee EDT analysis, the average T-C value was 0.56 indicating that the restoration potential was generally small. Additionally, the majority (85%) of action effectiveness designations were ≤ 30% (**Figure F7**). Therefore, absolute change between S1 (100% intensity) and S3 (33% intensity) was usually very small (**Figure F14**). However, in some assessment units where conditions were degraded, the difference between S1 and S3 was quite large (**Table F23**). The algorithms used in EDT to link habitat conditions with fish performance were not linear, so relatively large gains in survival could be obtained from small improvements in habitat conditions and vice versa (**Figure F15**; www.mobrand.com).

Table F22 A hypothetical example of changes to environmental attribute scores when various intensities of actions (S1 = 100%; S3 = 33%) were applied to current and template scores, assuming constant action effectiveness

		EDT Attribute "score"			
Environmental Attributes	**Action Effectiveness**	**Current**	**Template**	**S1**	**S3**
Bed Scour	30%	0	0	0.0	0.0
Riparian Function	30%	1	0	0.7	0.9
Wood	30%	2	0	1.4	1.8
Embeddedness	30%	3	0	2.1	2.7
Fine Sediment	30%	4	0	2.8	3.6

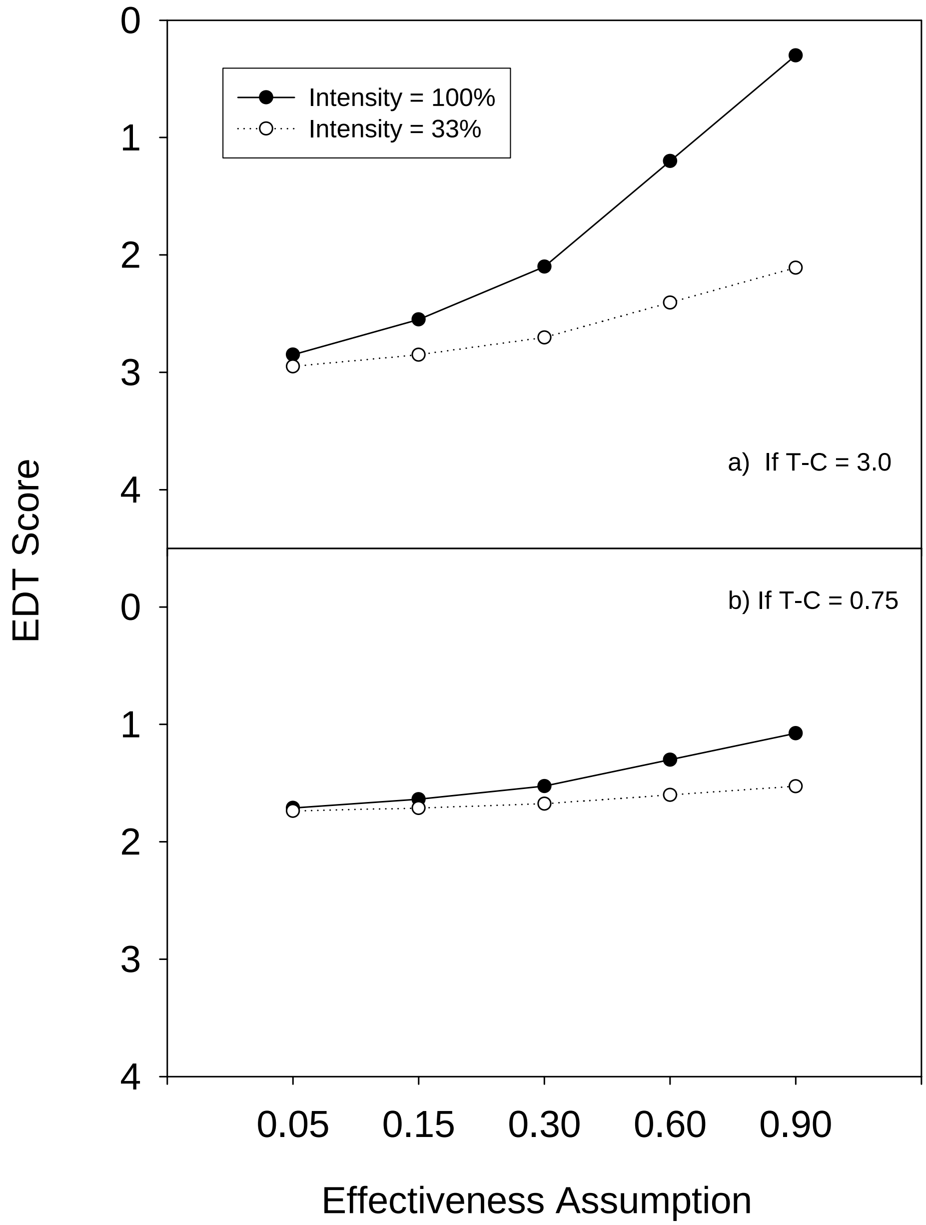


Figure F14. Change in EDT environmental attribute scores at two intensities and two restoration potentials using the effectiveness assumptions used for restoration action classes in the Upper Columbia. Graph a) represents a highly degraded attribute where the difference between template (T) and current (C) was 3.0 and graph b) represents a low level of degradation (T-C = 0.5).

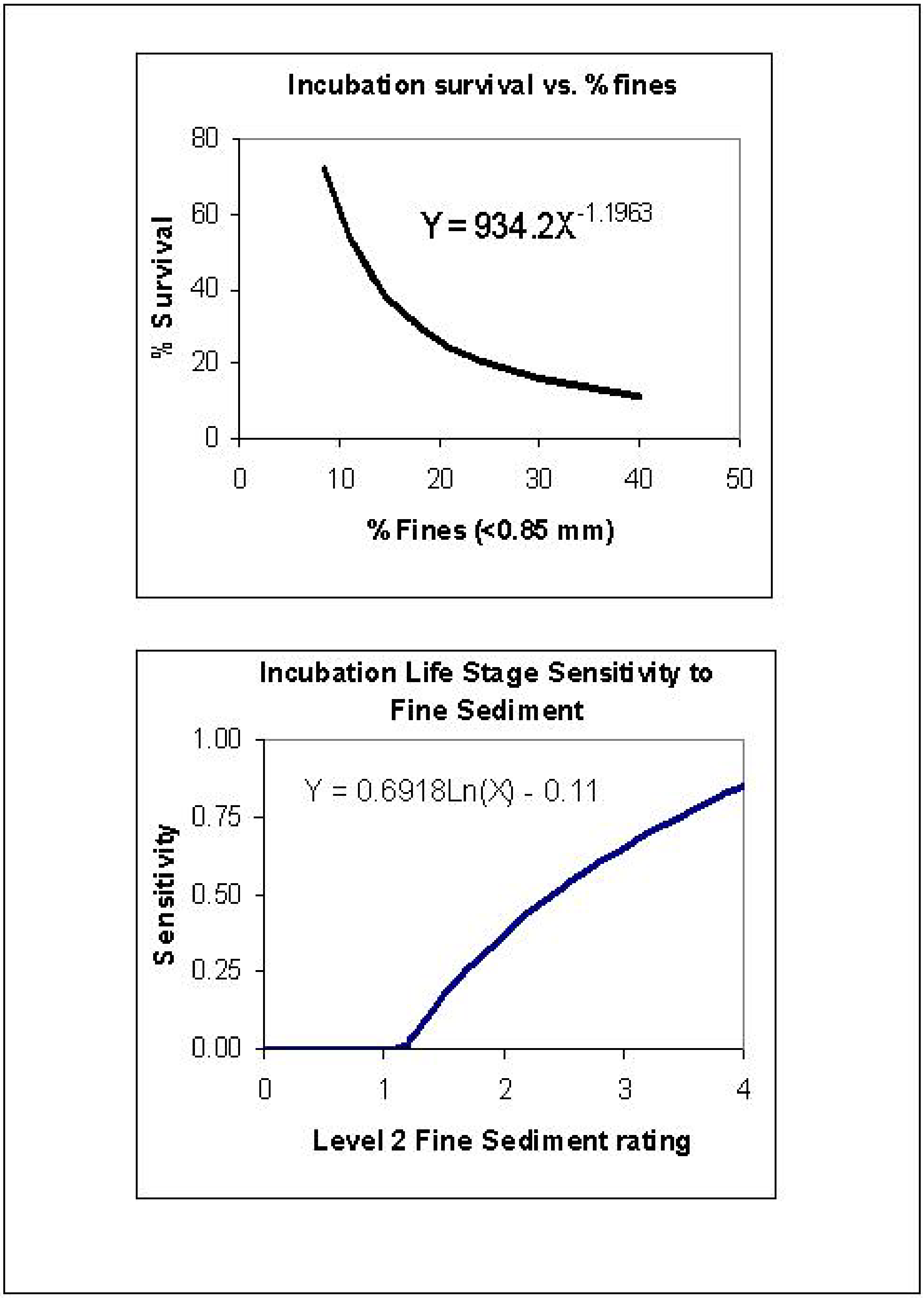


Figure F15. Relationship between percent fines and survival from egg deposition to emergence for coho salmon, adapted from Tagart (1984), and the relationship between ratings for Level 2 Fine Sediment and sensitivity of eggs in the EDT model (figure taken from Mobrand (2002).

Table F23. Ecosystem Diagnosis and Treatment (EDT) attribute scores and empirical data equivalents for large woody debris in the Wenatchee subbasin. Each number represents the average value of the reaches within each assessment unit. Lower EDT attribute score mean more wood was present.

	EDT Attribute Score				Empirical data equivalent (Pieces per mile)			
Assessment Unit	Current	S3	S1	Template	Current	S3	S1	Template
Beaver	3.0	2.0	0.0	0.0	13	36	75	75
Chiwaukum/Skinney	0.8	0.7	0.6	0.6	106	107	111	111
Chiwawa	0.9	0.8	0.8	0.5	100	106	106	113
Chumstick	3.0	2.0	0.0	0.0	13	36	75	75
Derby	3.0	2.0	0.0	0.0	13	36	75	75
Little Wenatchee	1.0	0.8	0.8	0.0	100	106	106	125
Lower Icicle	3.5	2.5	0.8	0.8	11	25	106	106
Lower Nason	2.0	1.5	0.7	0.7	51	76	109	109
Lower Peshastin	3.1	2.2	0.5	0.5	17	40	113	113
Lower Wenatchee	3.5	3.0	1.9	1.1	11	18	55	95
Mission	2.8	1.8	0.0	0.0	16	42	75	75
Tumwater Canyon	2.0	2.0	2.0	2.0	51	51	51	51
Upper Icicle	1.0	1.0	1.0	0.8	100	103	103	106
Upper Nason	2.6	2.4	2.4	1.8	24	30	30	60
Upper Peshastin	2.4	1.5	0.9	0.9	25	51	64	103
Upper Wenatchee	2.0	1.7	1.7	0.7	51	65	65	109
White River	1.5	1.3	1.3	0.5	76	85	85	113

F.6.3 Action Class Effects to Scenario Results

We conducted a series of additional model runs to better understand what factors were driving the results presented in section F.4 and F.5. Due to time and budget constraints, we were only able to do this assessment for Wenatchee spring Chinook. Although the concepts should be generally applicable to the other populations, we believe that these (and other) model sensitivity tests should be conducted for each population in order to understand what the model did with the information that was put into it.

Our objectives were to;

1. Understand the difference between S1 and S3.

2. Evaluate sensitivity to protection assumptions (i.e. the rate of passive restoration).

3. Understand the difference between S1 and Habitat Template.

To address the objectives we first examined the assessment unit specific restoration potential from the diagnosis phase of EDT, then conducted a series of additional model runs.

The model runs designed to meet objectives 1-3 were as follows:

1. Current (without harvest): See description in section F.3.

2. Protection (passive restoration): Applied only the protection measures outlined in section F.2. The goal was to understand what proportion of the improvements in performance measures were due to the passive restoration assumptions.

3. Protection and Obstructions: Applied the protection measures outlined in section x.1 and assumed that all obstructions would be made 100% passable. The goal was to assess the two actions that were applied with equal intensity to both scenarios 1 and 3. The remaining benefit could then be attributed to intensity of application of the restoration actions.

4. Scenario 3: See description in section F.3.

5. Scenario 2: See description in section F.3.

6. Scenario 1: See description in section F.3.

7. Scenario 1 (half protection): This scenario used all the same actions and intensities as S1, but used ½ the rate of passive restoration. Specifically, 12.5% improvement of environmental attributes related to the stream channel and riparian zone and 5% for attributes related to roads (see **Table F11** for details of which of the 46 attributes fall into each category). The goal of this model run was to determine how sensitive our results were to the rates of passive restoration.

8. Scenario 1 (double protection): This scenario used all the same actions and intensities as S1, but used double the rate of passive restoration. Specifically, 50% improvement of environmental attributes related to the stream channel and riparian zone and 20 % for attributes related to roads (see **Table F11** for details of which of the 46 attributes fall into each category). The goal of this model run was to determine how sensitive our results were to the rates of passive restoration.

9. Scenario 1 with template lower Wenatchee: This scenario used all the same actions as Scenario 1 then improved conditions in the Lower Wenatchee mainstem to template for all 46 environmental attributes. The goal of this model run was to see how much additional performance improvement potential remained in the lower mainstem after implementation of Scenario 1.

10. PFC: See description in section F.3.

11. Habitat Template: See description in section F.3.

12. True Template: See description in section F.3.

Modeling additional scenarios to evaluate assumptions revealed that the protection assumptions were particularly effective for increasing spring Chinook abundance and productivity but only very small gains could be made for productivity under any other scenario, except doubling the passive restoration assumption (**Table F24**, **Figure F16**). Similar gains were obtained for abundance under all of the test scenarios, indicating that one aspect of the model input was not driving the results for abundance. Conversely, the habitat quality improvements in S3 made a relatively large difference to the life history diversity index (**Figure F16**). This was somewhat contrary to our initial assumption that the life history diversity index was primarily driven by accessing formerly occupied habitat through obstruction removal. It emphasized the importance of restoring habitat quality in conjunction with removing obstructions because just providing more degraded habitat will not increase productivity and therefore will not increase the proportion of viable life history trajectories (diversity index). Further evidence of this was provided in the individual attribute sensitivity tests when productivity was reduced by removing obstructions without improving habitat behind the obstructions (**Table F21**). The scenario modeling results were not substantially altered by the magnitude of the passive restoration assumption (represented by error bars to S1 in **Figure F16**) because the assessment units where it was applied were in good condition so the restoration potential was relatively low. This was not particularly surprising for the diversity index and productivity because these performance measures were already very close to the maximum in-basin potential (**Figure F16**). Abundance, on the other hand, was still 15% below PFC and 31% from the habitat template indicating that additional improvements outside the major production areas still had potential to contribute to increased abundance. We hypothesized that the remaining abundance potential was in the mainstem Wenatchee River below Tumwater Canyon where degraded habitat conditions where effecting survival of sub-yearling parr that left the tributaries above Tumwater Canyon. To test this hypothesis we conducted an additional model run that used S1 conditions in all assessment units but improved middle and lower mainstem Wenatchee River conditions to the habitat template condition. This scenario increased the proportion of in-basin potential for abundance by an additional nine percent when compared to S1, but added nothing to productivity and very little to the diversity index. This scenario emphasized the importance of the lower Wenatchee mainstem for capacity through providing additional habitat quantity for transient rearing juvenile life stages (i.e. subyearling fall migrants that overwinter in the mainstem Wenatchee). It also highlights the kinds of improvements that could be made through addressing secondary limiting factors. The remaining difference between the scenarios and the habitat template were due to secondary limiting factors throughout the watershed.

Table F24 Ecosystem Diagnosis and Treatment model predictions of Diversity Index, Productivity, Capacity, and Abundance under various scenarios for Wenatchee spring Chinook.

		Adult Performance					Juvenile Performance		
Population	**Scenario**	**Diversity index**	**Productivity**	**Capacity**	**Abundance**	**Abundance with 0.63% SAR**	**Juvenile Productivity**	**Juvenile Capacity**	**Juvenile Abundance**
Wenatchee Spring Chinook	Current without harvest	48%	4.4	2,071	1604	741	236	170,763	117,619
	Protection (passive restoration)	50%	4.9	2,337	1859	830	257	181,892	131,674
	Protection and Obstr	55%	4.9	2,563	2,039	895	255	195,520	142,084
	Scenario 3	75%	5.0	3,114	2,496	1,085	271	231,024	172,176
	Scenario 2								
	S1 (half protection)	77%	5.0	3,253	2,600	1,176		250,279	186,675
	Scenario 1	78%	5.1	3,372	2,714	1,209	282	254,307	191,831
	S1 (double protection)	79%	5.4	3,563	2,904	1,272	288	263,211	201,908
	S1 w/ template lower Wen	79%	5.2	3,838	3,094	1,408	299	295,144	223,470
	PFC	81%	4.9	4,432	3,534	1,620	297	344,491	257,222
	Habitat Template	87%	6.5	4,990	4,221	1,922	287	377,537	305,060
	True Template	97%	26.8	23,978	23,084		376		

		Increase relative to current					Increase relative to current		
	Current without harvest	0%	0%	0%	0%	0%	0%	0%	0%
	Protection (passive restoration)	4%	10%	13%	16%	12%	9%	7%	12%
	Protection and Obstr	14%	10%	24%	27%	21%	8%	14%	21%
	Scenario 3	55%	14%	50%	56%	46%	15%	35%	46%
	Scenario 2								
Wenatchee Spring Chinook	S1 (half protection)	59%	12%	57%	62%	59%	20%	47%	59%
	Scenario 1	60%	16%	63%	69%	63%	22%	49%	63%
	S1 (double protection)	64%	22%	72%	81%	72%	27%	54%	72%
	S1 w/ template lower Wen	63%	16%	85%	93%	90%	26%	73%	90%
	PFC	67%	11%	114%	120%	119%	22%	102%	119%
	Habitat Template	79%	46%	141%	163%	159%	60%	121%	159%
	True Template	100%	504%	1058%	1339%				

		Proportion of In-basin Potential					Proportion of In-basin Potential		
Wenatchee Spring	Current without harvest	56%	68%	42%	38%	39%	63%	45%	39%

Chinook	Protection (passive restoration)	58%	75%	47%	44%	43%	68%	48%	43%
	Protection and Obstr	64%	75%	51%	48%	47%	68%	52%	47%
	Scenario 3	86%	78%	62%	59%	56%	72%	61%	56%
	Scenario 2								
	S1 (half protection)	88%	77%	65%	62%	61%	75%	66%	61%
	Scenario 1	89%	79%	68%	64%	63%	76%	67%	63%
	S1 (double protection)	91%	83%	71%	69%	66%	79%	70%	66%
	S1 w/ template lower Wen	91%	79%	77%	73%	73%	79%	78%	73%
	PFC	93%	76%	89%	84%	84%	76%	91%	84%
	Habitat Template	100%	100%	100%	100%	100%	100%	100%	100%
	True Template								

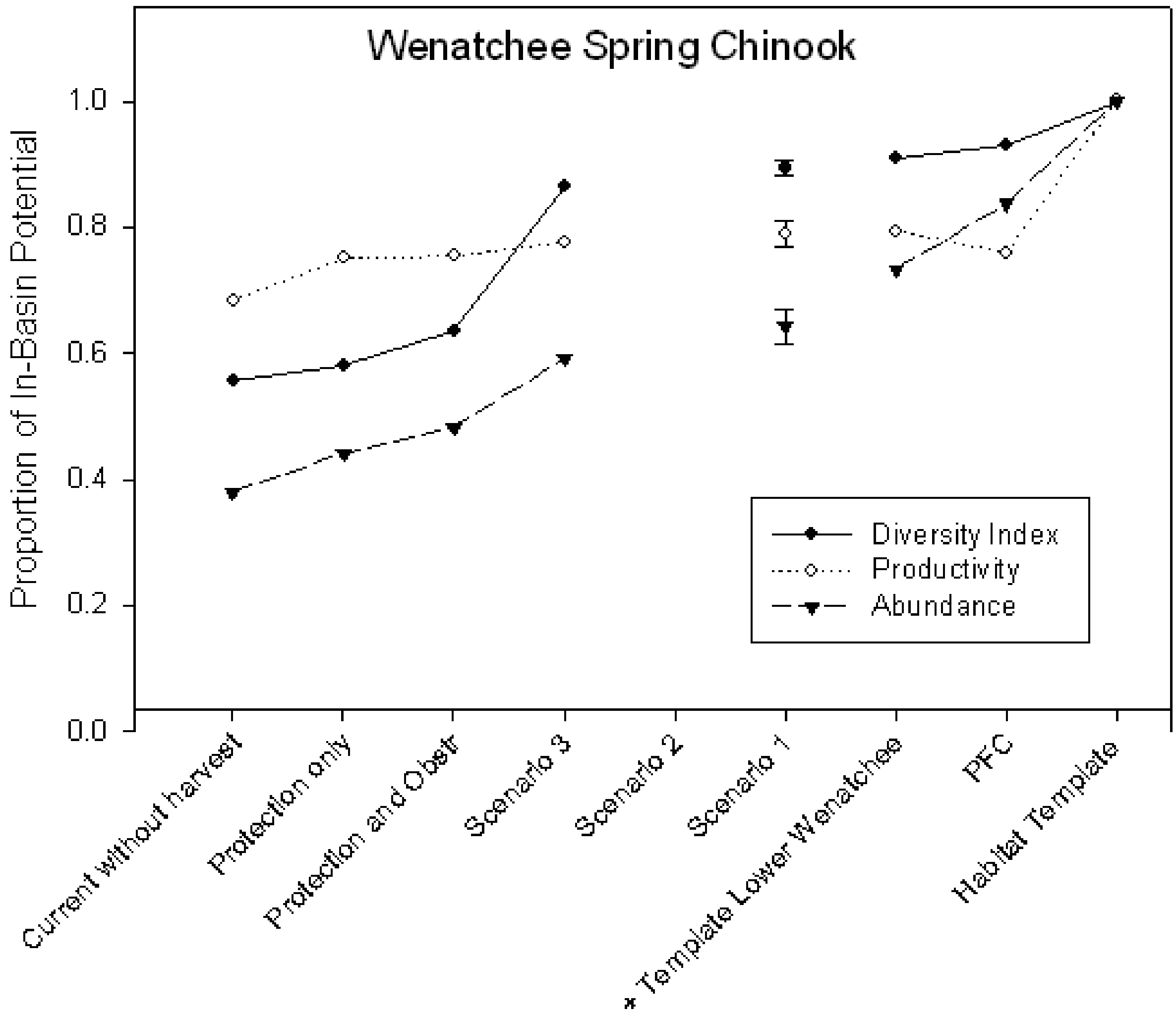


Figure F16. The proportion of in-basin potential predicted by EDT for Wenatchee spring Chinook under various modeling scenarios

Evaluation of the restoration potential from the diagnosis suggested that the assessment units where limiting factors were addressed with restoration actions were not necessarily the most important areas for increasing all the performance measures for both species. To evaluate this effect we summed the restoration potential from groups of subwatersheds above and below Tumwater Canyon from the "diagnosis" portion of the EDT analysis (section F.1). We hypothesized that high intensity restoration efforts in the small but more degraded subwatersheds below Tumwater Canyon (Mission, Peshastin, Chumstick, and Icicle Creeks) were not affecting population level performance as much as small degradations to large important production areas (Chiwawa, White, Little Wenatchee Rivers, and Nason Creek).

For spring Chinook, the model predicted no restoration potential for productivity in subwatersheds below Tumwater Canyon, similar potential above and below Tumwater Canyon for abundance, and much higher potential to improve diversity below Tumwater Canyon (**Figure F17**). The large improvement in the diversity index was not surprising considering that spring Chinook do not currently occupy this habitat but it represents a different range of elevations, temperatures, ecoregions, geologic, and hydrologic conditions than the spawning areas above Tumwater Canyon. Except for Lower Nason Creek, our scenarios only applied protection (and the resulting passive restoration) to the areas above Tumwater Canyon. In general, the passive restoration rates were applied to very small restoration potentials for individual environmental attributes (see LWD example; **Table F23**), but when summed over the large quantities of habitat in the upper watersheds the results indicated that considerable gains in performance could still be obtained from these areas **Table F25**). These results were not scaled to stream length or area, so general application of restoration efforts would probably not be very efficient. A reach level diagnosis within each subwatershed needs to be conducted to identify specific opportunities to improve habitat conditions.

For steelhead, there was relatively more potential benefit from restoration actions in the subwatersheds below Tumwater Canyon for all three performance measures (**Figure F17**).

Table F25 Restoration potential (% increase in each performance measure) from EDT for a subset of assessment units for Wenatchee spring Chinook and steelhead.

		Diversity Index	Productivity	Abundance
Population and Area	Assessment Unit	Restoration Potential	Restoration Potential	Restoration Potential
	Chiwawa River	0%	20%	13%
Spring Chinook	Lower Nason Ck	4%	23%	15%
(above Tumwater Canyon)	White River	0%	19%	8%
	Little Wenatchee	1%	6%	4%
	Subtotal	5%	68%	41%
	Mission Ck	15%	0%	7%
Spring Chinook	Lower Peshastin Ck	21%	0%	17%
(below Tumwater Canyon)	Chumstick Ck	6%	0%	3%
	Lower Icicle Creek	9%	0%	8%

	Subtotal	50%	0%	35%
Steelhead	Chiwawa River	5%	16%	18%
(above Tumwater Canyon)	Lower Nason Ck	12%	25%	20%
	White River	2%	19%	15%
	Little Wenatchee	1%	9%	7%
	Subtotal	20%	70%	60%
	Mission Ck	50%	13%	23%
Steelhead	Lower Peshastin Ck	35%	20%	49%
(below Tumwater Canyon)	Chumstick Ck	10%	1%	3%
	Lower Icicle Creek	22%	0%	28%
	Subtotal	116%	34%	103%

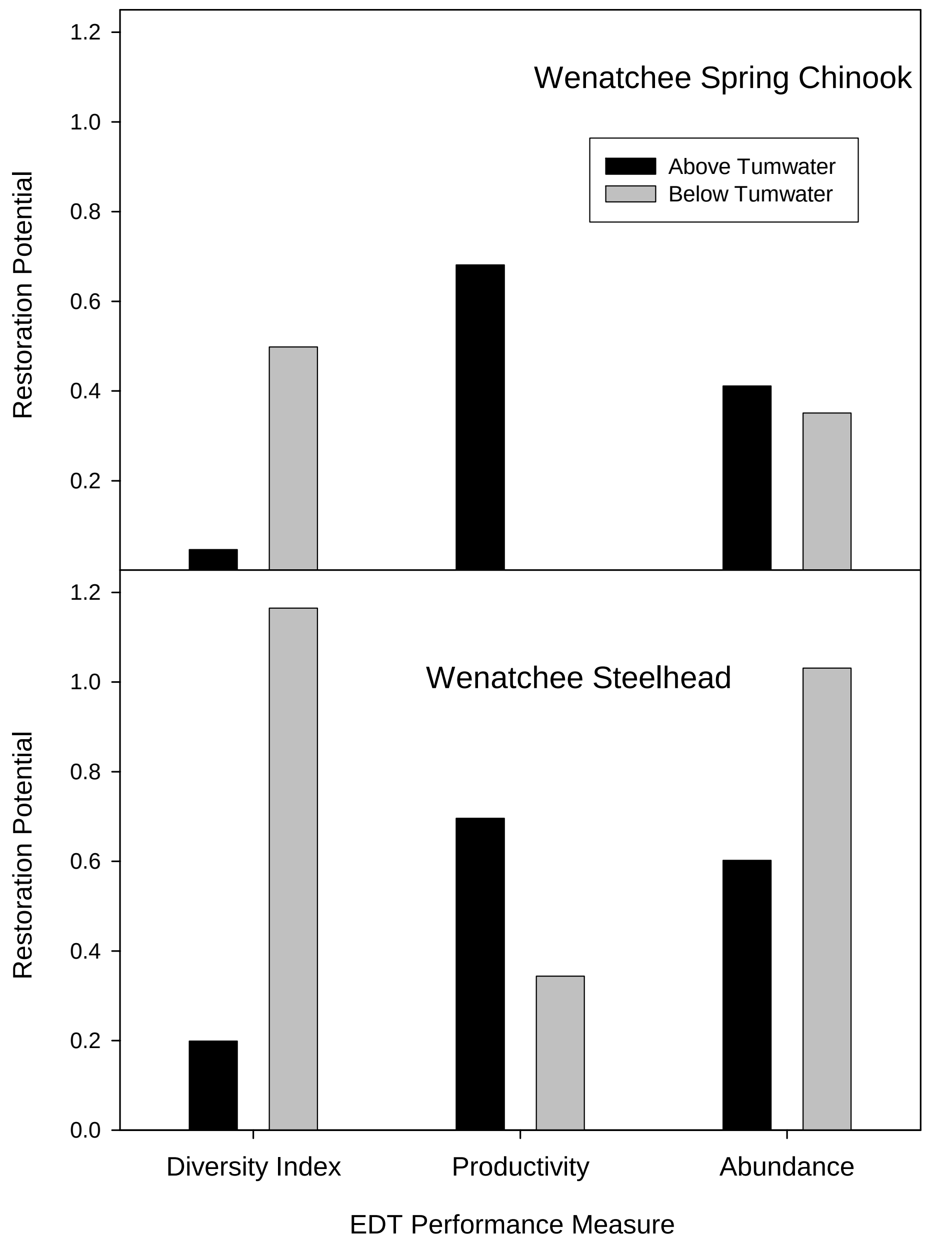


Figure F17 The sum of the restoration potential (% increase in each performance measure) from EDT for Wenatchee spring Chinook and steelhead. Above Tumwater Canyon assessment units included Chiwawa, Nason, White, and Little Wenatchee whereas the below Tumwater Canyon assessment units included Mission, Peshastin, Chumstick, and Icicle Creek.

We concluded that the relatively small difference in performance measures between scenarios 1 and 3 was a result of 4 factors;

1. The same protection and barrier removal action classes and intensities were applied to both scenarios.

2. Protection was the only action applied to most of the large important production areas (particularly for spring Chinook).

3. Restoration actions were generally applied to smaller subwatersheds with less inherent potential (stream area and intrinsic habitat quality) to contribute to abundance and productivity, or to large lower mainstem reaches where they were relatively less effective (due to limitations in applying actions to large systems and because fewer life stages use the lower mainstem.

4. The absolute change to individual environmental attributes was generally small (regardless of intensity of application) due to low restoration potential (small difference between current and template conditions).

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Appendix G

Identification of primary limiting factors and threats, objectives, and habitat actions for each listed species within each subbasin

(Table 1 begins on the next page.)

Table 1 List of habitat actions (and classes) that address primary limiting factors and threats within each assessment unit in the Wenatchee subbasin. Management objectives are identified for each species (CS = Chinook salmon; ST = steelhead; BT = bull trout) as well as the contribution of restoration actions to VSP (A/P = abundance/productivity; SS/D = spatial structure/diversity) for each species (X = large effect; x = small effect). Effect time indicates the amount of time it will take before the effects of the restoration action translate to changes in VSP parameters (S = 1-5 years; M = 6-20 years; L = >20 years)

Assessment Unit (Prioritization Category)	**Primary Limiting Factor**	**Primary Causal Factor/Threat**	**Management Objective**	**Appropriate Restoration Class**	**Specific Restoration Action (see Table 5.9)**	**Species Affected**	**Contribution to VSP**		**Effect Time**
							A/P	**SS/D**	
Lower Wenatchee (Category 2)	Habitat diversity and quantity; Channel stability	Roads/railways; Agriculture; Residential development	Improve riparian habitat conditions. CS: Increase juvenile overwinter surivival. ST: Increase juvenile and adult overwinter survival and spawning habitat. BT: Increase sub-adult and adult overwinter survival and spawning area.	Riparian restoration	All actions may be appropriate	CS ST BT	x x X	L	
			Increase off-channel habitat. CS: Increase juvenile overwinter survival ST: Increase juvenile and adult overwinter survival. BT: Increase sub-adult and adult overwinter survival	Side-channel reconnection	All actions may be appropriate	CS ST BT	x x X	 X	M
				Floodplain Restoration	All actions may be appropriate	CS ST BT	x x X	 X	M
			Increase habitat diversity. CS: Increase juvenile overwinter survival and adult holding areas. ST: Increase juvenile and adult overwinter survival and adult holding areas. BT: Increase sub-adult and adult overwinter survival and adult holding areas.	Large woody debris restoration	All actions may be appropriate	CS ST BT	x x X	S	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Lower Wenatchee (Category 2)	Water quantity	Agriculture	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	Actions 1-6, 9-12, and 14-19	CS ST BT	x x X	 X	S
	Water quality	Agriculture; Residential development	Reduce summer water temperatures. CS: Increase juvenile and adult survival and passage. ST: Increase juvenile and adult survival and passage. BT: Increase sub-adult and adult survival and passage.	Water quality restoration	Actions 1-3, and 6-30	CS ST BT	x x X	 x	M

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Mission Creek (Category 3)	Obstructions	Diversions; Culverts	Increase connectivity. CS: Improve adult and juvenile passage, increase high-flow refugia for juveniles, and increase access to spawning and rearing habitat. ST: Improve adult and juvenile passage, increase high-flow refugia for juveniles, and increase access to spawning and rearing habitat.	Obstruction restoration	Actions 1-4, and 6	CS ST	x x	x x	S
	Sediment	Agriculture; Roads	Reduce sediment load. CS: Improve spawning and incubation success. ST: Improve spawning and incubation success.	Riparian Restoration	All actions may be appropriate	CS ST	x x		
				Road maintenance	All actions may be appropriate	CS ST	x x	xL x	M
	Habitat diversity and quantity	Agriculture; Channelization; Residential development	Restore floodplain and off-channel habitat. CS: Increase juvenile survival. ST: Increase juvenile and adult survival.	Floodplain restoration	All actions may be appropriate	CS ST	x x		
				Side channel reconnection	All actions may be appropriate	CS ST	x x	M	
				Instream structures	All actions may be appropriate	CS ST	x x	M	

S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Mission Creek (Category 3)	Habitat diversity and quantity	Agriculture; Channelization; Residential development	Improve riparian habitat conditions. CS: Increase juvenile survival and adult holding area. ST: Increase juvenile survival and adult holding area.	Riparian restoration	All actions may be appropriate	CS ST	x x	L	
			Increase habitat diversity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat.	Large woody debris restoration	All actions may be appropriate	CS ST	x x		
				Instream structures	All actions may be appropriate	CS ST	x x	S	
	Water quantity	Agriculture; Residential development	Increase instream flows. CS: Increase juvenile and adult passage and survival. ST: Increase juvenile and adult passage and survival.	Water quantity restoration	Actions 1-6, and 9-19	CS ST	x x	S x x	S
	Water quality	Agriculture; Residential development	Decrease summer temperatures and improve water quality. CS: Increase juvenile and adult survival. ST: Increase juvenile and adult survival.	Water quality restoration	Actions 1-3; and 6-30	CS ST	x x	x x	M

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Peshastin Creek (Category 2)	Habitat diversity and quantity	Roads; Agriculture; Channelization; Residential development	Improve riparian habitat condition. CS: Increase juvenile survival and adult holding and spawning areas. ST: Increase juvenile and adult survival and adult holding and spawning areas. BT: Increase juvenile, sub-adult, and adult survival and adult holding areas.	Riparian restoration	All actions may be appropriate	CS ST BT	x x X	L	
			Increase habitat diversity. CS: Increase juvenile survival and adult holding and spawning areas. ST: Increase juvenile and adult survival and adult holding and spawning areas. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning areas.	Large woody debris restoration	All actions may be appropriate	CS ST BT	x x X	X X X	S
				Instream structures	All actions may be appropriate	CS ST BT	x x X	X X X	S
			Reduce artificial channel stability and restore off-channel habitat conditions. CS: Increase juvenile survival, adult holding, and high-flow refugia. ST: Increase juvenile and adult survival, adult holding areas, and high-flow refugia. BT: Increase juvenile, sub-adult, and adult survival, adult holding areas, and high-flow refugia.	Side channel reconnection	All actions may be appropriate	CS ST BT	x x X	X X X	M
				Floodplain restoration	All actions may be appropriate	CS ST BT	x x x	X X X	M
				Road maintenance	All actions may be appropriate	CS ST	x x		

M

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
						BT	X		

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Peshastin Creek (Category 2)	Obstructions	Diversions; Culverts	Increase connectivity. CS: Improve adult and juvenile passage and access to spawning and rearing habitat. ST: Improve adult and juvenile passage and access to spawning and rearing habitat. BT: Improve juvenile, sub-adult, and adult passage and access to spawning and rearing habitat.	Obstruction restoration	Actions 1-3, and 6	CS ST BT	x x x	X X X	S
	Water quantity	Diversions; Agriculture; Roads	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile and adult survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	Actions 1-6, 9-17, and 19	CS ST BT	x x X	X X X	S
	Water quality	Agriculture; Diversions; Residential development	Decrease summer temperatures. CS: Increase juvenile and adult survival. ST: Increase juvenile and adult	Water quality restoration	Actions 1-3, and 6-30	CS ST BT	x x X	X X X	M

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
			survival. BT: Increase juvenile, sub-adult, and adult survival.						

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Chumstick Creek (Category 3)	Obstructions	Culverts; Diversions	Increase connectivity. CS: Improve adult and juvenile passage and increase access to spawning and rearing habitat. ST: Improve adult and juvenile passage and increase access to spawning and rearing habitat.	Obstruction restoration	Actions 1-3, and 6	CS ST	x x	X X	S
	Habitat diversity and quantity	Roads/railroad; Agriculture; Residential development	Increase habitat diversity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat.	Large woody debris restoration	All actions may be appropriate	CS ST	x x	S	
			Restore floodplain and off-channel habitat conditions. CS: Increase juvenile survival, adult holding areas, and incubation success. ST: Increase juvenile and adult survival, adult holding areas, and incubation success	Road maintenance	All actions may be appropriate	CS ST	x x		
				Floodplain restoration	All actions may be appropriate	CS ST	x x	XM x	M
				Side channel restoration	All actions may be appropriate	CS ST	x x	X x	M
	Water quantity	Roads/railroad; Agriculture; Residential development	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile and adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	Actions 1-6, 9-17, and 19	CS ST	x x	X X	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Chumstick Creek (Category 3)	Water quality	Roads/railroad; Diversions; Agriculture; Timber harvest; Residential development	Improve riparian habitat condition. CS: Increase juvenile survival and adult holding and spawning areas. ST: Increase juvenile and adult survival and adult holding and spawning areas.	Riparian restoration	All actions may be appropriate	CS ST	x x		L
			Improve water quality. CS: Increase juvenile and adult survival. ST: Increase juvenile and adult survival.	Water quality restoration	Actions 1-3, and 6-30	CS ST	x x	x x	M
Lower Icicle Creek (mouth to boulder field) (Category 2)	Obstructions	Diversions	Increase connectivity. CS: Improve adult and juvenile passage and access to spawning and rearing habitat. ST: Improve adult and juvenile passage and access to spawning and rearing habitat. BT: Improve juvenile, sub-adult, and adult passage and access to spawning and rearing habitat.	Obstruction restoration	Actions 1-4, and 6	CS ST BT	x X X	x X X	S
	Sediment	Agriculture; Roads; Residential development; Fires	Reduce sediment load. CS: Improve spawning and incubation success. ST: Improve spawning and incubation success. BT: Improve spawning and incubation success.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x		L

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Lower Icicle Creek (mouth to boulder field) (Category 2)	Sediment	Agriculture; Roads; Residential development; Fires	Restore floodplain and off-channel habitat. CS: Increase juvenile survival. ST: Increase juvenile and adult survival. BT: Increase juvenile, sub-adult, and adult survival.	Floodplain restoration	All actions may be appropriate	CS ST BT	x x x	M	
	Habitat diversity and quantity	Roads; Agriculture; Residential development	Increase habitat diversity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Side channel restoration	All actions may be appropriate	CS ST BT	x x x	x	M
	Water quantity	Agriculture; Residential development	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile and adult survival, adult holding areas, passage, and spawning success. BT: Increase juvenile, sub-adult, and adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	Actions 1-6, and 9-19	CS ST BT	x x x	x	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Upper Icicle Creek (upstream from boulder field) (Category 2)	Water quantity	Diversions	Increase instream flows. ST: Increase juvenile and adult survival, adult holding areas, passage, and spawning success. BT: Increase juvenile, sub-adult, and adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	Actions 1-6, and 9-19	ST BT	x x	x	S
	Sediment	Roads	Reduce sediment load. ST: Improve spawning and incubation success. BT: Improve spawning and incubation success.	Road maintenance	All actions may be appropriate	ST BT	x x	M	
Middle Wenatchee (Tumwater Canyon) (Category 1)	None	None	None	None	None	CS ST BT			
Upper Wenatchee (upstream from Tumwater Canyon) (Category 1)	Habitat quantity	Roads; Residential development; Timber harvest	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	x X x	L	
				Side channel reconnection	All actions may be appropriate	CS ST BT	x X x	M	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Chiwaukum (includes Skinney Creek) (Category 2)	Habitat diversity	Roads; Campgrounds	Increase habitat diversity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	x X x	L	
				Floodplain restoration	All actions may be appropriate	CS ST BT	x x x	x X x	M
				Large woody debris restoration	All actions may be appropriate	CS ST BT	x X x	S	
	Obstructions	Roads	Increase connectivity. ST: Improve adult and juvenile passage and access to spawning and rearing habitat. BT: Improve juvenile, sub-adult, and adult passage and access to spawning and rearing habitat.	Obstruction restoration	Actions 1-3, and 6	ST BT	x x	X X	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Chiwawa River (Category 1)	Habitat quantity	Residential development	Increase habitat diversity. CS: Increase juvenile and adult survival. ST: Increase juvenile and adult survival. BT: Increase juvenile, sub-adult, and adult survival.	Riparian restoration	All actions may be appropriate	CS ST BT	x X x	L	
	Sediment	Roads	Reduce sediment load. CS: Improve spawning and incubation success. ST: Improve spawning and incubation success. BT: Improve spawning and incubation success.	Road maintenance	All actions may be appropriate	CS ST BT	x x x	M	
	Obstructions	Culverts	Increase connectivity. CS: Improve adult and juvenile passage and access to spawning and rearing habitat. ST: Improve adult and juvenile passage and access to spawning and rearing habitat. BT: Improve juvenile, sub-adult, and adult passage and access to spawning and rearing habitat.	Obstruction restoration	Actions 1-4, and 6	CS ST BT	x X X	x X X	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Nason Creek (Category 2)	Channel stability; Habitat diversity	Roads/railroad	Increase habitat diversity and natural channel stability. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	X X X	L	
				Side channel restoration	All actions may be appropriate	CS ST BT	X X X	M	
				Floodplain restoration	All actions may be appropriate	CS ST BT	X X X	M	
				LWD restoration	All actions may be appropriate	CS ST BT	X X X	S	
	Sediment	Timber harvest; Roads/railroad; Residential development	Reduce sediment load. CS: Improve spawning and incubation success. ST: Improve spawning and incubation success. BT: Improve spawning and incubation success.	Road maintenance	All actions may be appropriate	CS ST BT	X X X	M	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Nason Creek (Category 2)	Water quality	Timber harvest; Roads/railroad; Residential development	Decrease summer temperatures. CS: Increase juvenile and adult survival. ST: Increase juvenile and adult survival. BT: Increase juvenile, sub-adult, and adult survival.	Water quality restoration	Actions 2, 7-11, 14, 15, 16, and 19	CS ST BT	X X X	 X	M
	Obstructions	Roads/railroad; Culverts	Increase connectivity. ST: Improve adult and juvenile passage and access to spawning and rearing habitat. BT: Improve juvenile, sub-adult, and adult passage and access to spawning and rearing habitat.	Obstruction restoration	Actions 1-3, and 6	ST BT	X X	X X	S
Lake Wenatchee (Category 1)	None	None	None	None	None	CS ST BT			
Little Wenatchee (Category 1)	Sediment	Roads; Timber harvest	Reduce sediment load. CS: Improve spawning and incubation success. ST: Improve spawning and incubation success. BT: Improve spawning and incubation success.	Road maintenance	All actions may be appropriate	CS ST BT	X X X	M	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
White River (Category 1)	Habitat diversity	Timber harvest; Roads	Increase habitat diversity. CS: Increase juvenile, adult holding areas, and spawning habitat. ST: Increase juvenile and adult survival, adult holding areas, and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival, adult holding areas, and spawning habitat.	Floodplain restoration	Action 4 and 5	CS ST BT	x x x	M	

Table 2 List of habitat actions (and classes) that address primary limiting factors and threats within each assessment unit in the Entiat subbasin. Management objectives are identified for each species (CS = Chinook salmon; ST = steelhead; BT = bull trout) as well as the contribution of restoration actions to VSP (A/P = abundance/productivity; SS/D = spatial structure/diversity) for each species (X = large effect; x = small effect). Effect time indicates the amount of time it will take before the effects of the restoration action translate to changes in VSP parameters (S = 1-5 years; M = 6-20 years; L = >20 years)

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Lower Entiat (Category 2)	Habitat diversity and quantity	Channelization; Riprap and dikes; Roads; Wild fires; Historic timber harvest; Historic dams; Agriculture; Residential development;	Increase habitat diversity and off-channel habitat. CS: Increase juvenile overwinter survival, high-flow refugia, and adult holding areas; ST: Increase juvenile and adult overwinter survival, high-flow refugia, and adult holding areas. BT: Increase sub-adult and adult overwinter survival, high-flow refugia, and adult holding areas.	Large woody debris restoration	All actions may be appropriate	CS ST BT	X X X	x x x	S
				Instream structures	All actions may be appropriate	CS ST BT	X X X	x x x	S
				Side channel reconnection	All actions except 3	CS ST BT	X X X	x x x	M
			Improve riparian habitat conditions. CS: Increase juvenile overwinter survival and rearing habitat. ST: Increase juvenile and adult overwinter survival and rearing habitat. BT: Increase sub-adult and adult overwinter survival and adult holding and spawning area.	Riparian restoration	All actions may be appropriate	CS ST BT	X X X	L	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Lower Entiat (Category 2)	Excessive artificial channel stability	Channelization; Riprap and dikes; Agriculture; Residential development;	Reduce artificial channel stability and restore width:depth ratio. CS: Increase juvenile and adult holding and rearing habitat. ST: Increase juvenile and adult holding and rearing habitat. BT: Increase sub-adult and adult holding and rearing habitat.	Floodplain restoration	All actions may be appropriate	CS ST BT	X X X	x x x	M
	Water quantity	Agriculture; Residential development	Protect and whn feasible enhance instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	All actions except 6, 7, 8, 14, 15, 18, and 19	CS ST BT	x x x	x x x	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Middle Entiat (Category 1)	Habitat diversity	Roads; Wild fires; Riprap; Residential development	Increase habitat diversity. CS: Increase juvenile and adult survival and adult holding and spawning areas. ST: Increase juvenile and adult survival and adult holding and spawning areas. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning areas.	Large woody debris restoration	All actions may be appropriate	CS ST BT	X X X	x x x	S
			Improve riparian habitat condition. CS: Increase juvenile survival and adult holding and spawning areas. ST: Increase juvenile and adult survival and adult holding and spawning areas. BT: Increase juvenile, sub-adult, and adult survival and adult holding areas.	Riparian restoration	All actions may be appropriate	CS ST BT	X X X	L	
	Obstructions (Stormy Creek)	Culverts	Increase connectivity. CS: Improve juvenile access to rearing habitat. ST: Improve juvenile access to rearing habitat. BT: Improve juvenile and sub-adult access to rearing habitat.	Obstruction restoration	Actions 1 and 2	CS ST BT	x x x	X X X	S
Upper Entiat (Category 1)	None	None	Investigate presence or absence of resident bull trout.			BT			

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Mad River (Category 1)	Habitat diversity and quantity (lack of habitat diversity and spawning habitat in the lower 4 miles of the Mad River)	Roads; Residential development	Increase riparian habitat conditions and natural channel stability. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	X X X	L	
				Road maintenance	All actions may be appropriate	CS ST BT	X X X	M	
			Increase habitat diversity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Instream structures	Actions 1 and 4	CS ST BT	X X X	x X X	S
				Large woody debris restoration	Actions 4, 8, and 9	CS ST BT	X X X	x X X	S

Table 3 List of habitat actions (and classes) that address primary limiting factors and threats within each assessment unit in the Methow subbasin. Management objectives are identified for each species (CS = Chinook salmon; ST = steelhead; BT = bull trout) as well as the contribution of restoration actions to VSP (A/P = abundance/productivity; SS/D = spatial structure/diversity) for each species (X = large effect; x = small effect). Effect time indicates the amount of time it will take before the effects of the restoration action translate to changes in VSP parameters (S = 1-5 years; M = 6-20 years; L = >20 years)

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Lower Methow (Category 2)	Habitat diversity and quantity; Excessive artificial channel stability	Roads; Riprap; Residential development; Agriculture	Improve riparian habitat conditions. CS: Increase juvenile overwinter survival. ST: Increase juvenile and adult overwinter survival and spawning habitat. BT: Increase sub-adult and adult overwinter survival.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
			Increase off-channel habitat. CS: Increase juvenile overwinter survival ST: Increase juvenile and adult overwinter survival. BT: Increase sub-adult and adult overwinter survival	Floodplain restoration	All actions may be appropriate	CS ST BT	x x x	x x x	M
	Water quantity	Agriculture; Residential development	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult	Water quantity restoration	All actions may be appropriate	CS ST BT	x x x	x x x	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
			holding areas and passage.						

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Middle Methow (Category 2)	Habitat diversity and quantity; Excessive artificial channel stability	Roads; Riprap; Residential development; Agriculture	Improve riparian habitat conditions. CS: Increase juvenile overwinter surivival. ST: Increase juvenile and adult overwinter survival and spawning habitat. BT: Increase sub-adult and adult overwinter survival and spawning area.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
			Increase off-channel habitat. CS: Increase juvenile overwinter survival ST: Increase juvenile and adult overwinter survival. BT: Increase sub-adult and adult overwinter survival	Side channel reconnection	All actions may be appropriate	CS ST BT	x x x	x x x	M
				Floodplain restoration	All actions may be appropriate	CS ST BT	x x x	x x x	M
			Increase habitat diversity. CS: Increase juvenile overwinter survival and adult holding areas. ST: Increase juvenile and adult overwinter survival and adult holding areas. BT: Increase sub-adult and adult overwinter survival and adult holding areas.	Instream structures	All actions may be appropriate	CS ST BT	x x x	S	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Middle Methow (Category 2)	Water quantity	Agriculture; Residential development	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	All actions may be appropriate	CS ST BT	x x x	x x x	S
Upper-Middle Methow (Category 2)	Habitat quantity and diversity	Roads; Riprap; Residential development; Agriculture	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
				Side-channel reconnection	All actions may be appropriate	CS ST BT	x x x	x x x	M
				Floodplain restoration	All actions may be appropriate	CS ST BT	x x x	x x x	M

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Upper-Middle Methow (Category 2)	Water quantity	Residential development; Agriculture	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	All actions may be appropriate	CS ST BT	X X X	X X X	S
Upper Methow/Early Winters/Lost River (Category 1)	Water quantity	Residential development; Agriculture	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	All actions may be appropriate	CS ST BT	x x x	 X x	S
	Sediment	Fires; Timber harvest; Roads	Reduce sediment load. CS: Improve spawning and incubation success. ST: Improve spawning and incubation success. BT: Improve spawning and incubation success.	Road maintenance	All actions may be appropriate	CS ST BT	x x x	M	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Upper Methow/Early Winters/Lost River (Category 1)	Habitat diversity and quantity	Roads; Diking; Channelization	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Instream structures	All actions may be appropriate	CS ST BT	x x x	S	
				Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
				Side-channel reconnection	All actions may be appropriate	CS ST BT	x x x	x x x	M
Black Canyon/Squaw Creek (Category 3)	Habitat diversity and quantity	Roads; Riprap; Residential development	Increase habitat diversity and quantity. ST: Increase juvenile and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	ST	x		L
				Large woody debris restoration	All actions may be appropriate	ST	x		S
				Instream structures	All actions may be appropriate	ST	x		S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Black Canyon/Squaw Creek (Category 3)	Excessive artificial channel stability	Channelization	Reduce artificial channel stability and restore off-channel habitat conditions. ST: Increase juvenile and adult survival, adult holding areas, and high-flow refugia.	Side channel reconnection	All actions may be appropriate	ST	x		M
				Floodplain restoration	All actions may be appropriate	ST	x		M
	Water quantity	Agriculture	Increase instream flows. ST: Increase juvenile survival, adult holding areas, passage, and spawning success.	Water quantity restoration	All actions may be appropriate	ST	x	x	S
	Obstructions	Diversions; Culverts	Increase connectivity. ST: Improve adult and juvenile passage and access to spawning and rearing habitat.	Obstruction restoration	All actions except 5 may be appropriate	ST	x	x	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	**SS/D**	
Gold/Libby Creek (Category 3)	Habitat diversity and quantity	Roads; Residential development	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
				Large woody debris restoration	All actions may be appropriate	CS ST BT	x x x	S	
				Instream structures	All actions may be appropriate	CS ST BT	x x x	S	
	Water quantity	Agriculture	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	All actions may be appropriate	CS ST BT	X X X	X X X	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Gold/Libby Creek (Category 3)	Excessive artificial channel stability	Channelization	Reduce artificial channel stability and restore off-channel habitat conditions. CS: Increase juvenile survival, adult holding, and high-flow refugia. ST: Increase juvenile and adult survival, adult holding areas, and high-flow refugia. BT: Increase juvenile, sub-adult, and adult survival, adult holding areas, and high-flow refugia.	Side channel reconnection	All actions may be appropriate	CS ST BT	x x x	x x x	M
				Floodplain restoration	All actions may be appropriate	CS ST BT	X X X	X X X	M
	Obstructions	Diversions; Culverts	Increase connectivity. CS: Improve adult and juvenile passage and access to spawning and rearing habitat. ST: Improve adult and juvenile passage and access to spawning and rearing habitat. BT: Improve juvenile, sub-adult, and adult passage and access to spawning and rearing habitat.	Obstruction restoration	All actions except 5 may be appropriate	CS ST BT	X X X	X X X	S
Beaver/Bear Creek (Category 3)	Habitat diversity and quantity	Roads; Residential development; Fires; Agriculture	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
				Large woody debris restoration	All actions may be appropriate	CS ST BT	x x x	S	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Beaver/Bear Creek (Category 3)	Habitat diversity and quantity	Roads; Residential development; Fires; Agriculture	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Instream structures	All actions may be appropriate	CS ST BT	x x x	S	
	Sediment	Roads; Agriculture	Reduce sediment load. CS: Improve spawning and incubation success. ST: Improve spawning and incubation success. BT: Improve spawning and incubation success.	Road maintenance	All actions may be appropriate	CS ST BT	x x x	x x x	M
	Excessive artificial channel stability	Channelization; Riprap	Reduce artificial channel stability and restore off-channel habitat conditions. CS: Increase juvenile survival, adult holding, and high-flow refugia. ST: Increase juvenile and adult survival, adult holding areas, and high-flow refugia. BT: Increase juvenile, sub-adult, and adult survival, adult holding areas, and high-flow refugia.	Side channel reconnection	All actions may be appropriate	CS ST BT	x x x	x x x	M
				Floodplain restoration	All actions may be appropriate	CS ST BT	x x x	x x x	M

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Beaver/Bear Creek (Category 3)	Water quantity	Agriculture	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	All actions may be appropriate	CS ST BT	X X X	X X X	S
	Obstructions	Diversions; Culverts	Increase connectivity. CS: Improve adult and juvenile passage and access to spawning and rearing habitat. ST: Improve adult and juvenile passage and access to spawning and rearing habitat. BT: Improve juvenile, sub-adult, and adult passage and access to spawning and rearing habitat.	Obstruction restoration	All actions except 5 may be appropriate	CS ST BT	x x x	x x x	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Lower Twisp (Category 2)	Habitat diversity and quantity	Roads; Residential development	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
				Large woody debris restoration	All actions may be appropriate	CS ST BT	x x x	S	
				Instream structures	All actions may be appropriate	CS ST BT	x x x	S	
	Excessive artificial channel stability	Channelization; Riprap	Reduce artificial channel stability and restore off-channel habitat conditions. CS: Increase juvenile survival, adult holding, and high-flow refugia. ST: Increase juvenile and adult survival, adult holding areas, and high-flow refugia. BT: Increase juvenile, sub-adult, and adult survival, adult holding and spawning areas, and high-flow refugia.	Side channel reconnection	All actions may be appropriate	CS ST BT	X X X	X X X	M
				Floodplain restoration	All actions may be appropriate	CS ST BT	X X X	X X X	M

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Lower Twisp (Category 2)	Water quantity	Forest management; Agriculture	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	All actions may be appropriate	CS ST BT	X X X	X X X	S
	Obstructions	Diversions; Culverts	Increase connectivity. CS: Improve adult and juvenile passage and access to spawning and rearing habitat. ST: Improve adult and juvenile passage and access to spawning and rearing habitat. BT: Improve juvenile, sub-adult, and adult passage and access to spawning and rearing habitat.	Obstruction restoration	All actions except 5 may be appropriate	CS ST BT	X X X	X X X	S
Upper Twisp (Category 1)	Sediment	Timber harvest; Fires; Roads	Reduce sediment load. CS: Improve spawning and incubation success. ST: Improve spawning and incubation success. BT: Improve spawning and incubation success.	Road maintenance	All actions may be appropriate	CS ST BT	x x x	x x x	M

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Upper Twisp (Category 1)	Habitat diversity and quantity	Roads; Riprap and diking; Mining	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
				Floodplain restoration	All actions may be appropriate	CS ST BT	x x x	x x x	M
Lower Chewuch (Category 2)	Habitat diversity and quantity	Roads; Riprap; Residential development	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
				Large woody debris restoration	All actions may be appropriate	CS ST BT	x x x	S	
				Instream structures	All actions may be appropriate	CS ST BT	x x x	S	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Lower Chewuch (Category 2)	Excessive artificial channel stability	Channelization; Riprap	Reduce artificial channel stability and restore off-channel habitat conditions. CS: Increase juvenile survival, adult holding/spawning areas, and high-flow refugia, ST: Increase juvenile and adult survival, adult holding/spawning areas, and high-flow refugia, BT: Increase juvenile, sub-adult, and adult survival, adult holding/spawning areas, and high-flow refugia.	Side channel reconnection	All actions may be appropriate	CS ST BT	x x x	M	
				Floodplain restoration	All actions may be appropriate	CS ST BT	X X X	x x x	M
	Sediment	Fires; Agriculture; Roads; Residential development	Reduce sediment load. CS: Improve spawning and incubation success. ST: Improve spawning and incubation success. BT: Improve spawning and incubation success.	Road maintenance	All actions may be appropriate	CS ST BT	x x x	M	
	Water quantity	Agriculture; Roads; Residential development	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase sub-adult survival, adult holding areas, passage, and spawning success.	Water quantity restoration	All actions may be appropriate	CS ST BT	X X X	X X X	S

<table>
<tr><th rowspan="2">Assessment Unit
(Prioritization Category)</th><th rowspan="2">Primary Limiting Factor</th><th rowspan="2">Primary Causal Factor/Threat</th><th rowspan="2">Management Objective</th><th rowspan="2">Appropriate Restoration Class</th><th rowspan="2">Specific Restoration Action (see Table 5.9)</th><th rowspan="2">Species Affected</th><th colspan="2">Contribution to VSP</th><th rowspan="2">Effect Time</th></tr>
<tr><th>A/P</th><th>SS/D</th></tr>
<tr><td>Lower Chewuch
(Category 2)</td><td>Water quality</td><td>Agriculture;
Fires;
Roads;
Timber harvest;
Residential development</td><td>Decrease summer temperatures.
CS: Increase juvenile and adult survival and spawning habitat.
ST: Increase juvenile and adult survival and spawning habitat.
BT: Increase juvenile, sub-adult, and adult survival and spawning habitat.</td><td>Water quality restoration</td><td>Actions 1-3, and 6-30</td><td>CS
ST
BT</td><td>x
x
x</td><td>x
x
x</td><td>M</td></tr>
<tr><td rowspan="2">Upper Chewuch
(Category 1)</td><td rowspan="2">Habitat diversity and quantity;
Sediment</td><td rowspan="2">Timber harvest;
Fires;
Roads;
Channelization;
Riprap;
Agriculture</td><td rowspan="2">Increase habitat diversity and quantity.
CS: Increase juvenile survival and adult holding and spawning habitat.
ST: Increase juvenile and adult survival and adult holding and spawning habitat.
BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.</td><td>Riparian restoration</td><td>All actions may be appropriate</td><td>CS
ST
BT</td><td>x
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x</td><td>L</td><td></td></tr>
<tr><td>Road maintenance</td><td>All actions may be appropriate</td><td>CS
ST
BT</td><td>x
x
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x
x</td><td>M</td></tr>
</table>

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Wolf/Hancock Creek (Category 2)	Habitat diversity and quantity	Roads; Agriculture; Riprap	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile, sub-adult, and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
				Large woody debris restoration	All actions may be appropriate	CS ST BT	x x x	S	
				Instream structures	All actions may be appropriate	CS ST BT	x x x	S	
	Excessive artificial channel stability	Channelization; Riprap	Reduce artificial channel stability and restore off-channel habitat conditions. CS: Increase juvenile survival, adult holding and spawning areas, and high-flow refugia. ST: Increase juvenile and adult survival, adult holding and spawning areas, and high-flow refugia. BT: Increase juvenile, sub-adult, and adult survival, adult holding and spawning areas, and high-flow refugia.	Side channel reconnection	All actions may be appropriate	CS ST BT	x x x	M	
				Floodplain restoration	All actions may be appropriate	CS ST BT	x x x	M	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Goat/Little Boulder Creek (Category 3)	Habitat diversity and quantity	Roads; Riprap; Residential development	Increase habitat diversity and quantity. CS: Increase juvenile survival and adult holding and spawning habitat. ST: Increase juvenile and adult survival and adult holding and spawning habitat. BT: Increase juvenile and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	CS ST BT	x x x	L	
				Large woody debris restoration	All actions may be appropriate	CS ST BT	x x x	S	
				Instream structures	All actions may be appropriate	CS ST BT	x x x	S	
	Excessive artificial channel stability	Channelization; Riprap	Reduce artificial channel stability and restore off-channel habitat conditions. CS: Increase juvenile survival, adult holding, and high-flow refugia. ST: Increase juvenile and adult survival, adult holding areas, and high-flow refugia. BT: Increase juvenile survival, adult holding, and high-flow refugia.	Side channel reconnection	All actions may be appropriate	CS ST BT	x x x	M	
				Floodplain restoration	All actions may be appropriate	CS ST BT	x x x	M	

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Goat/Little Boulder Creek (Category 3)	Water quantity	Agriculture;	Increase instream flows. CS: Increase juvenile survival, adult holding areas, passage, and spawning success. ST: Increase juvenile survival, adult holding areas, passage, and spawning success. BT: Increase juvenile survival, adult holding areas, passage, and spawning success.	Water quantity restoration	All actions may be appropriate	CS ST BT	x x x	x x x	S
	Obstructions	Diversions; Culverts	Increase connectivity. CS: Improve adult and juvenile passage and access to spawning and rearing habitat. ST: Improve adult and juvenile passage and access to spawning and rearing habitat. BT: Improve adult and juvenile passage and access to spawning and rearing habitat.	Obstruction restoration	All actions except 5 may be appropriate	CS ST BT	x x x	x x x	S

Table 4 List of habitat actions (and classes) that address primary limiting factors and threats within each assessment unit in the Okanogan subbasin. Management objectives are identified for steelhead (ST) as well as the contribution of restoration actions to VSP (A/P = abundance/productivity; SS/D = spatial structure/diversity) (X = large effect; x = small effect). Effect time indicates the amount of time it will take before the effects of the restoration action translate to changes in VSP parameters (S = 1-5 years; M = 6-20 years; L = >20 years)

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Lower Okanogan (Category 2)	Habitat diversity and quantity	Dams; Agriculture	Improve riparian habitat conditions. ST: Increase juvenile and adult overwinter survival and spawning habitat.	Riparian restoration	All actions may be appropriate	ST	x		L
	Obstructions	Diversions	Screen irrigation diversions. ST: Increase juvenile survival.	Obstruction restoration	Action 1	ST	x		S
	Water quality	Agriculture; Residential development; Diversions and dams	Reduce summer water temperatures. ST: Increase juvenile and adult survival and passage (eliminate thermal block).	Floodplain restoration	All actions may be appropriate	ST	x	x	S
				Side-channel reconnection	All actions may be appropriate	ST	x	x	S
Middle Okanogan (Category 2)	Sediment	Agriculture; Residential development	Reduce sediment load. ST: Improve spawning and incubation success.	Floodplain restoration	All actions may be appropriate	ST	x	x	S
	Water quality	Agriculture; Diversions and dams; Residential development	Reduce summer water temperatures. ST: Increase juvenile and adult survival and passage (eliminate thermal block).	Floodplain restoration	All actions may be appropriate	ST	x	x	S
				Side-channel reconnection	All actions may be appropriate	ST	x	x	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Upper Okanogan (Category 2)	Habitat diversity and quantity	Channelization; Agriculture; Riprap and dikes; Residential development	Increase habitat diversity. ST: Increase juvenile and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	ST	x		L
	Water quality	Dams and diversions; Agriculture; Residential development	Reduce summer water temperatures. ST: Increase juvenile and adult survival and passage (eliminate thermal block).	Floodplain restoration	All actions may be appropriate	ST	x	x	S
				Side-channel reconnection	All actions may be appropriate	ST	x	x	S
	Sediment	Agriculture; Residential development	Reduce sediment load. ST: Improve spawning and incubation success.	Floodplain restoration	All actions may be appropriate	ST	x	x	S
Loup-Loup Creek (Category 4)	Habitat diversity and quantity	Channelization; Agriculture; Residential development; Roads	Increase habitat diversity. ST: Increase juvenile and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	ST	x		L
				Large woody debris restoration	All actions may be appropriate	ST	x		S
				Instream structures	All actions may be appropriate	ST	x		S
	Water quantity	Diversions; Agriculture	Increase instream flows. ST: Increase juvenile and adult passage and survival.	Water quantity restoration	All actions may be appropriate	ST	x	x	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Loup-Loup Creek (Category 4)	Obstructions	Culverts	Increase connectivity. ST: Improve adult and juvenile passage, increase high-flow refugia for juveniles, and increase access to spawning and rearing habitat.	Obstruction restoration	Actions 1-4, and 6	ST	x	x	S
Lower Salmon Creek (Category 3)	Water quantity	Diversions; Agriculture	Increase instream flows. ST: Increase juvenile and adult passage and survival.	Water quantity restoration	All actions may be appropriate	ST	x	x	M
				Side channel reconnection	All actions may be appropriate	ST	x	x	S
				Floodplain restoration	All actions may be appropriate	ST	x	x	S
	Obstructions	Physical barriers	Increase connectivity. ST: Improve adult and juvenile passage, increase high-flow refugia for juveniles, and increase access to spawning and rearing habitat.	Obstruction restoration	Actions 1-4, and 6	ST	x	x	S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Omak and Tributaries (Category 2)	Habitat diversity and quantity; Channel stability	Channelization; Agriculture; Residential development	Increase habitat diversity. ST: Increase juvenile and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	ST	x		L
				Large woody debris restoration	All actions may be appropriate	ST	x		S
				Instream structures	All actions may be appropriate	ST	x		S
	Sediment	Roads	Reduce sediment load. ST: Improve spawning and incubation success.	Road maintenance	All actions may be appropriate	ST	x	x	S
	Obstructions	Impediment at Mission Falls	Increase connectivity. ST: Improve adult and juvenile passage and increase access to spawning and rearing habitat.	Obstruction restoration	Action 2	ST	x	x	M
Small Tributary Systems (Category 4)	Habitat diversity and quantity; Channel stability	Roads; Channelization; Agriculture; Residential development	Increase habitat diversity. ST: Increase juvenile and adult survival and adult holding and spawning habitat.	Riparian restoration	All actions may be appropriate	ST	x		L
				Large woody debris restoration	All actions may be appropriate	ST	x		S
				Instream structures	All actions may be appropriate	ST	x		S
	Obstructions	Culverts	Increase connectivity. ST: Improve adult and juvenile passage and increase access to spawning and rearing habitat.	Obstruction restoration	All actions may be appropriate	ST	x	x	S
	Sediment	Roads	Reduce sediment load. ST: Improve spawning and incubation success.	Road maintenance	All actions may be appropriate	ST	x		S

Assessment Unit (Prioritization Category)	Primary Limiting Factor	Primary Causal Factor/Threat	Management Objective	Appropriate Restoration Class	Specific Restoration Action (see Table 5.9)	Species Affected	Contribution to VSP		Effect Time
							A/P	SS/D	
Small Tributary Systems (Category 4)	Water quantity	Diversions; Agriculture	Increase instream flows. ST: Increase juvenile and adult passage and survival.	Water quantity restoration	All actions may be appropriate	ST	x	x	M
Similkameen (Category 3)	Sediment	Mining; Agriculture	Reduce sediment load. ST: Improve spawning and incubation success.	Side-channel reconnection	All actions may be appropriate	ST	x	x	S
				Floodplain restoration	All actions may be appropriate	ST	x	x	M
	Water quality	Mining	Improve water quality. ST: Increase juvenile and adult survival.	Water quality restoration	Actions 3, 4, and 6	ST	x		M

Appendix H

A BIOLOGICAL STRATEGY TO PROTECT AND RESTORE SALMONID HABITAT IN THE UPPER COLUMBIA REGION

Discussion Draft (22 May 2003)

A Report to the Upper Columbia Salmon Recovery Board from the Upper Columbia Regional Technical Team:

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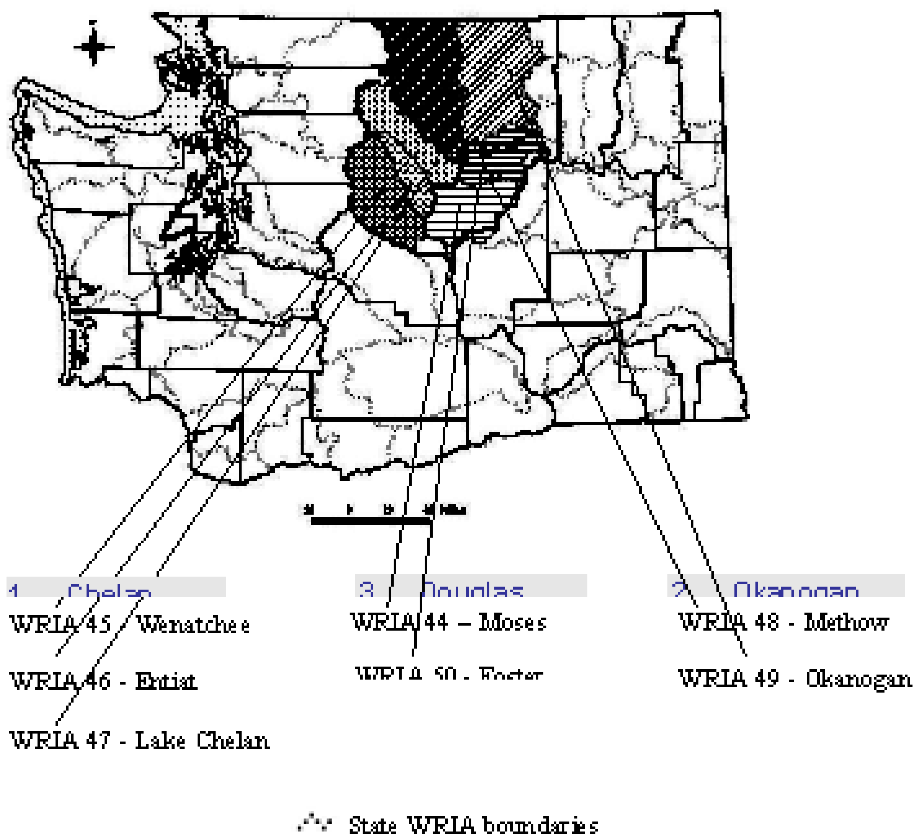
A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region

Introduction

Purpose

This document outlines a biological strategy to protect and restore salmonid habitat in the Upper Columbia Region. The intent of the document is to provide a technical foundation to set regional priorities for habitat protection and restoration, based on available information and the professional judgement of fisheries biologists familiar with the region. This report was developed by a Regional Technical Team (RTT), which was established by the Upper Columbia Salmon Recovery Board (UCSRB). This report is an update to initial documents provided to the UCSRB (RTT 2000, 2002a). Further updates may be provided as new information becomes available Recommendations contained herein may be used by decision-makers to more effectively allocate resources to contribute to the recovery of salmonids listed under the federal Endangered Species Act (ESA). This strategy identifies the key biological considerations in protecting and restoring habitat, yet does not provide recommendations on the means to accomplish these issues, as they generally entail important policy considerations on natural



Note: This figure is incomplete and will be fixed in the next version.

resource management. Project sponsors are encouraged to use this strategy to identify the locations and types of projects that would provide a high likelihood of benefit to salmonids, yet should work closely with the UCSRB in identifying appropriate means to implement the projects.

The UCSRB is a partnership among Chelan, Douglas, and Okanogan counties, the Yakama Nation, and Colville Confederated Tribes in cooperation with local, state, and federal partners. The mission of the UCSRB is to restore viable and sustainable populations of salmon, steelhead, and other at-risk species through the collaborative, economically sensitive efforts, combined resources, and wise resource management of the Upper Columbia Region. To better meet its mission, the UCSRB wishes to ensure that actions taken to protect and restore salmonid habitat in the region are based on sound scientific principles. The UCSRB may use these principles to develop strategies that address the needs of salmon in an economically viable manner.

One function of the RTT is to review the technical merits of projects to be submitted by project sponsors in the Upper Columbia Region for funding by the Washington State Salmon Recovery Funding Board (SRFB). The UCSRB directed the RTT to establish a scientific framework for this process, with the premise that it will enable them to identify projects that will best contribute to the recovery of salmonids listed under the ESA. This report is a technical guide to help the Lead Entities, Citizens' Committees, and project sponsors to develop and identify habitat protection and restoration projects.

Scope

The species included in this overview include chinook salmon (*Oncorhynchus tshawytscha*), sockeye salmon (*O. nerka*), steelhead (*O. mykiss*), westslope cutthroat trout (*O. clarki*) and bull trout (*Salvelinus confluentus*), although other species will benefit from the recommended priorities in this report. The Upper Columbia Region (Figure 1) is comprised of the mainstem Columbia River and its tributaries upstream of Rock Island Dam to the tailrace of Chief Joseph Dam. Within this region there are seven Water Resource Inventory Areas (WRIAs): Moses Coulee (44), Wenatchee (45), Entiat (46), Chelan (47), Methow (48), Okanogan (49), and Foster Creek (50), and the northernmost tip of Alkali-Squilchuck (40). These WRIAs are referred to as "subbasins" in this document, and are composed of "watersheds" (Hydraulic Unit Code 5). This report provides specific recommendations for each of the 31 watersheds (and the mainstem Columbia River) in the region.

The RTT considers this report to be iterative. New and more refined biological priorities could be developed when key policy directives are made, or when new biological data are gathered. The priorities suggested in this report are consistent with the 2000 and 2002 reports released by the RTT.

Relation to Other Assessments

This document complements the Habitat Limiting Factors Analyses (HLFA) conducted by the Washington Conservation Commission. It uses the information in the completed HLFA reports for the Wenatchee, Entiat, Foster Creek/Moses Coulee, Methow and Okanogan WRIAs to establish a common framework throughout the region, rather than on an individual WRIA basis. As this strategy develops, it will incorporate findings of individual WRIAs under the state's Watershed Planning Act (RCW 90.82). This strategy considers the biological priorities set in the Spirit of the Salmon Recovery Plan by the Columbia River Intertribal Fish Commission and the Tributary Assessment of the Mid-Columbia Mainstem Conservation Plan, and is intended to complement the Subbasin Summaries under the Northwest Power and Conservation Council's Provincial Rolling Review. The integration of tribal, local, state, and federal watershed planning and salmon recovery efforts into this strategy illustrates the coordinated and comprehensive approach of the Upper Columbia Salmon Recovery Board.

Priorities in Species Distribution

Threatened, endangered and unlisted salmonids are found in most, but not all watersheds in the Upper Columbia Region. In order to help guide protection and restoration programs, the RTT adapted the work of MacDonald et al. (1996) who identified Significant Subwatersheds (HUC-6 level) for spring chinook salmon, summer chinook salmon, sockeye salmon, summer steelhead, bull trout, and westslope cutthroat trout. Based on the framework established by MacDonald et al. (1996), we considered a subwatershed to be significant if any one of the following criteria was met:

- The subwatershed was identified as a stronghold for the species in the Interior Columbia Basin Assessment (ICBEMP 1997).

- The subwatershed provides the primary spawning and/or rearing habitat within the watershed.

- The subwatershed represents the only known occupied habitat within a watershed and is fairly isolated from populations in other watersheds, and thus is significant from a distribution standpoint.

- The subwatershed contributes toward the genetic integrity of a species. One of the problems facing many native fish populations is genetic introgression. Relatively pure populations, which may be very important to the evolutionary legacy of a species, may be limited. Recently genetic information has become available for some populations in the Upper Columbia Region. Populations judged to be "pure," "essentially pure," or "good" based upon genetic analysis were considered to be significant.

- The subwatershed is known or strongly suspected to support a stable, strong population of a species.

Appendix A contains maps of RTT identified Significant Subwatersheds for sockeye salmon, spring chinook salmon, summer chinook salmon, steelhead, and bull trout. Additional Significant Subwatersheds may be identified, or some Significant Subwatersheds may be determined not to be significant, based upon the above criteria, as more information becomes available.

The designation of Significant Subwatershed does not necessarily depict the total distribution or life history stages of salmonids in the Upper Columbia region. Appendix B contains the known distribution of salmonids in the region. However, the status of some salmonid species is not fully known, particularly for those that drain directly into the Columbia River. In an effort to better capture current, known salmonid distributions, the Washington Conservation Commission (WCC) completed GIS coverages for salmonid fish distribution the Upper Columbia region (except Lake Chelan). The coverages were developed by incorporating existing local, state, and federal electronic data and professional knowledge to update the data into 1:24,000 scale coverages. The GIS salmonid fish distribution coverages are available from the WCC office in Olympia, Washington. Available WCC salmonid fish distribution GIS coverages are as follows:

- WRIAs 44 and 50 (Moses Coulee and Foster Creek watersheds), including the mainstem Columbia River from one mile downstream of the Moses Coulee confluence (RM 447.9) upstream to Grand Coulee Dam (RM 596.6) - summer chinook, spring chinook, steelhead, sockeye, bull trout, and coho.

- WRIA 45 (Wenatchee Subbasin), including portions of WRIA 40 (Squilchuck, Stemilt and Colockum creeks) - summer chinook, spring chinook, steelhead, sockeye, and bull trout.

- WRIA 46 (Entiat Subbasin) – summer chinook, spring chinook, steelhead, and sockeye.

- WRIA 48 (Methow Subbasin) - summer chinook, spring chinook, steelhead, and bull trout.

- WRIA 49 (Okanogan Subbasin, U.S. portion only) - summer chinook, spring chinook, steelhead and sockeye.

In spring 2003, WDFW updated their salmonid fish distribution database, StreamNet, with associated GIS coverages, and incorporates the WCC salmonid distribution information. The updated 1:24,000 WDFW StreamNet fish distribution coverages will be available from the WDFW offices in Olympia, Washington.

Priorities in Habitat Activities

Habitat Protection

The highest priority for protecting biological productivity should be to allow unrestricted stream channel migration, complexity, and flood plain function. The principal means to meet this objective is to protect riparian habitat--in Category 1 and 2 subwatersheds. Predetermined riparian protection measures (i.e., buffer strip widths) for each site may not be biologically effective. Riparian function depends on site-specific considerations including channel type, floodplain character, presence of wetlands or off-channel features, and the potential for channel migration. Obviously, some areas have more acute needs, because they may be within significant population areas, or may be at risk to habitat degradation, and should be given greater emphasis. These efforts will likely occur throughout the subbasins where properly functioning habitat remains.

Protection of existing stream flows in virtually all subbasins in the Upper Columbia Region is important to maintaining biological productivity. Currently, the primary means to protect existing flows are regulatory in nature. Additionally, some Upper Columbia streams need increased flows to address chronic sources of mortality to salmonids; inadequate flows may be natural or human-caused. Diversion of water for out-of-stream uses (principally for irrigation and municipalities) is the most tangible impact to instream flow needs for fish. In addition, degradation of floodplain (and some upland) habitats exacerbates the peak and nadir of seasonal flows in all Upper Columbia subbasins; this strongly reduces the productivity and expression of diverse life histories in the region. The full effects of upland habitat degradation on peak flows in the Upper Columbia Region are not understood and should be assessed. The means to increase flows are discussed in the section on habitat restoration.

Habitat Restoration

The highest priority for increasing biological productivity is to restore the complexity of the stream channel and floodplain. The RTT recommends a range of strategies for habitat restoration in the Upper Columbia Region, based on a fundamental emphasis of promoting habitat diversity, instream flows, and water quality throughout the watershed. Most of these efforts will likely be on the lower stream reaches and aggradation zones (typically areas of low stream gradient where deposition of substrate materials occurs). Restoration in these areas would benefit a broad range of species and populations. Examples of restoration measures would include, but not be limited to:

- provide fish access to disconnected stream sections or oxbows,
- remove dikes (or similar structures) that prevent stream channel migration,

- change the points of origin for problematic water withdrawals to less sensitive site(s),
- screen water intakes to prevent impingement or stranding of juvenile fish,
- manipulate stream flows at critical periods through various means,
- provide alternative sources of irrigation and domestic water to mitigate impacts of problematic surface water diversions,
- remove passage barriers,
- use mechanical means to encourage natural development of riparian areas,
- implement upland management practices that reduce sediment delivery to streams, and
- use engineering techniques to increase complexity of permanently altered habitats.

We strongly recommend that structural manipulation of the stream channel (such as boulder or log placements) not be used unless (1) they are designed at the reach level or context and (2) those factors that are causing the habitat degradation cannot be corrected within a reasonable time. Remedial measures to rectify the effects of improper land use practices can have more benefits to biological productivity, may be economically more efficient, and be more permanent than measures that require active management of the stream channel. The simple alteration of physical features in the stream channel does not necessarily restore biological productivity when improper riparian or upland management practices continue to exert their effects on the aquatic ecosystem. Attempts to restore habitat are likely to fail if structures are placed in the stream channel without addressing those activities that are causing habitat degradation. For example, some short-term habitat benefits might be achieved by adding large woody debris (LWD) to streams, but the benefits can only be temporary from an ecological perspective unless riparian management practices ensure the long-term recruitment of LWD from the riparian zone.

In some isolated situations, restoration projects may be accomplished with both short-term and long-term objectives. For example, LWD may be secured to stabilize erosive banks, allowing interim streambank protection and salmonid habitat, while passive restoration and revegetation will ensure proper functioning riparian conditions for the long term. We feel these projects are biologically effective when the initiation of the short-term strategy has been integrated with the long-term strategy. Each active restoration project should be reviewed on a case-by-case basis.

Priorities Across Varied Landscapes

The consensus of the RTT is that protection and restoration should focus first on maintaining the best remaining examples of biological integrity, connectivity, and diversity. This strategy will allow the populations to stabilize in abundance and productivity over the long term. It may be likely however, that current core populations have inadequate diversity and spatial distribution to ensure population resiliency.

To provide a framework to set priorities consistent with this strategy, the RTT classified each watershed (HUC-5 level) in the Upper Columbia Region into four categories, based on the functionality of the aquatic ecosystems in those watersheds, and the capability of the ecosystem to protect against ecological catastrophe for endemic populations. We also designated the mainstem Columbia River as separate (Category 5) because of its unique features. We adapted the classification system used by Quigley and Arbelbide (1997) for this report. In general, Category 1 watersheds should receive priority allocation of financial and management resources. Subsequent allocation of resources should be given to Categories 2 and 3, in that order, once refuge habitats (Category 1) for the target species are protected and secure. This does not mean however, that specific actions should not occur in Category 2 and 3 watersheds until all activities in Category 1 watersheds are completed. Any project within those watersheds that increase the range, life history diversity, or age cohorts of one or more species would contribute to the overall strategy of making them more robust to disturbances within and outside the region. As salmon recovery progresses, founder populations from core areas would colonize many watersheds that are suitable, yet unoccupied. Restoration of Category 4 watersheds should be considered in the regional recovery planning process, but immediate actions there would not be a priority.

Category 1:

These watersheds represent systems that most closely resemble natural, fully functional aquatic ecosystems (Table 1). In general, they comprise large, often continuous blocks of high-quality habitat and subwatersheds supporting multiple populations. Connectivity among subwatersheds and through the mainstem river corridor is good, and more than two species of federally listed fish are known to occur. Exotic species may be present but are not dominant. Protecting the functioning ecosystems in these watersheds is a priority.

Category 2:

These watersheds support important aquatic resources, often with subwatersheds classified as strongholds (Appendix A), for one or more populations throughout. The most important difference between Category 1 and Category 2 is an increased level of fragmentation that has resulted from habitat disturbance or loss (Table 1). These watersheds have a substantial number of subwatersheds where native populations have been lost or are at risk for a variety of reasons. At least one federally listed fish species can be found within the watershed. Connectivity among subwatersheds may still exist or could be restored within the watershed so that it is possible to maintain or rehabilitate life history patterns and dispersal. Restoring ecosystem functions and connectivity within these watersheds are priorities.

Category 3:

These watersheds may still contain subwatersheds that support salmonids (Table 1). In general, however, these watersheds have experienced substantial degradation and are strongly fragmented by extensive habitat loss, most notably through loss of connectivity with the mainstem corridor. At this time, there are limited opportunities for restoring full expression of life histories for multiple populations found within the watershed. The priority for funding in these watersheds should be to rectify the primary factor that is causing the habitat degradation.

Category 4:

These watersheds contain both functional and non-functional habitats that historically supported populations of one or more federally listed species (Table 1). Exotic species may now be dominant in one or more subwatersheds; native species are typically not present in sustainable numbers.

Category 5:

The Upper Columbia River is a migration and movement corridor for anadromous and inland species, and has documented spawning, rearing, and overwinter habitat for several species (Table 1). Hydroelectric dams primarily effect habitat quality and use in the mainstem, but shoreline management also influences salmonid habitat use. Protection of shoreline areas should be a priority. Restoration should be considered, if it can be shown to cause sustainable and reasonable improvements to productivity of salmonids in the Upper Columbia Region.

Table 1 Comparison of key indicators for watershed categories used to identify priority actions for protection and restoration of salmonid habitat in the Upper Columbia Region. The mainstem Columbia River is a separate category, and is treated separately in this analysis.

Category	Significant subwatersheds	Principle actions	Habitat fragmentation	Exotic species	Listed species
1	Yes	Protection	Low	Low	Two or more

2	Yes	Protection/ restoration	Medium	Medium	One or more
3	Possible	Restoration	High	High	Possible
4	No	Restoration	High	High	Possible

Interim Objectives by Subbasin and Watershed

The following narratives for each subbasin (HUC-4) provide interim (five-year) objectives for protection and restoration of salmonid habitats. In these assessments, we identify priorities within and across the subbasins. The tables in Appendix B provide greater detail: they outline the status of each watershed (HUC-5), classify them by the above categories, identify Significant Subwatersheds (HUC-6), recommend priority approaches, and lay the foundation for a region-wide effectiveness monitoring program (discussed in Section 7).

The Wenatchee Subbasin (WRIA 45)

The Wenatchee River is unique among subbasins in the Upper Columbia Region in that it supports the greatest diversity of populations and overall abundance of salmonids, yet is facing the greatest risk of habitat loss and degradation. State highways, railroads, and housing development have substantially diminished the overall function of the stream channel and floodplain. This has impaired stream complexity, wood and gravel recruitment, floodwater desynchronization and retention, late summer flows, and water quality.

There are core populations of sockeye salmon, steelhead, bull trout and both spring and summer chinook salmon in the upper Wenatchee Subbasin that are relatively strong, when compared to other populations in the Columbia Basin. The highest regional priority should be the protection of this salmonid community. The immediate strategy should be to protect the watersheds that contain these core populations so that they are robust to normal environmental disturbances, and then to expand their range to adjacent watersheds. Priority (Category 1) watersheds within the Wenatchee Subbasin are White River, Chiwawa River, and the upper and middle mainstem Wenatchee River (including Lake Wenatchee, Table 2). These watersheds are well connected and support a diverse assemblage of native species. Efforts should be made to connect Category 1 and 2 watersheds (Nason Creek, Middle Mainstem Wenatchee River, and Icicle Creek) to these strongholds, which would enable a fuller expression of life history strategies and increase population resilience.

Recent research indicates that the mainstem Wenatchee River provides important habitat for many life stages of spring and summer chinook salmon, steelhead, and bull trout. The mainstem at this time is most vulnerable to riparian and instream habitat degradation. All remaining intact areas on the mainstem should be protected, and flood plain function should be restored, particularly from the Mission Creek confluence downstream to the Columbia River confluence. This could primarily be done with passive restoration. Since this reach has the highest discharge in the subbasin, the extent of riparian vegetation needed to restore flood plain function would be larger than the tributaries. Benefits of this action would be numerous to anadromous and inland salmonids, as well as a myriad of wildlife species.

The Entiat Subbasin (WRIA 46)

The Entiat River has been affected by upland management activities throughout the subbasin and construction of flood control dikes in the lower mainstem. To encourage properly functioning and stable habitats in the subbasin, four actions should be approached simultaneously:

1. protect core subwatersheds in the upper subbasin and upper Mad River (Category 1 watersheds),
2. continue restoration of highly erosive upland areas in Fox, McCree, Brenegan, Preston, and Mud creeks, Crum Canyon, and the mainstem Entiat between Fox and Stormy creeks (Category 1 and 2 subwatersheds),
3. restore habitat diversity and channel function in the lower Entiat River (a Category 2 watershed), and
4. increase late summer instream flows in the lower Entiat and lower Mad rivers (Category 2 watersheds).

Upland erosion is a severe chronic problem in the Entiat Watershed, yet substantial restoration efforts are underway in the Wenatchee National Forest to address this problem. Erosion on private lands contributes little to the overall problem of sediment delivery to the stream.

Low stream channel complexity is the primary limitation to productivity of salmonids on the lower 20-km of the mainstem Entiat River (downstream of the terminal moraine: Category 2). Stream sinuosity is low, with very few point bars for gravel accumulation. Instream habitat diversity is also low, with few pools, glides, pocket waters or LWD accumulations. As a result, there are very few resting areas for both adult and juvenile salmon through this important migration corridor. Efforts to improve stream sinuosity and channel forming processes in the lower reach should be considered.

Based on the work of NRCS, we believe the most feasible means to restore habitat in the lower Entiat River is primarily in structure placement as an immediate improvement, and floodplain restoration as the long-term solution. This short term/long term approach is the most pragmatic restoration practice available for the lower Entiat River. Initially, managers should actively restore the lower Entiat River to increase stream habitat complexity, encourage thalweg development, and deposition of spawning gravels. The long-term approach should be to restore riparian and floodplain habitat in the lower Entiat River. Such measures would also be feasible in the lower Mad River (a Category 2 subwatershed).

A multi disciplinary team of fishery biologists, hydrologists, and fluvial geomorphologists should provide specific recommendations on the types of structures that would work best, based upon channel configuration. Active restoration projects should be reviewed on a case-by-case basis. We caution that these approaches to increase productivity are short-term, and will likely require maintenance. The lower Entiat River is one of the few watersheds in the Upper Columbia Region where active manipulation of the stream channel is appropriate, and should only be done with a strategy in place to restore floodplain function on a permanent basis.

The most pressing needs on the lower Entiat River are the lack of instream complexity and riparian cover, yet there are other factors that adversely affect salmonids. It is our opinion that instream flows limit salmonid production in the lower Entiat River, but not to the chronic and severe extent seen in other subbasins of the Upper Columbia Region. This is partly a result of the natural characteristics of the watershed, upland slope condition, irrigation water withdrawals, and stream channel modifications in lower Entiat River. Projects that increase late summer flows in the lower Entiat River should be a subbasin priority.

The Methow Subbasin (WRIA 48)

The Methow River has a high proportion of pristine habitats, relative to other subbasins in the region. However, late summer and winter instream flow conditions often reduce migration, spawning, and rearing habitat for stream-type chinook salmon. This problem is partly natural (a result of watershed-specific weather and geologic conditions) but is exacerbated by irrigation, particularly at the points of surface water withdrawals. The immediate strategy to protect and restore the Methow Subbasin has two factors:

1. Protect riparian habitats in the mainstem Methow River and in the lower reaches of some of the key tributaries: Lost River, Early Winters Creek, Gold Creek, Libby Creek, Wolf Creek, Chewuch River,

and Twisp River, (Category 1 and 2 watersheds). Protection of riparian and floodplain habitats should benefit instream flow conditions.

2. Increase late summer and winter instream flows in these streams.

Both of these factors will serve to stabilize and improve winter and late summer flows, and should be considered a regional priority. Within the Methow Subbasin, three other factors are of secondary, yet still critical importance, and should be addressed as subbasin priorities:

1. passage barriers created by irrigation diversion dams (primarily push up dams) and road culverts should be corrected,

2. improper irrigation screens should be modified to meet current standards, or points of diversions changed to minimize impacts to salmonids, and

3. dikes and hardened banks should be corrected to allow less restricted stream channel migration.

The Okanogan Subbasin (WRIA 49)

The Okanogan/Similkameen is the largest and most complex subbasin in the region, and has a relatively high proportion of land in private ownership. Poor water quality and low late summer instream flows strongly limit the survival, distribution, and productivity of both anadromous and inland salmonids. More than half of the subbasin is within British Columbia and many of the causes for water pollution begin there, making an acute need for a coordinated transboundary process. There is an effort underway to convene all tribal, local, state, provincial, and federal governments to begin a comprehensive water planning and management process in the subbasin.

Water temperatures often exceed lethal tolerance levels for salmonids in United States portion of the Okanogan Subbasin. This exceedence is partly a result of natural phenomena (low gradient and solar radiation on the upstream lakes), but is exacerbated by sedimentation and summer low flows caused by dam operations, irrigation, and highly erosive uplands. High water temperatures and low flows in summer and fall effectively exclude juvenile salmon from rearing in most tributaries of the basin.

In addition to the thermal barrier on the mainstem Okanogan River, there are three structural barriers to upstream migration in the Okanogan Subbasin: (1) Enloe Dam on the Similkameen River (There is debate within the region whether anadromous salmonids historically passed the natural waterfalls that existed prior to construction of the dam on the lower Similkameen River.),

(2) McIntyre Dam on the mainstem Okanagan River in British Columbia, and (3) low flows on Salmon Creek caused by the Okanogan Irrigation District diversion dam. Each of these substantially reduces the distribution and abundance of anadromous salmonids. Correction of these barriers would have lasting and important increases in salmon productivity, and would enable colonization and expansion from core populations.

Sedimentation is a major water quality concern in the Okanogan Subbasin. Naturally erosive soils coupled with improper land use management have resulted in accelerated sediment delivery to the stream system. The effects of sedimentation include channel widening, loss of pool habitat, shallower, broader channels, elevated water temperatures, and substrate embeddedness. Soil erosion is most severe in the Similkameen watershed, but is also a concern in Bonaparte, Antoine, and Omak creeks. Overall, the Similkameen, Bonaparte, and the Okanogan mainstem itself contribute the most sediment to the Okanogan River.

The immediate strategy should be to protect the remaining sockeye and summer chinook spawning and rearing habitat that remains within this watershed. In particular, the summer chinook spawning habitat located in the lower Similkameen (Category 2) and in the mainstem Okanogan River between Ellisford and Riverside (Category 2) and the remaining sockeye spawning habitat that remains downstream of McIntyre Dam (Category 2). Strategies should also be explored to reconnect smaller tributary streams with the mainstem Okanogan River. Many of the smaller tributaries once provided thermal refuge for summer and fall migrating adults and for rearing of stream-type juvenile salmonids. These actions would allow recolonization of summer chinook, sockeye and summer steelhead into historical areas. Any effort to establish a normative hydrograph, decrease the width: depth ratio, increase riparian coverage, and decrease sediment input will improve water quality, quantity and would provide for improved upstream migration and over-summer rearing conditions. Late-summer instream flows of tributary streams should be increased.

The Foster Creek/Moses Coulee Subbasin (WRIAs 50 and 44)

Relative to other subbasins in the region, the habitats in these streams have limited capability to sustain natural populations of salmonids (Category 4). This limitation is mostly a result of very low levels of precipitation and resultant stream flows, and the topography near the streams as they enter the Columbia River. Some human activities may have reduced survival and distribution of salmonids—particularly steelhead/rainbow trout. There is evidence that juvenile salmon and steelhead rear and overwinter in the mouths of Foster Creekand Rock Island Creek. Steelhead have spawned in high escapement years in Foster Creek. Sediment from upland activities may affect spawning and rearing conditions; agricultural practices that reduce upland erosion would have sustainable benefits. Conversion of upland, riparian, and wetland habitats into arable land probably reduced water storage and runoff patterns.

The immediate strategy should be to monitor the presence of salmonids (at several life stages) in streams suspected to support natural populations (Foster Creek and Rock Island Creek). For these streams that support salmonids, assess habitat condition and evaluate barriers to upstream passage, and develop a strategy to increase productivity.

North Alkali/Squilchuck (Partial WRIA 40)

Colockum, Stemilt, and Squilchuck creeks support small numbers of spring chinook salmon and steelhead, yet little is known about their abundance and productivity. We speculate that passage barriers and intermittent stream flows limit the distribution of anadromous salmonids, and likely isolate populations of inland trout. The immediate strategy for these Category 4 streams would be twofold: 1) Increase late summer instream flows, if it can be shown to contribute to sustainable habitat conditions, and 2) Develop and implement an approach to correct passage barriers, if it can be shown that sufficient flows will be available for sustainable spawning and rearing in the newly accessible habitats.

Both these actions require a fundamental information base on habitat conditions and the current (and potential) distribution of anadromous and resident salmonids. These data should be collected before any restoration projects begin. A survey should be done on the population and genetic structure of inland trout, as it is likely that fragmented populations of redband trout (*O. mykiss gairdneri*) may persist in these streams.

Table 2 Categories of watersheds (HUC-5 level) and number of Significant Subwatersheds (HUC-6 level) within those watersheds in the Upper Columbia Salmon Recovery Region. Definitions of watershed categories and Significant Subwatersheds are provided in text.

Subbasin	Watershed	Category	Significant subwatersheds
Wenatchee	Mainstem Upper Wenatchee	1	2
	Mainstem Middle Wenatchee	1	2
	Mainstem Lower Wenatchee	2	1
	White River	1	5
	Little Wenatchee River	1	5
	Lake Wenatchee	1	- -[a]
	Nason Creek	2	3
	Chiwawa River	1	6
	Icicle Creek	2	4
	Chumstick Creek	3	0
	Peshastin Creek	2	3
	Mission Creek	3	3
Entiat	Mainstem Upper Entiat	1	2
	Mainstem Lower Entiat	2	0

[a] The criteria for designation of significance does not apply to Lake Wenatchee, Upper Okanogan, and mainstem Columbia River, yet each contain important habitats.
b There is insufficient information to designate the significance of Colockum Creek.

	Mad River	1	3
Methow	Mainstem Upper Methow	2	6
	Mainstem Middle Methow	2	0
	Mainstem Lower Methow	2	0
	Early Winters Creek	1	1
	Lost River	1	2
	Chewuch River	2	3
	Twisp River	2	4
Okanogan	Mainstem Upper Okanogan	2	--
	Mainstem Lower Okanogan	2	3
	Similkameen River	3	1
	Bonaparte Creek	4	0
	Omak Creek	2	0
	Salmon Creek	3	0
Foster	Foster Creek	4	0
Moses Coulee	Moses Coulee	4	0
Squilchuck	Squilchuck	4	0
	Stemilt	4	0
	Colockum	4	--b
Columbia	Mainstem Columbia	5	--

Information Needs

The RTT is concerned that some active restoration projects in the Upper Columbia Region may be undertaken without a solid understanding of the geomorphic and hydrologic processes in the watersheds. This may result in projects that are not biologically effective—or potentially counter-productive. We recommend that the following assessments be undertaken to improve our understanding of salmonid habitat and productivity. All assessments should address the levels of certainty within one or more watersheds (Appendix C) and should lead to projects or management decisions within a reasonable time frame. We have not assigned priorities to these information needs.

Fluvial processes in many Upper Columbia streams are not fully understood, particularly in the lower Wenatchee, middle Methow, and lower Entiat rivers. Stream channels in these reaches are constrained by railroads, highways, dikes, and development, causing reduced channel sinuosity, flood attenuation, gravel recruitment, large woody debris recruitment, and connection to side channels. Information needs include historical and current channel migration rates, factors affecting migration rates, means to restore floodplain function, and the appropriate types and locations of restoration.

More information is needed on the water balance and the relation of surface and groundwater in Upper Columbia streams, particularly in the Methow Subbasin. A hydrologic assessment should identify critical ground water recharge areas and determine locations where groundwater contributes to surface water. This assessment should include measuring interactions between groundwater management and surface water flows during critical periods. The role of upslope forest and range management on water balance and hyporheic flows needs to be further understood.

The Okanogan and Foster Creek subbasins require an inventory and assessment of fish passage barrier and screens. A comprehensive inventory would include identification and prioritization of both artificial and natural barriers (culverts, diversions, diversion dams, gradients, etc.), and the locations of water diversions (both gravity and pump). Inventories are now completed in the Wenatchee, Entiat, and Methow subbasins, yet full assessments of these structures may be required to correct the barriers in a systematic and strategic order. We recommend that the UCSRB develop a comprehensive strategy to address barriers in the region using the information garnered from the completed surveys.

An understanding of habitat/productivity relations in Upper Columbia streams would help guide land and water management decisions contributing to recovery of salmonids in the region. Upstream/downstream salmonid migrant trapping, parr production surveys, and spawning ground surveys in selected index streams (such as the Chiwawa River) would greatly contribute to our knowledge base, and lead to more appropriate resource allocation decisions. Indicator streams should be established.

The extent of salmonid rearing in small-order tributaries to the Columbia River is not known. Many streams (such as Douglas, Sand, Rock Island, Colockum, Stemilt, and Squilchuck creeks) may be rearing or overwinter refuges when flows are present, which could be important to the population structure and dispersal patterns of salmonids in the region. The presence of redband trout in these streams should be determined.

Implementation and Effectiveness Monitoring

All projects undertaken to protect and restore salmonid habitat in the Upper Columbia Region must be monitored for implementation. However, not all projects should be monitored for effectiveness. A series of standardized indicators of habitat condition (with data quality guidelines) should be set for selected watersheds within each subbasin. Collection of indicator data for these watersheds should be coordinated at the regional level and based on state and federal guidelines. The RTT will submit a companion document in late 2003 to set the foundation for an effectiveness monitoring strategy for the Upper Columbia Region. This report will build upon our previous outline (RTT 2002b) and will be consistent with standards and guidelines established through the State Comprehensive Monitoring Strategy.

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RTT 2000. Priority considerations for protection and restoration of salmonid habitat in the Upper Columbia Region. Available from the Upper Columbia Salmon Recovery Board, Chelan, Washington.

RTT 2002a. A biological strategy to protect and restore salmonid habitat in the Upper Columbia Region. Available from the Upper Columbia Salmon Recovery Board, Chelan, Washington.

RTT 2002b. An outline to assess salmonid productivity and habitat in the Upper Columbia Evolutionarily Significant Unit. Available from the Upper Columbia Salmon Recovery Board, Chelan, Washington.

SSRS 1999. Statewide Strategy to Recover Salmon: Extinction is Not an Option. Available from Governor's Salmon Recovery Office, Olympia, Washington.

APPENDIX

Appendix A. Maps of Significant Subwatersheds for spring chinook salmon, summer chinook salmon, sockeye salmon, steelhead, and bull trout in the Upper Columbia Region. These maps are based on the most current information and will be continuously updated.

Appendix B. Maps of known distribution of spring chinook salmon, summer chinook salmon, sockeye salmon, steelhead, and bull trout in the Upper Columbia Region. These maps are based on the most current information and will be continuously updated.

Appendix C. Population and habitat status of each watershed and recommended priority approaches for protection and restoration of habitat.

Appendix C.1: Wenatchee River Subbasin

MAINSTEM UPPER WENATCHEE RIVER (LAKE WENATCHEE TO TUMWATER CANYON) ASSESSMENT AND INTERIM STRATEGY	
Native species: Sockeye salmon, spring and summer chinook salmon, steelhead, bull trout.	Drainage area:
STATUS: Category 1 ▪ Important passage corridor for many species. ▪ Important spawning habitat for summer chinook salmon and steelhead. ▪ The mainstem from Lake Wenatchee to the Chiwawa River confluence is designated as a Key Watershed in the Northwest Forest Plan (NWFP).	
SIGNIFICANT SUBWATERSHEDS: Upper Wenatchee, Lake Wenatchee	
FACTORS AFFECTING HABITAT CONDITION: ▪ The state highway, railroad, and private land development affect woody debris recruitment, channel migration, and gravel recruitment. ▪ The state highway cut off a large oxbow near Nason Creek confluence. ▪ Historical log drives and resultant loss of wood recruitment has reduced channel complexity. ▪ Fecal coliform and water temperatures are slightly elevated.	

LEVEL OF CERTAINTY:

- Extensive field surveys and analysis of aerial photographs provide strong evidence of impacts to stream channel function.
- There is some uncertainty about the most appropriate means to restore floodplain function, given the existing constraints.
- There is some uncertainty of the extent to which oxbows are disconnected, and what efforts should be done to provide access to the mainstem.
- There is a high level of concern about impacts of land development on this stream reach, which leads to a strong consensus among RTT members on the priority of this watershed in the region.

RECOMMENDATIONS (IN PRIORITY):

1. Protect remaining floodplain and riparian habitat.
2. Restore channel migration to resemble historical function.
3. If restoration is not possible, improve fish access to oxbows and historical side channels that have been cut off from main channel.
4. Initiate public information efforts to discourage harassment of spawning summer chinook salmon.
5. Reduce nonpoint pollution from septic tanks and livestock.
6. Initiate public information efforts to encourage protection of riparian habitat.

MAINSTEM MIDDLE WENATCHEE (TUMWATER CANYON) ASSESSMENT AND INTERIM STRATEGY	
Native species: Sockeye salmon, spring and summer chinook salmon, steelhead, bull trout.	Drainage area:
STATUS: Category 1 ▪ Important passage corridor. Important spawning habitat for summer chinook salmon and steelhead.	
SIGNIFICANT SUBWATERSHEDS: Tumwater Canyon, Chiwaukum Creek	
FACTORS AFFECTING HABITAT CONDITION: ▪ Coarse sedimentation impacts from fire. ▪ The state highway negatively affects gravel and LWD recruitment.	
LEVEL OF CERTAINTY: ▪ Recent USFWS bull trout surveys provide higher level of certainty.	

RECOMMENDATIONS (IN PRIORITY):

1. Protect existing riparian habitat
2. Address passage barriers at Skinney Creek near mouth

MAINSTEM LOWER WENATCHEE RIVER (TUMWATER TO MOUTH)

ASSESSMENT AND INTERIM STRATEGY

<u>Native species:</u> Sockeye salmon, spring and summer chinook salmon, steelhead, bull trout.	<u>Drainage area:</u>

STATUS: Category 2

- Important passage corridor for many species.
- Spawning and rearing habitat for summer chinook salmon and steelhead.

SIGNIFICANT SUBWATERSHEDS:

Lower Wenatchee

FACTORS AFFECTING HABITAT CONDITION:

- Land development, state highway and railroad affect channel migration, woody debris recruitment, and gravel recruitment.
- Riparian habitat and off-channel habitat have been significantly lost or degraded in this reach.
- Late summer instream flows are often critically low throughout this reach.
- Floodplain function has been impaired by development, causing extremes in the peaks and nadir of the hydrograph.
- Stream temperatures often exceed standards, which is contributed to by riparian habitat loss and low instream flows.
- There is a high level of concern about impacts of land development on this stream reach, which leads to a strong consensus among RTT members on the priority of this watershed in the region.

LEVEL OF CERTAINTY:

- Field and aerial surveys give strong indication of channel constriction and riparian habitat loss. Historical photos indicate loss of floodplains.
- The relation of fish habitat and instream flow in this reach was studied in 1980s; this assessment needs to be refined.
- The relative extent to which irrigation withdrawal and riparian loss affect water temperature is not known.

RECOMMENDATIONS (IN PRIORITY):

1. Protect existing riparian habitat and channel migration floodplain function.

2. Restore channel migration to normative function.

3. If restoration is not possible, improve fish access to oxbows and historical side channels

4. Increase late summer flows.

MISSION CREEK WATERSHED ASSESSMENT AND INTERIM STRATEGY	
Native species: Spring chinook salmon, steelhead.	Drainage area: 59,609 acres
STATUS: Category 3	
SIGNIFICANT SUBWATERSHEDS: Sand Creek, Devils Gulch, Lower Mission	
FACTORS AFFECTING HABITAT CONDITION: ▪ Low or non-existent flows with associated high instream temperatures in lower Mission Creek disrupt distribution and abundance of native species, particularly in summer. ▪ Channelization of lower Mission, Brender and Yaksum creeks. ▪ Degraded water quality and loss of riparian habitat, road construction, urban/residential and agricultural development, especially in the floodplains, grazing, and soil compaction have changed channel function. ▪ There are several culverts throughout the watershed that are passage barriers when flows are available. ▪ Loss of channel sinuosity and floodplain function in the Mission Creek watershed.	

LEVEL OF CERTAINTY: ▪ Watershed surveys by USFS and Chelan Conservation District provide high level of certainty of watershed conditions and causal mechanisms.
RECOMMENDATIONS (IN PRIORITY): 1. Increase stream flow. 2. Reduce nonpoint pollution from septic tanks and livestock. 3. Restore channel sinuosity and floodplain function upstream of Yaksum Creek confluence. 4. Other projects should be delayed until flow and water quality are addressed.

PESHASTIN CREEK WATERSHED ASSESSMENT AND INTERIM STRATEGY	
Native species: Spring chinook salmon, steelhead, bull trout.	Drainage area: 78,780 acres
STATUS: Category 2 ▪ Important steelhead spawning and rearing habitat, both in the mainstem and subwatersheds.	
SIGNIFICANT SUBWATERSHEDS: Upper Peshastin, Lower Peshastin, Ingalls Creek	
FACTORS AFFECTING HABITAT CONDITION: ▪ Channel migration, riparian habitat, floodplain function, stream sinuosity, and gravel recruitment are severely impacted by state highway. ▪ Low instream flows in lower Peshastin Creek impede upstream migration, reduce rearing habitat, and likely contribute to elevated water temperature. ▪ Loss of riparian habitat resulting from land development and state highway reduces quantity and quality of spawning and rearing habitat. ▪ .	

LEVEL OF CERTAINTY:

- Cumulative effects of current gold mining in tributaries on sediment delivery, water quality, and channel conditions are not fully understood, but are of concern.
- Cumulative effects of past timber harvest in tributaries on sediment delivery and water quality are not fully understood, but are of concern.
- There is uncertainty on the status of Ingalls Creek bull trout.

RECOMMENDATIONS (IN PRIORITY):

1. Increase stream sinuosity and floodplain function from Ingalls Creek to mouth.
2. Restore flow from Camas Creek to mouth.
3. Other projects should be delayed until stream sinuosity and flows are addressed.

ICICLE CREEK WATERSHED ASSESSMENT AND INTERIM STRATEGY	
Native species: Steelhead, bull trout, cutthroat trout, redband trout	Drainage area: 136,960 acres
STATUS: Category 2 ▪ Relatively good habitat ▪ Inland fish are present and of concern. ▪ Designated as Key Watershed in Northwest Forest Plan.	
SIGNIFICANT SUBWATERSHEDS: Upper Icicle Creek, Jack Creek, French Creek, Headwaters Icicle Creek.	

FACTORS AFFECTING HABITAT CONDITION:

- Land development downstream of Leavenworth Hatchery has affected stream channel migration, recruitment of large woody debris, and off channel habitat.
- There are barriers to migration on Icicle Creek at Leavenworth Hatchery and possibly in the boulder field near Snow Creek
- Water withdrawals in Icicle Creek (primarily between Rat Creek and the hatchery) likely contribute to low flows and high summer temperatures in lower Icicle Creek.
- The Icicle Road upstream of Chatter Creek at places may confine the stream channel and affect floodplain function.
- The 1994 Rat Creek fire caused increased sedimentation and water temperature in the middle and lower Icicle drainage.

LEVEL OF CERTAINTY:

- Field and aerial reconnaissance of lower Icicle Creek provide strong certainty of need for stream channel protection and restoration.
- The adult passage conditions at boulder field near Snow Creek is not known.

RECOMMENDATIONS (IN PRIORITY):

1. Protect remaining floodplain and riparian habitat downstream of Chatter Creek. Emphasis should be placed on habitat downstream of Leavenworth Hatchery.

2. Rectify human-made passage barriers.

3. Restore flow conditions on Icicle Creek downstream of Rat Creek.

4. Investigate the role of surface and well water withdrawals on instream flows and habitat use. Develop strategies with water users to reduce effects, if any.

5. Initiate public information efforts to discourage harassment of spawning salmonids.

6. Manage recreation areas to reduce impacts to riparian cover.

CHUMSTICK CREEK WATERSHED ASSESSMENT AND INTERIM STRATEGY	
<u>Native species:</u> Steelhead.	<u>Drainage area:</u> 47,000 acres
STATUS: Category 3 ▪ Chumstick Creek was historical steelhead habitat. ▪ Likely, it was very important coho salmon habitat, although few records exist.	
SIGNIFICANT SUBWATERSHEDS: None	
FACTORS AFFECTING HABITAT CONDITION: ▪ Private land development and high road density affects sediment delivery. ▪ Channel migration affected by state highway, the railroad, multiple water crossing structures, and private land development. ▪ Fecal coliform and water temperature levels are elevated, mostly a result of livestock and improper septic tanks. ▪ Passage is impeded at the North Road and numerous smaller culverts upstream. ▪ Riparian habitat has been degraded or lost from Little Chumstick Creek to mouth.	

LEVEL OF CERTAINTY:

- This watershed is only accessible to steelhead at this time, yet it is unknown whether it is accessible to other species.
- The loss of riparian vegetation in Chumstick Creek is readily observable, yet cumulative effects on instream habitat, channel function, and water quality are not quantified.
- Constraint of the stream channel by human-made structures is readily observable; the means to address these effects are not established.
- Field inventory and assessment of passage barriers enable a high level of certainty regarding habitat degradation.
- Consistent yearly water quality monitoring provides certainty on fecal coliform and temperature.
- The extent of the effect of private and public roads on stream channel function and sediment delivery is not fully assessed, but of concern.
- The potential for impacts from unscreened water diversions is not known. An inventory and assessment are required.
- The cumulative effects of surface water diversions and ground water withdrawal from wells on low flows is not known, but of concern.

RECOMMENDATIONS (IN PRIORITY):

1. Restore passage for anadromous and inland fish. This should be done in a comprehensive, coordinated strategy, rather than a piecemeal approach.
2. Protect remaining floodplain and riparian habitat
3. Increase stream flow.
4. Restore riparian habitat, primarily from Eagle Creek to Suntisch Canyon.
5. Reduce road densities.
6. Restore stream channel migration.
7. Reduce nonpoint pollution from septic tanks and livestock.
8. Reduce fine sediment input from roads and some land management activities.

CHIWAWA RIVER WATERSHED ASSESSMENT AND INTERIM STRATEGY

Native species: Spring chinook salmon, steelhead, and migratory bull trout.	Drainage area: 117,000 acres

STATUS: Category 1

- Designated as Key Watershed in Northwest Forest Plan.
- Critical spawning and rearing habitat for multiple species.

SIGNIFICANT SUBWATERSHEDS:

Headwaters Chiwawa, Upper Chiwawa, Middle Chiwawa, Lower Chiwawa, Rock Creek, Chikamin Creek

FACTORS AFFECTING HABITAT CONDITION:

- Most of this watershed is in public ownership and protected as Wilderness Area or under the Northwest Forest Plan. Habitat within these areas is essentially pristine.
- There is limited housing development in private parcels on the lower Chiwawa River. Loss of riparian vegetation in these reaches may influence water temperatures and hiding cover.
- Water withdrawals in the lower Chiwawa River may affect rearing habitat in low flow years.

LEVEL OF CERTAINTY:

- The effect of water withdrawals on lower Chiwawa River salmonid habitat is not known.
- There is concern over the potential impacts of development in Chikamin Creek on salmonid productivity and water temperatures.

RECOMMENDATIONS (IN PRIORITY):

1. Protect remaining floodplain and riparian habitat, particularly around Chikamin Flats.
2. Investigate the role of surface and well water withdrawals on instream flows and habitat use. Develop strategies with water users to reduce effects, if any.
3. Initiate public information efforts to discourage harassment of spawning spring chinook salmon and bull trout.
4. Manage recreation areas to reduce or avoid impacts to riparian habitats.

NASON CREEK WATERSHED ASSESSMENT AND INTERIM STRATEGY	
Native species: Spring chinook salmon, steelhead, bull trout.	Drainage area: 69,000 acres
STATUS: Category 2	
SIGNIFICANT SUBWATERSHEDS: Headwaters Nason, Upper Nason, Lower Nason	
FACTORS AFFECTING HABITAT CONDITION: ▪ The state highway, railroad, and private land development affect woody debris recruitment, channel migration, and gravel recruitment. ▪ Lower Nason Creek is on the state 303(d) list for water temperature.	

LEVEL OF CERTAINTY:

- Extensive field surveys and analysis of aerial photographs provide strong evidence of impacts to stream channel function. There is some uncertainty about the most appropriate means to restore floodplain function, given the existing constraints. The recently funded channel migration study should assist in this assessment.
- There is some uncertainty of the extent to which oxbows are disconnected, and what efforts should be done to provide access to Nason Creek.
- The cumulative effects of timber harvest, development, and road densities on stream channel function and sediment delivery is not fully known, but of concern.

RECOMMENDATIONS (IN PRIORITY):

1. Protect remaining floodplain and riparian habitat.
2. Restore channel migration to historical function.
3. If restoration is not possible, improve fish access to oxbows and historical side channels.
4. Initiate public information efforts to discourage harassment of spawning salmonids.

WHITE RIVER WATERSHED ASSESSMENT AND INTERIM STRATEGY	
Native species: Sockeye salmon, spring chinook salmon, steelhead, bull trout.	Drainage area: 99,956 acres
STATUS: Category 1. ▪ Designated as Key Watershed in Northwest Forest Plan. ▪ Critical spawning and rearing habitat for many species.	
SIGNIFICANT SUBWATERSHEDS: Headwaters White, Upper White, Lower White, Napeequa Creek, Panther Creek	
FACTORS AFFECTING HABITAT CONDITION: ▪ Past riparian harvest and log drives have altered woody debris accumulations and channel morphometry. ▪ Habitat is intact and contiguous, but development pressures place a critical need to protect and maintain stream channel and floodplain integrity	

LEVEL OF CERTAINTY:

- Field habitat analysis has been completed on public lands, enabling high confidence in assessment.
- Field analyses are incomplete on private lands, yet reviews of aerial photographs in combination with field reviews have allowed strong inferences on habitat needs.
- There is a high level of concern about impacts of land development on this stream, which leads to a strong consensus among RTT members on the priority of this watershed in the region.

RECOMMENDATIONS (IN PRIORITY):

1. Protect stream channel, riparian and floodplain function: focus on Panther Creek downstream to mouth.
2. Restore wetland complexes that connect to stream channel
3. Protect shorelines along Lake Wenatchee near White River mouth
4. Initiate public information efforts to discourage harassment of spawning spring chinook, sockeye salmon, and bull trout.
5. Manage recreation areas to reduce impacts to riparian cover.

<table>
<tr><td colspan="2">LITTLE WENATCHEE WATERSHED ASSESSMENT AND INTERIM STRATEGY</td></tr>
<tr><td><u>Native species:</u> Sockeye salmon, spring chinook salmon, steelhead, bull trout.</td><td><u>Drainage area:</u> 75,329 acres</td></tr>
<tr><td colspan="2">STATUS: Category 1
▪ Designated as Key Watershed in Northwest Forest Plan.
▪ Critical spawning and rearing habitat for many species.
▪ Bull trout numbers above the waterfalls are extremely low.</td></tr>
<tr><td colspan="2">SIGNIFICANT SUBWATERSHEDS:
Headwaters Little Wenatchee, Upper Little Wenatchee, Lower Little Wenatchee, Rainy Creek, Lake Creek</td></tr>
<tr><td colspan="2">FACTORS AFFECTING HABITAT CONDITION:
▪ Past riparian harvest and log drives below the waterfalls may have affected stream channel morphometry and function.
▪ Habitat above the waterfalls is intact and relatively pristine: essentially need to protect and maintain stream channel and floodplain integrity.
▪ The lower Little Wenatchee is on the state 303(d) list for water temperature.</td></tr>
</table>

LEVEL OF CERTAINTY:

- Field habitat analysis has been completed on public lands, enabling high confidence in assessment.
- Field analyses are incomplete on private lands, yet reviews of aerial photographs in combination with field reviews have allowed strong inferences on habitat needs.
- Some uncertainty exists on effects of logging and road management on stream channel function, water temperature, flow, and possible input of large woody debris.

RECOMMENDATIONS (IN PRIORITY):

1. Protect stream channel, riparian and floodplain function: focus on Little Wenatchee River falls downstream to mouth.
2. Address road impacts in the drainage, emphasis on Rainy Creek and Little Wenatchee between Hidden Creek and Fir Creek.
3. Restore wetland complexes that connect to stream channel.
4. Manage recreation areas to reduce impacts to riparian cover.
5. Initiate public information efforts to discourage harassment of spawning salmonids.

LAKE WENATCHEE ASSESSMENT AND INTERIM STRATEGY	
Native species: Sockeye salmon, spring chinook salmon, steelhead, bull trout.	Drainage area:
STATUS: Category 1. ▪ Necessary adult holding and juvenile rearing area for sockeye salmon and bull trout.	
SIGNIFICANT SUBWATERSHEDS: Not applicable.	
FACTORS AFFECTING HABITAT CONDITION: ▪ Shoreline development. Bulkheads change dynamics of near shore wave action, affecting invertebrate production, gravel deposition, and habitat use.	
LEVEL OF CERTAINTY: ▪ Quantified field analyses have not been conducted, yet reviews of aerial photographs in combination with field reviews have allowed strong inferences on habitat needs.	

RECOMMENDATION:

- Protect remaining near shore habitat, and develop a means to reduce impacts of bulkheads.

Appendix C.2: Entiat River Subbasin

MAINSTEM ENTIAT FROM ENTIAT FALLS TO POTATO MORAINE ASSESSMENT AND INTERIM STRATEGY	
Native species: Critical habitat for spring chinook salmon, steelhead, bull trout.	Drainage area:
STATUS: Category 1 ▪ Designated as Key Watershed in Northwest Forest Plan	
SIGNIFICANT SUBWATERSHEDS: Upper Mid-Entiat, Lower Mid-Entiat	
FACTORS AFFECTING HABITAT CONDITION: ▪ Surface erosion and sediment delivery hazard is high. ▪ Fluvial processes are now good within this reach, but they are at risk from development pressure in bottomlands. ▪ Past stream clean-outs and salvage logging activities after major fire events have affected stream channel complexity.	

LEVEL OF CERTAINTY: Field habitat analysis has been completed on most areas, providing a high confidence in assessment. ▪ The status of bull trout in the upper Entiat is not well understood. ▪ There is a high level of concern about the impact of land development on this reach. There is a strong consensus among RTT members on the need to protect stream channel function.
RECOMMENDATIONS (IN PRIORITY): 1. Protect fluvial processes and floodplain function from the falls to the moraine. 2. Continue road closure and reforestation in highly erosive uplands, particularly Fox, McCree, Brenegan, Preston, and Mud creeks, and the mainstem Entiat between Fox and Stormy creeks. 3. Initiate public information efforts to discourage harassment of spawning salmonids.

<table>
<tr><td colspan="2">MAD RIVER WATERSHED ASSESSMENT AND INTERIM STRATEGY</td></tr>
<tr><td><u>Native species:</u> Spring chinook salmon, steelhead, bull trout, cutthroat trout.</td><td><u>Drainage area:</u></td></tr>
<tr><td colspan="2">STATUS: Category 1

▪ Designated as Key Watershed in Northwest Forest Plan</td></tr>
<tr><td colspan="2">SIGNIFICANT SUBWATERSHEDS:

Upper Mad River, Middle Mad River, Lower Mad River</td></tr>
<tr><td colspan="2">FACTORS AFFECTING HABITAT CONDITION:

▪ Historical sheep grazing and timber harvest practices have increased upland erosion and sediment delivery to the stream, and has impacted snow melt runoff and resultant streamflow.

▪ Road constricts channel on mainstem from Pine Flat campground downstream to mouth.

▪ Anchor ice formations associated with loss of riparian cover and changes in channel.</td></tr>
</table>

LEVEL OF CERTAINTY:

- Field habitat analysis has been completed on most areas, providing a high confidence in assessment.
- Mad River is considered a stronghold for bull trout, but their habitat use outside the watershed is not well understood.

RECOMMENDATIONS (IN PRIORITY):

1. Protect fluvial processes and floodplain function.
2. Continue reforestation in highly erosive uplands.
3. Initiate public information efforts to discourage harassment of bull trout.
4. Reduce impacts from roads in floodplains, and relocate where appropriate. Restore riparian areas in lower Mad River.

<table>
<tr><td colspan="2">LOWER ENTIAT (FROM MORAINE DOWNSTREAM TO MOUTH) ASSESSMENT AND INTERIM STRATEGY</td></tr>
<tr><td><u>Native species:</u> Spring and summer chinook salmon, steelhead, bull trout.</td><td><u>Drainage area:</u></td></tr>
<tr><td colspan="2">STATUS: Category 2

▪ Migration corridor for spring chinook salmon, steelhead and bull trout. Spawning and rearing habitat for steelhead and summer chinook salmon.</td></tr>
<tr><td colspan="2">SIGNIFICANT SUBWATERSHEDS:

None</td></tr>
<tr><td colspan="2">FACTORS AFFECTING HABITAT CONDITION:

▪ Loss of channel complexity and lateral migration

▪ Loss of riparian habitats and floodplain connectivity

▪ Loss of gravel recruitment

▪ Sediment delivery from Potato Creek and Mud Creek</td></tr>
</table>

LEVEL OF CERTAINTY: ▪ Extent of irrigation water withdrawal on instream flows and temperature is not known. ▪ Extent of riparian cover and channel shape on anchor ice formation is not known.
RECOMMENDATIONS (IN PRIORITY): 1. Restore stream channel complexity and lateral migration. 2. Protect existing riparian and floodplain habitats. 3. Restore degraded riparian habitats.

Appendix C.3: Methow River Subbasin

EARLY WINTERS CREEK ASSESSMENT AND INTERIM STRATEGY	
Native species: Spring chinook salmon, steelhead, bull trout.	Drainage area: 51,925 acres
STATUS: Category 1 ▪ Designated as a Key Watershed in Northwest Forest Plan	
SIGNIFICANT SUBWATERSHEDS: Early Winters Creek	
FACTORS AFFECTING HABITAT CONDITION: ▪ Channel constriction by state highway precludes natural flood plain function, reduces the number of side channels, and increases water velocities and resultant scour. ▪ Riparian areas have been degraded at campgrounds, resulting in loss of cover and woody debris recruitment. ▪ Fine sediment and chemical runoff from highway may impact water quality.	

LEVEL OF CERTAINTY:

- Field assessment of stream channel function provides strong indication of high water velocities and resultant bedload, channel scour, and riparian degradation in lower Early Winters Creek.
- Low flows are readily measurable, but groundwater/surface water interaction is complex and not fully understood.

RECOMMENDATIONS (IN PRIORITY):

1. Restore natural stream channel functions within the alluvial fan.
2. Improve riparian conditions in the lower reach.
3. Manage recreation areas to reduce or avoid impacts to riparian areas.

LOST RIVER ASSESSMENT AND INTERIM STRATEGY	
<u>Native species:</u> Spring chinook salmon, steelhead, bull trout.	<u>Drainage area:</u> 107,400 acres
STATUS: Category 1 ▪ Designated as a Key Watershed in Northwest Forest Plan.	
SIGNIFICANT SUBWATERSHEDS: Upper Lost River, Lost River	
FACTORS AFFECTING HABITAT CONDITION: ▪ A dike on the Methow River at the confluence of the lower Lost River constrains floodplain function. ▪ Residential construction on the alluvial fan may lead to a constrained channel in the future. ▪ Large woody debris levels in the lower Lost River are currently low, due to removal for flood control and firewood. The potential for recruitment of woody debris is at natural levels however.	
LEVEL OF CERTAINTY: ▪ Watershed surveys by USFS provide high level of certainty.	

RECOMMENDATIONS (IN PRIORITY):

1. Develop a flood hazard protection plan that is compatible with natural channel maintaining processes and flood plain function.

2. Allow for woody debris recruitment.

<table>
<tr><td colspan="2">CHEWUCH RIVER ASSESSMENT AND INTERIM STRATEGY</td></tr>
<tr><td>Native species: Spring chinook salmon, steelhead, bull trout, westslope cutthroat trout.</td><td>Drainage area: 340,000 acres</td></tr>
<tr><td colspan="2">STATUS: Category 2
▪ Designated as a Key Watershed in NWFP.</td></tr>
<tr><td colspan="2">SIGNIFICANT SUBWATERSHEDS:
Perrygin Creek, Lake Creek, Lower Chewuch River</td></tr>
</table>

FACTORS AFFECTING HABITAT CONDITION:

- Channel clearing and LWD removal reduced channel complexity in the Chewuch River from RM 0 to 20.
- Road placement and bank hardening have isolated sections of the main channel from its floodplain and side channels in a few places from the mouth to Boulder Creek.
- Skid roads in riparian areas upstream of Boulder Creek increase dispersed recreation use impacts to the stream.
- Low flows in late summer through winter reduce quantity of rearing habitat in the lower Chewuch River.
- High water temperatures in the lower river may at times cause a migration barrier.
- Livestock grazing may have potential impacts on riparian areas of mainstem Chewuch and tributaries.
- High road densities in Cub, Eightmile, and Boulder creeks combined with highly erosive soils create sediment and bank erosion problems.

LEVEL OF CERTAINTY:

- Field habitat analyses have been conducted on both private and public lands, allowing a high confidence in assessment.
- The relation of instream flows and fish habitat in the lower Chewuch River are not fully understood, yet some studies provide a strong level of inference.

RECOMMENDATIONS (IN PRIORITY):

1. Restore habitat-forming processes and channel complexity of the Chewuch River from RM 0 to 28.

2. Increase LWD recruitment and retention in the mainstem Chewuch River from RM 0 to 30.

3. Increase stream flows on the lower mainstem Chewuch River.

4. Reduce road densities, particularly in highly erosive areas (such as mid-slope areas) and riparian areas.

5. Manage recreation activities in riparian areas; include an educational component.

6. Assess the condition of roads in the Chewuch Watershed and their contribution to sediment delivery to the surface water network.

7. Monitor summer and winter thermal refugia in the lower mainstem Chewuch River. Protect and restore key thermal refuges.

8. Assess grazing effects on riparian areas in upper mainstem Chewuch River, and in Eightmile, Boulder, Falls and Cub creeks on sediment delivery and channel stability.

TWISP RIVER ASSESSMENT AND INTERIM STRATEGY	
Native species: Spring chinook salmon, steelhead, bull trout, westslope cutthroat trout.	Drainage area: 157,000 acres
STATUS: Category 2 ▪ Designated as a key watershed in NWFP.	
SIGNIFICANT SUBWATERSHEDS: Middle Twisp, Lower Twisp, North Creek, Buttermilk Creek	

FACTORS AFFECTING HABITAT CONDITION:

- Low instream flows in the lower Twisp River affect several species at several life history stages.
- The Twisp River (from Buttermilk Creek to the mouth) has been diked and riprapped in places, resulting in a highly simplified channel.
- In the lower Twisp River (RM 0.0 – 16.5) LWD levels and recruitment potential are well below amounts expected.
- The MVID East Canal diversion on the Twisp River at RM 3.9 is a rock levee dam that must be pushed up each year, disturbing salmonid rearing and spawning habitat.
- The lower Twisp River is listed on the Washington State 303(d) list for inadequate instream flow and for temperature exceedence.
- Beaver activity is very limited in the lower Twisp River where the large cottonwood galleries and low gradients would once have supported beaver colonies.
- The road in Little Bridge Creek affects stream channel function.

LEVEL OF CERTAINTY:

- Field habitat analyses have been conducted on public lands, allowing a high confidence in assessment.
- Field analyses are incomplete on private lands, yet reviews of aerial photographs in combination with field reviews have allowed strong inferences on habitat needs.
- Some uncertainty exists on relation of instream flows and fish habitat.

Increasing recreational demand in key salmonid production areas in the Upper Twisp River is a concern.

RECOMMENDATIONS (IN PRIORITY):

1. Investigate and implement alternatives to improve low flow conditions in the lower Twisp River.

2. Protect and restore access to floodplains, side channels, and riparian areas in the lower 15 miles of the Twisp River.

3. Increase LWD recruitment and retention in the lower 11 miles of Twisp River.

4. Eliminate MVID push up dam on lower Twisp River.

5. Reduce road densities in Lower Bridge Creek and Buttermilk Creek and their effects on hydrology and instream sediment conditions.

6. Gather baseline temperature data throughout the watershed.

7. Provide alternative sites in the upper Twisp River for developed and dispersed recreation.

8. Reestablish a sustainable population of beaver.

UPPER MAINSTEM METHOW (HEADWATERS TO CHEWUCH CONFLUENCE) ASSESSMENT AND INTERIM STRATEGY

Native species: spring chinook salmon, steelhead, bull trout.	Drainage area: 322,385 acres

STATUS: Category 2

SIGNIFICANT SUBWATERSHEDS:

Upper Methow, Mainstem West Fork Methow, Upper Goat Creek, Lower Goat Creek, Little Boulder Creek, Hancock Creek

TRIBUTATIES WITHIN THIS REACH: Brush Creek, Trout Creek, Rattlesnake Creek, Robinson Creek, Gate Creek, Goat Creek, Little Boulder Creek, Fawn Creek, Hancock Creek, Little Falls Creek, and Wolf Creek.

FACTORS AFFECTING HABITAT CONDITION:

- The mainstem Methow River between RM 59 and 74 goes dry in low flow years.
- All reaches of the mainstem upper Methow River have LWD levels below USFS standards. Timber harvest and stream cleaning have reduced LWD recruitment in Goat Creek.
- Several small dikes cut off important side channel habitats.

Residential construction in flood prone areas has resulted in clearing of riparian habitat.

LEVEL OF CERTAINTY:

- Watershed and stream analyses by USFS and USGS provide high level of certainty on habitat conditions. The effect of surface water and groundwater withdrawal on the dewatered reach is not fully understood. The role of riparian condition and channel morphometry on stream flows in this reach is not understood.
- The contribution of tributaries and mainstem bank erosion to sediment levels in the mainstem Methow River is not understood.
- There is concern about the effect of snowmobiles in the main channel Methow River on habitat and water quality.

RECOMMENDATIONS (IN PRIORITY):

1. Protect functioning floodplain, riparian habitat, and side channels in the upper Methow River.
2. Protect LWD accumulations in the channel.
3. Protect habitat within this reach that sustains flows through the winter, and stream channel sections where ground water is recharged.
4. Improve late summer and winter instream flows through several means: restore drained wetlands, restore cut off side channels, rehabilitate riparian areas, and remove constrictions and constraints within the channel migration zone.
5. Restore access to habitat blocked by dikes and restore the channel function of the reach upstream of the dikes.
6. Increase recruitment and retention of LWD within the mainstem Methow River.
7. Reduce streambank erosion on mainstem Methow River from Goat Creek to Mazama. Evaluate the location of these eroding sites relative to the channel migration zone.
8. Manage dispersed recreation use in riparian areas throughout the watershed.
9. Develop and implement a snowmobile management plan.

MIDDLE MAINSTEM METHOW RIVER (CHEWUCH RIVER CONFLUENCE TO TEXAS CREEK CONFLUENCE) ASSESSMENT AND INTERIM STRATEGY	
Native species: Spring and summer chinook salmon, steelhead, bull trout.	Drainage area: 15,600 acres
STATUS: Category 2 ▪ The mainstem Methow River is an important migration corridor for spring chinook salmon, steelhead and bull trout. Spawning and rearing habitat for summer chinook salmon and steelhead.	
SIGNIFICANT SUBWATERSHEDS:	
TRIBUTARIES WITHIN THIS REACH: Alder Creek, Bear Creek, Beaver Creek and Benson Creek	
FACTORS AFFECTING HABITAT CONDITION: ▪ Residential development is affecting riparian and floodplain condition. ▪ The Methow Valley Irrigation District fish screens and diversion structures do not meet state and federal standards. ▪ Low flows in late summer and winter may affect juvenile survival. ▪ Structures in tributaries are passage barriers for adult and juvenile salmonids. ▪ The mainstem Methow is on the state 303(d) list for temperatures.	

LEVEL OF CERTAINTY:

- Habitat in the Middle Mainstem Methow River and lower reaches of its tributaries has not been surveyed. Some recommendations are based on professional judgement. Habitat in upper reaches of the tributaries has been assessed by USFS.
- The effects of irrigation water withdrawal on stream flows are not fully understood.
- Passage barriers have been inventoried, but not fully assessed.

RECOMMENDATIONS (IN PRIORITY):

1. Protect functioning floodplain, riparian habitat, and side channels in the middle Methow River.
2. Restore access by the mainstem channel to floodplains and side channels disconnected by dikes.
3. Correct the MVID screens and diversion.
4. Modify existing bank hardening projects to incorporate design elements to reduce water velocity and increase instream complexity.
5. Increase recruitment and retention of LWD within the mainstem Methow River.

LOWER METHOW (TEXAS CREEK CONFLUENCE TO MOUTH)

ASSESSMENT AND INTERIM STRATEGY

Native species: Summer and spring chinook salmon, steelhead, bull trout.	Drainage area: 200,000 acres

STATUS: Category 2

- The mainstem Methow River is an important migration corridor for spring chinook salmon, steelhead and bull trout. Spawning and rearing habitat for summer chinook salmon and steelhead.

SIGNIFICANT SUBWATERSHEDS:

None.

IMPORTANT TRIBUTARIES: Texas Creek, Libby Creek, Gold Creek, McFarland Creek, French Creek, Squaw Creek and Black Canyon Creek.

FACTORS AFFECTING HABITAT CONDITION:

- Culverts, roads, and irrigation diversion structures impede salmonid passage on several tributaries.
- Roads on several tributaries contribute to sedimentation and riparian degradation.
- Low instream flows in Libby and Gold creeks likely impact salmonid distribution and abundance.

LEVEL OF CERTAINTY: ▪ Habitat in the mainstem lower Methow River and lower reaches of its tributaries has not been surveyed. Some recommendations are based on professional judgement. Habitat in upper reaches of the tributaries has been assessed by USFS. ▪ Spawning and rearing of salmonids in the mainstem and tributaries are regularly surveyed, providing a higher level of certainty.
RECOMMENDATIONS (IN PRIORITY): 1. Develop and implement a plan to correct fish passage barriers on tributaries. 2. Evaluate habitat conditions in the lower mainstem Methow River. 3. Address sedimentation in the drainage by identifying roads for closure, relocation, obliteration, and drainage improvements. 4. Protect and restore riparian habitats in Gold and Libby creeks. 5. Irrigation diversions in Gold and Libby creeks should be assessed and screened according to standards 6. Increase instream flows in Gold Creek.

Appendix C.4: Okanogan River Subbasin

UPPER MAINSTEM OKANOGAN (MCINTYRE DAM TO SIMILKAMEEN CONFLUENCE) ASSESSMENT AND INTERIM STRATEGY	
Native species: Sockeye salmon, summer chinook salmon, steelhead.	Drainage area:
STATUS: Category 2 ▪ This reach is the only remaining spawning habitat for sockeye salmon.	
SIGNIFICANT SUBWATERSHEDS: Data are not available.	

FACTORS AFFECTING HABITAT CONDITION: ▪ Late summer water temperatures exceed salmonid tolerance levels, both in the river and in Lake Osoyoos. The North Basin of Lake Osoyoos provides the only thermal refuge for adult sockeye. ▪ Turbidity, suspended sediment, and nutrient loading exacerbate water temperature and water quality exceedences, and effect spawning and rearing habitat. ▪ The stream corridor has been modified, disconnecting floodplain from the stream channel, and reducing riparian habitat. ▪ Vertical Drop Structures in stream channel affect bedload movement and channel forming processes. ▪ Okanagan Falls Dam and Zosel Dam modify hydrograph, which in some years may affect upstream/downstream migration. ▪ Urbanization of region is affecting water quality and quantity and is accelerating the eutrophication of Osoyoos Lake.
LEVEL OF CERTAINTY: ▪ Annual surveys indicate level and areas of sockeye salmon use. ▪ Water quality parameters documented through state and federal studies. ▪ Instream and riparian habitats have not been quantified; critical areas have not been established. ▪ Radio telemetry studies verify effects of dam operations and water temperatures on upstream migration behavior of sockeye, summer chinook and steelhead.

RECOMMENDATIONS (IN PRIORITY):

1. Protect habitat and flows from McIntyre Dam downstream to Osoyoos Lake.
2. Manage water releases through Okanagan Falls Dam to prevent redd scour/desiccation.
3. Restore floodplain function in this reach.
4. Develop a normative flow pattern in this reach.
5. Reduce sedimentation and nonpoint pollution in the reach and Lake Osoyoos.

MAINSTEM OKANOGAN RIVER (SIMILKAMEEN CONFLUENCE TO MOUTH) ASSESSMENT AND INTERIM STRATEGY	
Native species: Sockeye salmon, summer chinook salmon, bull trout, cutthroat trout, and steelhead.	Drainage area:
STATUS: Category 2 ▪ Important migration corridor for sockeye salmon and steelhead. Spawning and rearing habitat for summer chinook salmon.	
SIGNIFICANT SUBWATERSHEDS: Upper Okanogan River, Middle Okanogan River, Lower Okanogan River, North Fork Salmon Creek.	
FACTORS AFFECTING HABITAT CONDITION: ▪ Late summer water temperatures exceed salmonid tolerance levels. ▪ Turbidity, suspended sediment, and nutrient loading exacerbate water temperature exceedences, and effect spawning and rearing habitat. ▪ Extensive riparian habitat loss and degradation throughout the mainstem Okanogan River, causing very high width:depth ratios, low woody debris levels, sedimentation, and embedded spawning gravels. ▪ Upstream dams modify hydrograph, which in some years may affect upstream/downstream migration.	

LEVEL OF CERTAINTY: ▪ Annual surveys indicate level and areas of summer chinook salmon use. ▪ Water quality parameters documented through state and federal studies. ▪ Instream and riparian habitats have not been quantified; critical areas have not been established. ▪ Radio telemetry studies verify effects of dam operations on upstream migration behavior of sockeye, summer chinook and steelhead.
RECOMMENDATIONS (IN PRIORITY): 1. Release water from upstream dams at critical periods to aid adult sockeye salmon migration. 2. Increase seasonal flows in small tributary streams to mainstem Okanogan River. 3. Protect and passively restore riparian habitat on the mainstem, with upstream reaches having priority. 4. Implement agricultural practices that reduce sediment delivery to the river.

SIMILKAMEEN RIVER ASSESSMENT AND INTERIM STRATEGY	
<u>Native species:</u> Summer chinook salmon, steelhead.	<u>Drainage area:</u>
STATUS: Category 3 ▪ Highly used summer chinook salmon spawning downstream of Enloe Dam (at RK 14), which is a barrier to migration.	
SIGNIFICANT SUBWATERSHEDS: Similkameen River	
FACTORS AFFECTING HABITAT CONDITION: ▪ Grazing, mining, irrigation, and road building have caused extensive upland erosion and floodplain degradation, which has deteriorated several water quality parameters and both riparian and instream habitat. ▪ Enloe Dam blocks upstream migration of summer chinook salmon, although a natural waterfall may have historically blocked migration.	
LEVEL OF CERTAINTY: ▪ Sedimentation impacts from most significant sources are well documented. ▪ There is uncertainty over historical distribution of anadromous salmonids in this watershed.	

RECOMMENDATIONS (IN PRIORITY):

1. Protect riparian and instream habitats from Enloe Dam to the Okanogan confluence.
2. Reduce impacts from roads in floodplains, and relocate where appropriate.
3. Implement agricultural practices that reduce sediment delivery to the river.
4. Increase knowledge base on heat loading processes in this reach.
5. Clean up mine tailings in riparian areas that have connectivity to the river.

BONAPARTE CREEK ASSESSMENT AND INTERIM STRATEGY	
Native species: Steelhead.	Drainage area:
STATUS: Category 4	
SIGNIFICANT SUBWATERSHEDS: None	
FACTORS AFFECTING HABITAT CONDITION: ▪ Channel cutting and bank erosion, loss of channel sinuosity and riparian habitat. ▪ High levels of sheet and rill erosion.	
LEVEL OF CERTAINTY: ▪ NRCS studies provide high level of certainty.	
RECOMMENDATIONS (IN PRIORITY): 1. Reduce impacts from roads in floodplains, and relocate where appropriate. 2. Implement agricultural practices that reduce sediment delivery to the river.	

OMAK CREEK ASSESSMENT AND INTERIM STRATEGY	
Native species: Steelhead.	Drainage area: 90,684 acres
STATUS: Category 2	
SIGNIFICANT SUBWATERSHEDS: None	
FACTORS AFFECTING HABITAT CONDITION: ▪ Poor upslope condition in rangeland and forested areas contribute to water quality and quantity concerns. ▪ Loss of riparian habitat and floodplain due to increased channel incision.	
LEVEL OF CERTAINTY: ▪ Range and forest conditions assessed through federal and tribal surveys. ▪ Water quality information derived from periodic sampling.	

RECOMMENDATIONS (IN PRIORITY):

1. Implement forest and agricultural practices that reduce sediment delivery to the river.
2. Increase stream flow.
3. Protect and restore riparian habitat in middle and lower reaches.

SALMON CREEK ASSESSMENT AND INTERIM STRATEGY	
Native species: Steelhead, redband trout.	Drainage area: 675,849 acres
STATUS: Category 3 ▪ Historical spring chinook salmon and bull trout habitat.	
SIGNIFICANT SUBWATERSHEDS: None	
FACTORS AFFECTING HABITAT CONDITION: ▪ Dewatered reach downstream of irrigation diversion dam prevents upstream migration to entire watershed, and all life histories in lower reach. ▪ Dam operations have substantially modified stream channel morphology and function. ▪ Some reaches upstream of dam have high width: depth ratios, and lack streambank vegetation and woody debris.	
LEVEL OF CERTAINTY: ▪ Habitat conditions well documented through joint studies of Colville Tribe and Okanogan Irrigation District.	

RECOMMENDATIONS (IN PRIORITY):

1. Provide suitable instream flows for lower Salmon Creek.

2. Create a stream channel morphology in lower Salmon Creek that is consistent with the historical stable stream type, and raise the water table to support riparian vegetation by developing a small but effective floodplain.

3. Use passive restoration for riparian areas between Conconully Reservoir and diversion dam.

Appendix C.5: Foster Creek and Moses Coulee Subbasin

FOSTER CREEK ASSESSMENT AND INTERIM STRATEGY	
Native species: Steelhead	Drainage area: 213,639 acres
STATUS: Category 4	
FACTORS AFFECTING HABITAT CONDITION: ▪ Low flows, intermittent flows and seasonal flows. ▪ Fish passage barriers likely limit distribution in some streams. ▪ Flood events and human activities have altered instream and riparian habitats. ▪ Distribution of anadromous fish is affected by natural variations in stream flow and escapement levels.	
LEVEL OF CERTAINTY: ▪ Distribution of fish is based on professional judgement and intermittent surveys ▪ Data on habitat conditions, flow conditions, and fish passage barriers are limited.	

RECOMMENDATIONS (IN PRIORITY):

1. Determine life history of salmonids in Foster Creek.

2. Collect baseline habitat data in Foster Creek.

3. Evaluate surface and groundwater conditions.

MOSES COULEE ASSESSMENT AND INTERIM STRATEGY	
Native species: Steelhead	Drainage area: 776,222 acres
STATUS: Category 4	
SIGNIFICANT SUBWATERSHEDS: None	
FACTORS AFFECTING HABITAT CONDITION: ▪ All streams have low seasonal stream flows. ▪ Fish passage barriers limit distribution in some streams. ▪ Flood events and human activities have altered instream and riparian habitats.	
LEVEL OF CERTAINTY: ▪ Distribution of fish is based on professional judgement and intermittent surveys. ▪	

RECOMMENDATIONS (IN PRIORITY):

1. Determine life history of salmonids in, Rock Island Creek.

2. Continue to collect baseline habitat data in Rock Island Creek.

3. Evaluate surface and groundwater conditions in Moses Coulee.

Appendix C.5: Squilchuck Watershed

SQUILCHUCK ASSESSMENT AND INTERIM STRATEGY	
Native species: steelhead.	Drainage area:
STATUS: Category 4	
FACTORS AFFECTING HABITAT CONDITION: ▪ Low stream flows and passage barriers limit distribution and abundance of salmonids. ▪ Upstream populations are likely isolated by fragmented habitats in lower reaches.	
LEVEL OF CERTAINTY: ▪ Distribution and status of salmonids in streams are not well known. ▪ Low flows and passage barriers are readily apparent, but no formal surveys have been made to assess benefits of restoration practices in these streams. ▪ There is likelihood that there are isolated populations of redband trout in these streams.	
RECOMMENDATIONS (IN PRIORITY): ▪ Assess the distribution, abundance, and genetic structure of salmonids in these streams. ▪ Identify habitat conditions that limit their productivity, and develop a protection and restoration plan accordingly.	

Appendix C.6. Mainstem Columbia River

MAINSTEM COLUMBIA RIVER ASSESSMENT AND INTERIM STRATEGY
<u>Native species:</u> spring, summer, and fall chinook salmon, steelhead, sockeye salmon, coho salmon, bull trout.
STATUS: Category 5 ▪ Upstream and downstream migration corridor, and a documented spawning habitat in some areas for summer and fall chinook salmon. Likely overwinter habitat for many species and age groups.
FACTORS AFFECTING HABITAT CONDITION: ▪ Hydroelectric dams inundated habitats and impaired passage conditions. ▪ Habitat degradation and loss on shorelines from land development and road construction may affect salmonids at some life history stages. ▪ Stormwater and agricultural runoff contribute to water quality degradation.
LEVEL OF CERTAINTY: ▪ Hydropower impacts are well studied. ▪ Impacts to salmonids from Columbia River shoreline management are inferred from studies on smaller-order streams.

RECOMMENDATIONS (IN PRIORITY):

1. Hydropower impacts are an obvious concern, but are not addressed in this assessment.

2. Protect any remaining riparian habitat.

3. Evaluate potential for impacts to salmonids from shoreline management: develop recommendations to lessen impacts, as appropriate.

Appendix I

Integration of Recommended Recovery Actions

Introduction

At this time it is very difficult to assess the cumulative beneficial effects of actions across all sectors (Hs), because regionally accepted tools for assessing effects across sectors are currently not available. Therefore, this appendix describes a simple analytical approach to integrating the effects of actions recommended in the recovery plan. There is no attempt at this time to account for confidence intervals around any of the parameters or in the integrated estimates. Consequently, the certainty of the preliminary results presented in this appendix remains unknown. However, despite these deficiencies, it is important to estimate how much the status of Upper Columbia steelhead and spring Chinook might improve with implementation of the recommended actions within this plan. Because there is currently not enough information on bull trout within the Upper Columbia populations to estimate abundance and productivity, bull trout were omitted from this appendix. However, we recognize that implementation of the actions proposed in the plan will have a positive effect on bull trout habitat and subsequent population dynamics.

In this appendix we refer to the "gap," analysis which estimates how much survival improvement is needed to move the current status of the populations toward recovery. The gap analysis was prepared by the ICBTRT (2006) for the Federal Columbia River Power System (FCRPS) remand process. We then summarize out-of-basin factors that affect the survival of Upper Columbia stocks. NOAA Fisheries prepared hydro, harvest, and estuary modules that describe limiting factors and threats, and expected actions or strategies to address those threats. Finally, we use a simple analytical approach to assess the potential benefits of recovery actions across sectors and compare the results to the gap identified by the ICBTRT.

Gap Analysis

The ICBTRT (2006) recently estimated survival rate changes needed to meet their abundance and productivity viability criteria for a 5% risk of extinction for Upper Columbia ESUs. The change in survival from current conditions to viability is referred to as the "gap." Productivity is a key component of the gap and it relates directly to the ability of a population to be self sustaining. The ICBTRT expressed productivity as recruits per spawner or the rate at which spawning adults in one generation are replaced by spawning adults in the next generation. Importantly, gaps do not identify or target a particular life stage. Gaps can therefore be addressed by improvements to survival rates at any life stage (e.g., tributary residence, migration, estuarine, early ocean, upstream migration).

Survival changes estimated to meet abundance and productivity viability criteria for Upper Columbia spring Chinook and steelhead are presented in Table 1. The numbers in the table represent survival multipliers for both good (historical) and poor (pessimistic) ocean conditions.[1] For example,

[1] Good or historical ocean conditions assume that ocean survival over the next 100 years will have the same characteristics as those experienced over the past 50-100 years. Poor or pessimistic ocean conditions assume that ocean survival over the next 100 years will have the same characteristics as those experienced by the 1975-1997 brood years.

in Table 1, a survival multiplier of 1.67 for Entiat spring Chinook requires increasing average life-cycle survivals by 67% over current levels, assuming good ocean conditions over the next 100 years. A 178% increase (2.78 survival multiplier) is needed if poor ocean conditions prevail for the next 100 years. Note that these survival estimates incorporate many of the improvements in hydropower survivals estimated from current management strategies.[2] Thus, the survival multipliers in Table 1 represent the portion of the gap that should be filled largely by habitat, harvest, and hatchery actions.

Table 1. Survival multipliers needed to meet abundance and productivity criteria for Upper Columbia spring Chinook and steelhead ESUs (from ICBTRT 2006). A survival multiplier of 2.56 requires increasing average life-cycle survivals by 156% over current levels.

Species	Population	Survival increase needed to achieve 5% extinction risk under relatively good (historical) ocean conditions (adjusted for Hydro)	Survival increase needed to achieve 5% extinction risk under poor ocean conditions (adjusted for Hydro)
Spring Chinook	Wenatchee	1.53	2.56
	Entiat	1.67	2.78
	Methow	1.29	2.15
Steelhead	Wenatchee	2.83	4.72
	Entiat	4.12	6.87
	Methow	4.46	7.45
	Okanogan	5.67	9.46

It is important to point out that NOAA Fisheries advises that these gaps do not constitute a legal determination of the status of Upper Columbia ESUs nor of the adequacy of any particular set of actions under the ESA. Rather, the gap provides a sense of how much effort is needed for planning purposes.

Although the ICBTRT (2006) did not identify a gap for spatial structure and diversity in the FCRPS Remand Process, they have identified necessary improvements in spatial structure and diversity needed to meet viability criteria (ICBTRT 2005). Needed improvements in these VSP parameters are identified in Appendix B and Section 4 of the Plan.

Out-of-Basin Modules

NOAA Fisheries recently developed modules that describe limiting factors, threats, and expected actions to address those threats for out-of-basin factors (i.e., hydro, harvest, and estuary). In addition, where possible, they also estimated potential survival improvements that may be realized if the

[2] These estimates do not include the estimated long-term survival improvements for spring Chinook and steelhead at the four federal projects, nor do they include the estimated survival improvements associated with dams owned by Grant County Public Utility District.

recovery actions are implemented. Summarized below is information contained in those modules that relate to Upper Columbia spring Chinook and steelhead. Those who desire greater detail than what is presented here should consult the modules.

Hydro Module

The hydro module summarizes the effects of present management of the Columbia River mainstem hydropower projects on ESA-listed ESUs in the Columbia Basin. These effects could be subject to some changes as a result of new or amended strategies or actions through the redevelopment of the FCRPS section 7 biological opinion. The area addressed in the module that affects Upper Columbia ESUs includes the accessible habitat from the tailrace of Chief Joseph Dam downstream to the tailrace of Bonneville Dam (the area downstream from Bonneville Dam is covered in the estuary module). The two Upper Columbia ESUs use the mainstem Columbia River for migration to and from freshwater natal areas to the Pacific Ocean. Survival through the migration corridor declines with distance traveled, whether because of hazards (including predation), mortality because of passage at hydroelectric projects, or other factors associated with development (exotic predators, habitat conditions that make native predators more efficient, water quality, etc.).

Upper Columbia ESUs migrate through four federally owned projects and three to five projects owned by public utility districts. The four federally owned projects include McNary, John Day, The Dalles, and Bonneville dams, power plants, and reservoirs in the lower Columbia River. These projects are part of the Federal Columbia River Power System (FCRPS). Projects owned and operated by public utility districts (PUD) include Wells (Douglas County PUD), Rocky Reach and Rock Island (Chelan County PUD), and Wanapum and Priest Rapids (Grant County PUD). These projects are licensed by the Federal Energy Regulatory Commission.

Hydropower development in the Columbia Basin has affected salmonid migrations, altered habitats, and increased predation on juvenile salmonids. For example, hydropower development can (1) alter flows, which affect fish migration and survival both directly and indirectly; (2) increase average water temperatures beyond optimums for fish migration, behavior, and survival; (3) modify riverine habitat resulting in changes in habitat availability, migration patterns, feeding ecology, predation, and competition; and (4) impede juvenile and adult fish migration. These factors acting in concert reduce the survival of listed populations in the Upper Columbia Basin.

The operation of projects owned by Chelan (Rocky Reach and Rock Island dams) and Douglas PUDs (Wells Dam) fall under 50-year anadromous fish agreements and habitat conservation plans (HCPs) that set a “no net impact” standard to protect salmon and steelhead at the projects. The HCPs established a standard of 91% combined adult and juvenile passage survival at each project.[3] The combined survival standard is comprised of 93% juvenile and 98% adult project passage survival for all anadromous salmonids. At the time the Incidental Take Permits were issued (August 20, 2003), NOAA Fisheries estimated that the HCPs represented a 22 to 45% survival improvement potential over the survival levels observed under the historical operations of these three hydroelectric projects.

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[3] The HCPs allowed the PUDs to compensate for up to 9% project passage mortality through up to 7% hatchery production and up to 2% funding of tributary habitat enhancement projects. That is, the mitigation is intended to match the level of impact.

The modified IPP for projects owned and operated by Grant County (Priest Rapids and Wanapum dams) sets survival standards that are identical to those described above for the HCPs. The following measures will be implemented to strengthen the likelihood that the standards are met:

- Downstream passage measures, including spill through existing and top spill through future units; turbine operations and the installation of advanced turbines; total dissolved gas abatement; avian predator control; and a Northern Pikeminnow removal program.
- Continued operation and maintenance, and where needed, improvements to adult. fishways at both Priest Rapids and Wanapum dams.
- Design and construction of an off-ladder trap and fish-handling facilities at Priest Rapids Dam.
- Sluiceway operations for steelhead fallbacks (kelts).

The plan of operation of the FCRPS through 2014 includes the following general hydrosystem actions.

- Continue adult fish passage operations.
- Improve juvenile fish passage.
- Continue and enhance spill for juvenile fish passage.
- Continue reservoir operations and river flows to benefit migrating fish.
- Modify fish transportation to improve juvenile survival.

The level of juvenile and adult survival expected for the near-term (2004-2009), mid-term (2010-2013), and long-term (2014), per the updated proposed actions are shown in Table 2a and 2b. The levels of survival are those the NOAA Fisheries estimated will occur as the FCRPS action agencies (U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and Bonneville Power Administration) carry out the hydro operations and system configuration improvements they proposed in 2004.

Table 2a. Near-term (2004-2009), mid-term (2010-2013), and long-term (2014) average and range (in parentheses) juvenile survival estimates for Upper Columbia populations migrating through the mainstem hydropower system. At this time there are no estimates for Okanogan steelhead.

Species	Population	Juvenile Survival		
		Near-Term	Mid-Term	Long-Term
Spring Chinook	Wenatchee	0.554 (0.447-0.625)	0.592 (0.583-0.665)	0.605 (0.489-0.690)
	Entiat	0.509 (0.407-0.580)	0.550 (0.449-0.618)	0.562 (0.480-0.640)
	Methow	0.490 (0.384-0.577)	0.549 (0.423-0.616)	0.541 (0.422-0.638)
Steelhead	Wenatchee	0.340 (0.115-0.461)	0.406 (0.139-0.548)	0.412 (0.428-0.618)
	Entiat	0.326 (0.107-0.452)	0.389 (0.129-0.538)	0.395 (0.400-0.607)
	Methow	0.314 (0.101-0.451)	0.374 (0.139-0.536)	0.380 (0.376-0.605)

Table 2b. Near-term (2004-2009), mid-term (2010-2013), and long-term (2014) average and range (in parentheses) adult survival estimates for Upper Columbia populations migrating through the mainstem hydropower system. At this time there are no estimates for Okanogan steelhead.

Species	Population	Adult Survival		
		Near-Term	Mid-Term	Long-Term
Spring Chinook	Wenatchee	0.904 (0.895-0.918)	0.904 (0.895-0918)	0.904 (0.895-0.944)
	Entiat	0.897 (0.889-0.912)	0.898 (0.889-0.918)	0.900 (0.899-0.913)
	Methow	0.892 (0.884-0.907)	0.892 (0.884-0.907)	0.892 (0.884-0.907)
Steelhead	Wenatchee	0.907 (0.889-0.926)	0.907 (0.889-0.926)	0.907 (0.889-0.926)
	Entiat	0.897 (0.879-0.916)	0.897 (0.879-0.916)	0.897 (0.879-0.916)
	Methow	0.885 (0.868-0.904)	0.885 (0.868-0.904)	0.885 (0.868-0.904)

Harvest Module

The harvest module describes mortality resulting from current, historic, and expected future fisheries based on present management strategies. It also summarizes the complexities of management programs and describes different fisheries (e.g., ocean, mainstem, tributary, tribal, commercial, and recreational). Managing the various fisheries is very complex and readers should refer to the harvest module or Sections 3.4 and 5.2 in the recovery plan for more details. Here we only summarize the salient points that relate to Upper Columbia stocks.

Salmon and steelhead from the Upper Columbia Basin may be caught in ocean, mainstem Columbia River, or tributary fisheries depending on their timing and distribution relative to fishery openings. Although Upper Columbia stocks are subject to little or no ocean fishing mortality, they are affected to some degree by fisheries in the mainstem Columbia River. Characterizing harvest mortality associated with tributary fisheries is more complicated. Ocean and mainstem fisheries are assumed to affect all populations in the ESU equally. Because of their location, tributary fisheries generally affect one or sometimes a few populations, but have no affect on the remainder of the ESU. As a result, estimates of mortality to populations in tributary fisheries cannot simply be added to estimates of mortality to the ESU in the mixed-stock ocean and mainstem fisheries unless it is clear that the additional impacts are population specific. Harvest mortality estimates described below therefore refer to impacts in ocean and mainstem fisheries.

As noted above, the current ocean fishery mortality on Upper Columbia spring Chinook is very low and assumed to be zero based on the rare occurrence of coded wire tag (CWT) recoveries in ocean fisheries. Fisheries in the mainstem Columbia River are subject to a harvest rate schedule ranging from 5.5-17% as described in the 2005-2007 Interim Management Agreement. The harvest rate varies depending on the total abundance of upriver spring Chinook including the summer component of the Snake River spring/summer Chinook ESU. The harvest rate also depends on the abundance of naturally produced Upper Columbia River spring Chinook and Snake River spring/summer Chinook. The harvest rate schedule was modified slightly before the 2005 season to accommodate the inclusion of the summer component of the Snake River spring/summer Chinook ESU, but is otherwise the same as that used in the 2001 Interim Agreement. Under the terms of the 2005-2007 Agreement, survival may range from 83-94.5%. The observed harvest rate on naturally produced Upper Columbia spring Chinook from 2000-2004 averaged 10.7% (an 89% survival rate). Historically (based on the 1960-1964 period)[4], harvest rates on Upper Columbia spring Chinook averaged 46.4% (a 54% survival rate).

The current ocean fishery mortality on Upper Columbia steelhead is assumed to be zero. Harvest management constraints and harvest rates for naturally produced steelhead in Columbia River mainstem fisheries are similar to those for Snake River A-run steelhead. This fishery is currently managed subject to the terms of the *U.S. v Oregon* Interim Management Agreement for 2005-2007. The expected harvest rates on Upper Columbia steelhead in non-Indian and treaty Indian fisheries are 1.0-1.8% and 3.5-8.2%, respectively. The combined harvest rate on Upper Columbia River steelhead is therefore expected to range from 4.5-10% (a 90-95% survival rate). Historical mainstem harvest rates on steelhead were 21% (a 79% survival rate) and if these fish were subject to an additional 50% tributary harvest rate the resulting survival would be 40%.

For the near term, harvest impacts will likely be similar to current levels. Any changes in harvest strategies would be determined through the *U.S. v Oregon* forum. Provisions of the Pacific Salmon Treaty that relate to management of Chinook fisheries will be in place through 2008. Fisheries managed under the jurisdiction of the Pacific Fishery Management Council are subject to long-term biological opinions that are in place until changed. Fisheries in the mainstem Columbia River will be managed subject to the *U.S. v Oregon* Interim Management Agreement through at least 2007. If and how these fisheries will change thereafter is unclear. The existing fishery regimes have developed over the years since the first listings in the Columbia River Basin in 1991, and include substantial reductions in fisheries considered necessary to comply with ESA requirements to date. Fishery management provisions will continue to evolve in response to new information including recommendations developed through the recovery planning process. At this time it is not possible to predict the direction or magnitude of change for any particular ESU. Given these uncertainties, a reasonable assumption is that future harvest impacts will be similar to current levels.

Estuary Module

The estuary module discusses the estuary, lower mainstem, and plume as they relate to salmon and steelhead recovery. The module identifies limiting factors and threats, focusing on flow, tidal effects, ecological interactions, and toxics. The module includes options for management actions or strategies that link the estuary to species life-history characteristics and survivals. The area addressed by the module extends from Bonneville Dam downstream to the plume.

The estuary serves an important role beyond simply providing a corridor that Upper Columbia populations use to migrate between freshwater and the ocean. It is well established that the habitat in the estuary is part of the continuum of ecosystems that salmon and steelhead use to complete their life cycles. Throughout the estuary, the distribution and quality of habitat has been negatively affected by a variety of anthropogenic factors and natural changes. These alterations have not only

[4] The period from 1960-1964 is used to represent the period before reduction in harvest for conservation reasons.

affected the abundance and productivity of populations, but have also affected their spatial structure and diversity.

Of the many factors in the estuary that affect salmon and steelhead viability, four appear to be the most important: flow, habitat, contaminants/toxics, and predation. Alterations in flows, loss of emergent marsh, tidal swamp, and forested wetlands, shifts in organic matter important to estuarine food webs, and changes in the plume have affected population productivity and diversity. Changes in the plume may have a greater effect on yearling life-history strategies (e.g., Upper Columbia ESUs) than changes in shallow-water habitat. Exposure to waterborne and sediment-associated chemical contaminants can also affect productivity of salmon and steelhead. Upper Columbia populations are likely to be most affected by short-term exposure to waterborne contaminants such as pesticides and dissolved metals. Finally, predation is a major source of mortality on all listed populations. Both adults and juveniles suffer relatively high predation loss in the estuary. Upper Columbia populations, because of their life-history characteristics, are especially susceptible to Caspian tern predation.

Flow changes in the estuary are primarily a result of dam operations, whereas habitat changes are a function of both hydropower operations and other, non-hydro issues, notably the construction of dikes and levees in the estuary. The main effects of flow on Upper Columbia populations are associated with changes in the plume. Thus, actions that affect the plume, decrease exposure to toxicants, and decrease predation (especially Caspian tern predation) should improve the abundance/productivity and diversity of Upper Columbia ESUs.

The estuary module assumes a 20% improvement that might be realized through the implementation of actions in the estuary. The 20% improvement is a hypothetical target that is plausible if constraints to implementation can be overcome and that threats and limiting factors can effectively be reduced. The improvement level is based on overall estimates of juvenile mortality in the estuary, known mortality that can be attributed to specific threats, and professional judgment regarding the efficacy of the different management actions and the likelihood that constraints to their implementation can be overcome.

Integration Approach

The simple analytical approach used in this plan relied on information from Sections 2, 3, and 5 to provide an estimate of the likelihood that the actions recommended within the plan would meet viability criteria for a 5% risk of extinction. The simulation also used additional information and assumptions (which are outlined below) to evaluate the actions that have either been recently enacted, or recommended within the recovery plan. Below, we outline by sector the associated assumptions and information that were used to estimate the increase in productivity and spatial structure/diversity. Potential changes in abundance were not estimated because the "gap" was expressed in terms of productivity, not abundance.

Productivity

For all sectors, we assumed a 50% hatchery effectiveness (reproductive success) rate for steelhead. As such, the values for productivity reported for steelhead within this appendix differ from those reported in Section 2 of the recovery plan.[5] The run was reconstructed using 50% of the hatchery fish included with naturally produced fish to determine productivity values. We estimated for all sectors a low and high potential increase in productivity. The lower and upper estimates were determined by modeling (e.g., EDT for habitat) or professional judgment.

Potential productivity (productivity that may be achieved if recovery actions are implemented) of naturally produced fish was estimated from the sum of the percent increase in a particular sector, multiplied by the current estimate of productivity. Productivity was based on the latest year of data for a particular brood year of fish (1999 for spring Chinook and 1996 or 1997 for steelhead).

Harvest Sector

As discussed in detail in Section 5.2 of the recovery plan and in the Harvest Module, harvest on Upper Columbia steelhead and spring Chinook has been significantly reduced over the last several decades. As a result, there is limited opportunity to reduce harvest rates beyond their current limits. The recovery actions identified in the Plan may result in a small reduction in harvest through improved management strategies, harvest methods, and marking techniques. Therefore, for the purposes of this exercise, we assumed a range of change in potential productivity from 0% (lower potential) to 1% (upper potential) (Table 3).

We also estimated potential survival benefits associated with terminating all harvest on spring Chinook and steelhead. The results indicated a potential increase of 9-10% in productivity of spring Chinook, but steelhead productivity actually decreased. This is because a large number of hatchery produced steelhead would escape to spawning grounds and “swamp” the spawning population. Hatchery produced steelhead currently have a lower reproductive success than naturally produced fish (we optimistically assumed a reproductive success of 0.5 for hatchery steelhead) and therefore would drive the productivity of the population down to low levels. Harvest on hatchery produced steelhead means fewer hatchery fish escape to spawning grounds. This results in a greater percentage of the spawning escapement consisting of naturally produced fish that are more productive than hatchery steelhead.

Hatchery Sector

To determine hatchery changes that contribute to productivity, we used the theoretical difference between the productivities for steelhead estimated in Section 2 of the recovery plan. As described in Section 2, we reconstructed the historical steelhead run using two different reproductive success scenarios for hatchery spawners: (1) hatchery spawners were as effective as wild spawners (100%; H = 1) and (2) hatchery spawners did not contribute to returning spawners at all (0%; H = 0).

In the Wenatchee and Entiat rivers[6], there is a 63% difference between zero contribution of hatchery spawners (return per spawner is 0.81) and 100% effectiveness (return per spawner is 0.25). In the

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[5] In Section 2 and Appendix C we modeled steelhead runs assuming two different reproductive successes. The first scenario assumed that steelhead were equally as effective in producing returning spawners as naturally produced steelhead (reproductive success = 100%), while the second scenario assumed that hatchery fish contributed no returning spawners (reproductive success = 0%). In the absence of empirical data, we assumed in this exercise that hatchery steelhead were half as effective in producing returning spawners as naturally produced steelhead (reproductive success = 50%).

[6] Wenatchee-Entiat, and Methow-Okanogan returns per spawner cannot be separated because the base population (dam counts) is the same (see Appendix C for further details).

Methow and Okanogan rivers the difference is 89% (0.89 if H = 0 and 0.09 for H = 1). Because no data currently exist in the Upper Columbia[7] to determine true hatchery spawner effectiveness, we assumed in this exercise that hatchery spawners are half (50%; H = 0.5) as effective as naturally produced spawners for both steelhead and spring Chinook. We also assumed that the relationship between 100% hatchery spawner effectiveness and 0% hatchery spawner effectiveness for steelhead also applies to spring Chinook within the Wenatchee, Entiat, and Methow rivers.

In the absence of empirical data, we estimated that improvements in hatchery practices would result in a 3-5% survival increase in naturally produced spring Chinook and steelhead in the Wenatchee-Entiat populations, and a 5-10% increase in the Methow-Okanogan populations (Table 3). The greater increase in the Methow-Okanogan populations reflects the recommended action of collecting local broodstock within tributaries rather than composite fish at Wells Dam. These survival changes also appear to be supported by AHA modeling results (see Appendix J).

Hydro Sector

We applied the calculated increases in juvenile survival from the draft QAR (Cooney et al. 2000) to the calculated geo-mean of returns per spawner from Section 2 for spring Chinook and steelhead. This was applied basin-specific, where applicable. We used the estimated increase in juvenile survival from Table 24 in Cooney et al. (2000) for all five PUD dams, and also applied their estimated increase in juvenile survival in the lower Columbia River from McNary to downstream from Bonneville dam (14.5% improvement; Table 27 in Cooney et al. 2000) to the estimated increases from the HCPs on local hydro dams. We assume 1:1 increase in spawners from an increase in juvenile survival from the proposed actions (i.e., if juvenile survival increased 10%, we assumed a 10% increase in spawners). Based on this information, productivity could increase between 35-51% for spring Chinook populations and 30-40% for steelhead populations (Table 3). We used these estimates for both low and high productivity potentials.

Habitat Sector

We applied the EDT results for the Wenatchee, Entiat[8], Methow, and Okanogan to determine what percent increase in productivity could be expected from implementing habitat actions recommended in the Plan (from Section 5.5). Using the EDT results in Appendix F, we estimated density-independent survival changes as smolts per spawner across a range of spawner abundances less than 2,000 spawners (the minimum recovery abundance for large populations established by the ICBTRT). Because we did not know the extent to which the proposed habitat actions would be implemented, EDT modeled two different scenarios: (1) implementation intensity of 33% and (2) implementation intensity of 100% (see Appendix F). This allowed us to show a potential range of effects from recommended habitat actions. It is important to understand that the 100% intensity may not be reasonable or feasible. The habitat actions proposed in the Plan have not been evaluated for social/economic feasibility.

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[7] There is currently a study underway to estimate spring Chinook hatchery spawner effectiveness in the Wenatchee River, and Chelan and Douglas PUDs will be determining the same for steelhead through their HCP hatchery M&E programs.

[8] In the Entiat, a different model run was used. Since the Entiat Watershed Plan has run EDT for various scenarios (see Plan for details), we used Scenario 5, as described in the Watershed Plan, and compared it to the “33%” run from the other subbasins. The Entiat Watershed Plan did not model steelhead and there has been no attempt to model steelhead in the Entiat.

Under the 33% intensity scenario (lower potential), productivity of spring Chinook populations could increase 3-25% (Table 3). Under 100% intensity (upper potential), productivity of spring Chinook populations could increase 3-36% (Table 3). Productivity of Upper Columbia steelhead populations under the 33% scenario could increase 14-47%, while steelhead productivities under the 100% scenario could increase 31-64% (Table 3). Note that there is no estimate for Entiat steelhead because there was no EDT analysis completed for this population.

Integration Across Sectors

To determine the total change in survival for each population, we multiplied the changes in productivity (calculated as the ratio of proposed productivity to current productivity within a sector) across sectors to estimate the total survival multiplier from the proposed actions. For Upper Columbia spring Chinook populations, survival could increase 99-137% under the lower potential productivity scenario to 107-198% under the higher potential productivity scenario (Table 3). Survival for steelhead populations could increase 85-178% under the low productivity scenario to 90-226% under the higher productivity scenario (Table 3).

We compared these survival changes with the gap analysis to see if the estimated changes met recovery criteria (i.e., filled the gap). Table 4 compares the survival changes needed to meet abundance and productivity viability criteria for Upper Columbia ESUs. It is important to note that the survival improvements in the gap analysis are already adjusted for most hydro effects.

Table 3. Summary of possible increases in productivity from recommended actions identified in the recovery plan. The numbers in red indicate minimum estimates for Entiat steelhead, because there are no productivity estimates from recommended habitat actions.

Sector	Area	Spring Chinook Productivity					Steelhead Productivity[1]				
		Current (C)	Low Potential (P)	High Potential (P)	Low P/C	High P/C	Current (C)	Low Potential (P)	High Potential (P)	Low P/C	High P/C
Harvest	Wenatchee	0.74	0.74	0.75	1.00	1.01	0.69	0.69	0.70	1.00	1.01
	Entiat	0.76	0.76	0.77	1.00	1.01	0.69	0.69	0.70	1.00	1.01
	Methow	0.51	0.51	0.52	1.00	1.01	0.91	0.91	0.92	1.00	1.01
	Okanogan	---	---	---	---	---	0.91	0.91	0.92	1.00	1.01
Hatchery	Wenatchee	0.74	0.76	0.78	1.03	1.05	0.69	0.71	0.72	1.03	1.05
	Entiat	0.76	0.78	0.80	1.03	1.05	0.69	0.71	0.72	1.03	1.05
	Methow	0.51	0.54	0.56	1.05	1.10	0.91	0.96	1.00	1.05	1.10
	Okanogan	---	---	---	---	---	0.91	0.96	1.00	1.05	1.10
Hydro[2]	Wenatchee	0.74	1.09	1.09	1.47	1.47	0.69	0.97	0.97	1.40	1.40
	Entiat	0.76	1.20	1.20	1.58	1.58	0.69	1.03	1.03	1.49	1.49
	Methow	0.51	0.84	0.84	1.65	1.65	0.91	1.36	1.36	1.49	1.49
	Okanogan	---	---	---	---	---	0.91	1.36	1.36	1.49	1.49
Habitat (33%-100%)[3]	Wenatchee	0.74	0.93	1.00	1.25	1.35	0.69	0.87	0.90	1.26	1.31
	Entiat[4]	0.76	0.78	0.78	1.03	1.03	0.69	---	---	---	---
	Methow	0.51	0.58	0.69	1.14	1.36	0.91	1.04	1.24	1.14	1.36
	Okanogan	---	---	---	---	---	0.91	1.34	1.49	1.47	1.64
Integration across all sectors[5]	Wenatchee	0.74	1.69	1.89	2.29	2.56	0.69	1.51	1.61	2.19	2.33
	Entiat	0.76	1.51	1.57	1.99	2.07	0.69	1.28	1.31	1.85	1.90
	Methow	0.51	1.21	1.52	2.37	2.98	0.91	1.97	2.47	2.16	2.71
	Okanogan	---	---	---	---	---	0.91	2.53	2.97	2.78	3.26

[1] Productivity was based on a hatchery effectiveness of H = 0.5.

[2] The survival estimates provided here were based on the draft Quantitative Analysis Report (QAR). Survival estimates include improvements associated with long-term benefits from the FCRPS. The method used here (QAR) differed from those in the Gap Analysis.

[3] EDT modeled two habitat improvement scenarios for the Wenatchee, Methow, and Okanogan populations: (1) 33% intensity and (2) 100% intensity (See Appendix F). The 100% intensity may not be feasible to implement because of social/economic factors.

[4] Because the Entiat was not modeled the same as the other subbasins, the total increase in productivity would be greater than shown here (See Appendix F). There was no 100% intensity scenario for the Entiat.

[5] Includes an estimated 20% survival benefit from the implementation of estuary actions.

Table 4. Comparison of survival multipliers needed to meet abundance and productivity criteria for Upper Columbia spring Chinook and steelhead populations and those expected from implementing recommended actions within the recovery plan. A survival multiplier of 2.56 requires increasing average life-cycle survivals by 156% over current levels.

Species	Population	Gap Analysis		Recovery Plan	
		Survival increase needed to achieve 5% extinction risk under relatively good (historical) ocean conditions (adjusted for Hydro)	**Survival increase needed to achieve 5% extinction risk under poor ocean conditions (adjusted for Hydro)**	**Lower survival increase expected from plan (not counting hydro)[1]**	**Upper survival increase expected from plan (not counting hydro)[1]**
Spring Chinook	Wenatchee	1.53	2.56	1.69	1.89
	Entiat	1.67	2.78	1.37	1.43
	Methow	1.29	2.15	1.57	1.97
Steelhead	Wenatchee	2.83	4.72	1.89	2.01
	Entiat	4.12	6.87	---	---
	Methow	4.46	7.45	1.75	2.19
	Okanogan	5.67	9.46	2.25	2.64

[1] These survival estimates include a 12% increase for steelhead resulting from actions that will be implemented at Priest Rapids and Wanapum dams (owned by Grant County Public Utility District) and an 8% and 9% increase for steelhead and spring Chinook, respectively, from long-term actions taken at the four federal dams on the lower Columbia River. They also include an estimated 20% survival benefit associated with the implementation of proposed actions in the estuary.

Except for perhaps the Wenatchee and Methow spring Chinook populations, these results suggest that the recommended actions within the recovery plan may not fill the gap between the ESUs' present status and the 5% extinction risk viability criteria. There are a number of reasons why this may have occurred.

(1) Methods used by the ICBTRT to calculate productivities for the gap analysis were different than those used in the recovery plan. In the recovery plan, productivity was calculated as the 12-yr geometric mean of consecutive brood years. The ICBTRT calculated a 20-yr geometric mean that was adjusted for SAR and delimited at the median. This means that they excluded any spawner/return pair where the spawner number exceeded the median. The intent was to remove density-dependent effects that may influence the productivity estimate.

(2) Our inability to estimate accurately the probable survival changes associated with each recommended action identified in the plan may have greatly underestimated the expected survival change for each population. For example, there is no method currently available that

calculates expected survival changes associated with hatchery actions. If the actions recommended in the plan significantly contribute to natural production, then the survival changes assumed here may greatly underestimate the contribution of hatchery actions.[9]

(3) The integration analysis included a hypothetical improvement level associated with management actions in the estuary. Actions that reduce toxics and predation may translate into a relatively large survival benefit for Upper Columbia populations. Benefits associated with changes in flow and the plume were included in the hydro sector under the ICBTRT gap analysis.

(4) The potential survival gains associated with hatchery actions may be greatly underestimated. Current analyses indicate that Methow steelhead require a 4-7 fold increase in survival to meet viability criteria, while Methow spring Chinook only need a 1-2 fold increase in survival. This indicates that the productivity of Methow steelhead has been much more affected by hatchery programs than Methow spring Chinook.[10] Changes in the hatchery programs could close the gap between current and desired productivities.

Recovery planning for salmonids in the Upper Columbia suffers, as recovery planning for nearly all species does, by a lack of information that ties human actions explicitly to a quantitative response in stage-specific survival, life-cycle productivity or abundance. While a recovery plan is not required by the ESA to provide such a quantitative evaluation, recovery planners and stakeholders in the Upper Columbia would like a sense of how much is enough for their planning purposes. The lack of quantitative information makes it challenging to provide this estimate of “how much is enough” robustly. This is particularly true for the Upper Columbia steelhead and similar ESUs, where the difference between current abundance and productivity and ICBTRT viability targets for abundance and productivity appears to be very large.

However, this apparent difference between current status and abundance and productivity targets is affected by at least two additional factors. First, for all ESUs, population modeling and other analysis conducted by the ICBTRT, the NWFSC, and by other researchers (ICBTRT and Zabel 2006; Zabel et al. 2006; McClure et al. 2004; Mantua et al. 1997) indicates that climate and associated ocean conditions have a very large impact on overall population productivity, likely by affecting estuarine and early ocean survival. The proportion of the difference between current status and abundance and productivity viability targets that has to be “made up” by human actions changes dramatically under different climate or ocean scenarios. While this proportion is quite large under scenarios that impose poor estuarine and early ocean survival, scenarios that incorporate early ocean survival more like those seen over the last 60 to 100 years appear to require much less human action (ICBTRT 2006).

[9] Upper Columbia steelhead have been heavily affected by out-of-basin hatchery stocks and past harvest management. Such hatchery stocks generally have productivities (reproductive success) that are much lower than native spawners. Thus, there is potential to improve the productivity of the populations through management strategies that include the use of locally-derived broodstock and promote adaptation of natural spawners to local conditions. Such a change has the potential to reduce the difference between current productivity and desired productivity. Currently, however, there is no way to estimate what the potential change in productivity would be if the hatchery actions identified in the plan were implemented.

Second, the Upper Columbia steelhead ESU has been heavily affected by use of out-of-ESU hatchery broodstock and past harvest management. As a result of these past practices, current natural spawners may be nearly entirely derived from those out-of-ESU sources. Exogenous hatchery stocks such as these often have reproductive success that is lower than that of native wild populations (review in Berejikian and Ford 2006). Thus, there may be potential to improve the productivity of the populations within this ESU through a management strategy that includes the use of locally-derived broodstock and promotes adaptation of natural spawners to local conditions. Such a change has the potential (although it is not guaranteed) to reduce the difference between current observed productivity and desired population productivity.

Although we cannot demonstrate conclusively at this time that the actions identified in the Plan will meet the 5% viability criteria identified by the ICBTRT, neither can we demonstrate conclusively that they will not. We do believe that the actions identified in the Plan will move the populations to a more viable state and that there is an opportunity to significantly reduce extinction risk. The monitoring and adaptive management program outlined in Section 8 of the Plan will be used to demonstrate progress toward recovery of Upper Columbia ESUs.

Spatial Structure and Diversity

The spatial structure and diversity of each population of steelhead and spring Chinook in the Upper Columbia Basin was discussed in Appendix B and Section 2 in the Plan. The status of spatial structure and future improvements are most relevant in the habitat sector, except that low abundance can lead to functional habitat being unoccupied. We did not attempt to integrate future abundance increases with suitable but unoccupied habitat, but assumed that more fish would "fully seed" the available functioning habitat. Species diversity, on the other hand, is affected by multiple sectors, primarily hatchery operations.

Spatial Structure

Six of the seven populations were at low to moderate risk for goal A (spatially mediated processes), which dealt primarily with distribution across major spawning areas (See Table 2.2 in the Plan and Appendix B). This conclusion was based on the presence of natural origin spawners and/or functional habitat within the major and minor spawning areas consistent with the ICBTRT guidance. Okanogan steelhead was the exception, and the high risk rating for goal A was because only 1 of 2 major spawning areas was occupied. In order to achieve low or moderate risk, the Okanogan population will need to occupy both MSAs.

The intended actions in the habitat sector will improve the spatial distribution and habitat quality within the major spawning areas, so we expect the status of spatial structure to continue to improve. The ICBTRT has suggested that a population and ESU could be viable with moderate risk for spatial structure and diversity so no further actions would be required. Our conceptual representation of current and future status with respect to spatial structure for the ESU can be seen in Figure 1. We chose to leave the emphasis on providing access to suitable habitat, although we recognize that hatcheries could contribute by seeding unoccupied habitat and hydro and harvest could contribute by helping to increase abundance, which should lead to more occupied areas.

Diversity

Our risk assessment for goal B (maintaining natural levels of variation) concluded that all spring Chinook and steelhead populations were at high risk (See Table 2.2 in the Plan and Appendix B). Past and current hatchery operations were largely responsible for the high risk ratings for both species (Appendix B). Addressing these hatchery issues would remove the threats to diversity and likely lead to a diversity status that would meet the requirements of a VSP. We generated a conceptual graphic of the relative contribution of each sector to the current and future status of diversity for the ESU (Figure 2). Small gains could be made by reducing the risk of selective pressures that select for or against phenotypic traits in the harvest and hydro sectors; however, the emphasis was on habitat and hatcheries. Although some gains can be made in the habitat sector, VSP levels cannot be achieved without adequate contributions in the hatchery sector (Figure 2).

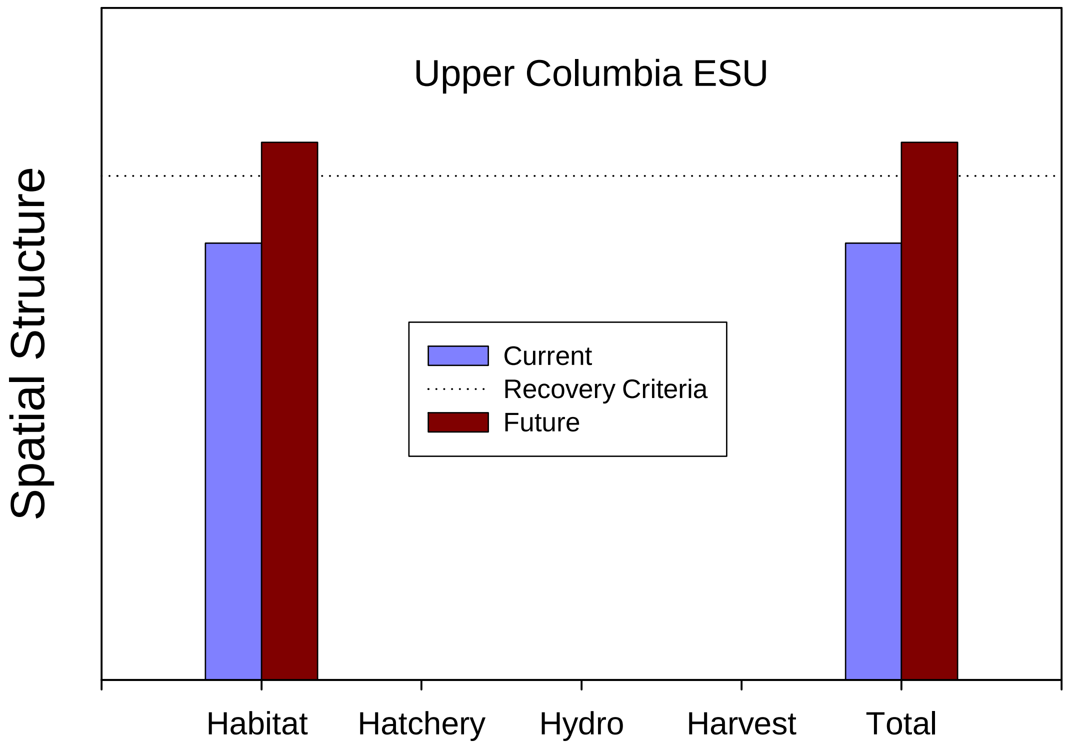


Figure 1. Conceptual representation of the current and future contribution of the four sectors to spatial structure for the Upper Columbia ESU.

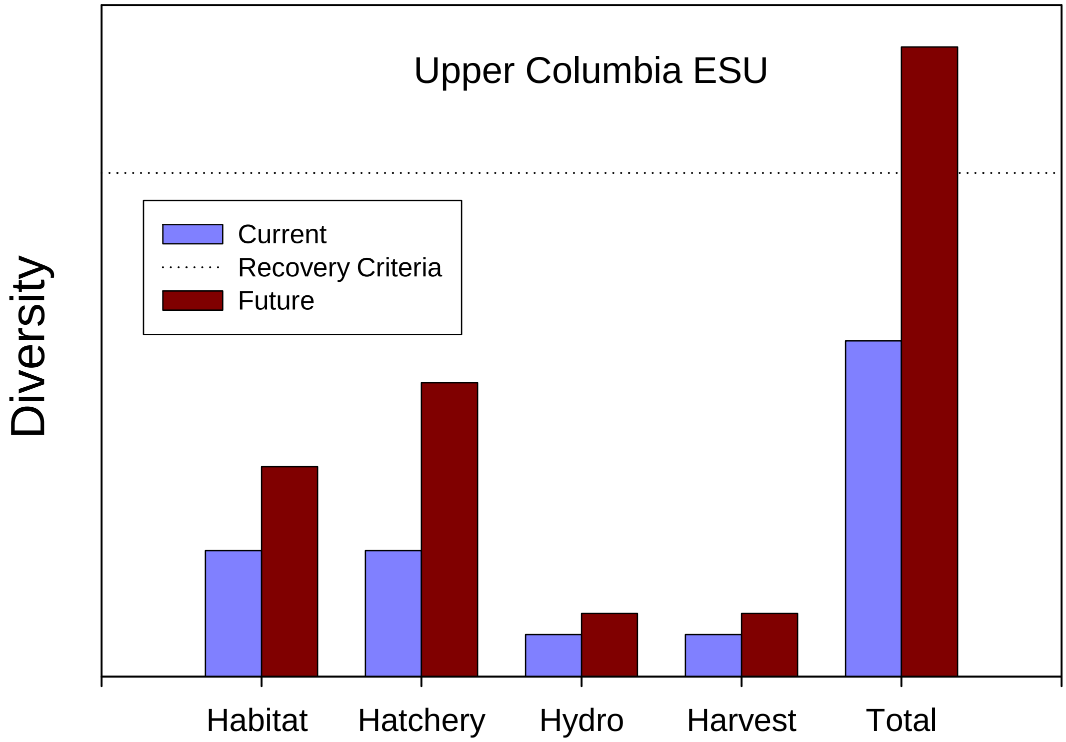


Figure 2. Contribution of different sectors to recovery of the diversity attributes for Viable Salmonid Populations of spring Chinook and steelhead in the Upper Columbia ESU. Units were intentionally left off the y-axis because diversity is not a quantitative attribute. Although the relative length of the bars might shift slightly for each population, the concept for each is the same throughout the ESU. Some gains can be made in the habitat sector, but recovery cannot be achieved without changes to hatchery operations that will decrease the risk to diversity.

Appendix J

All H Analyzer: Introduction

This appendix contains preliminary results from the May 11, 2005, All H Analysis Workshop. These preliminary results depict how population structure changes over time and across sectors. No changes in SARs were made in these scenarios. The J appendices are:

Appendix J.1. Methow Spring Chinook (Excel Spreadsheet)

Appendix J.2. Methow Summer Steelhead (Excel Spreadsheet)

Appendix J.3. Okanogan Summer Steelhead (Excel Spreadsheet)

Appendix J.4. Wenatchee Spring Chinook (Excel Spreadsheet)

Appendix J.5. Wenatchee Summer Steelhead (Excel Spreadsheet)

Appendix K1

Major and Representative Finding from Literature and Research on Economic Benefits to Restored Fisheries in the Pacific Northwest

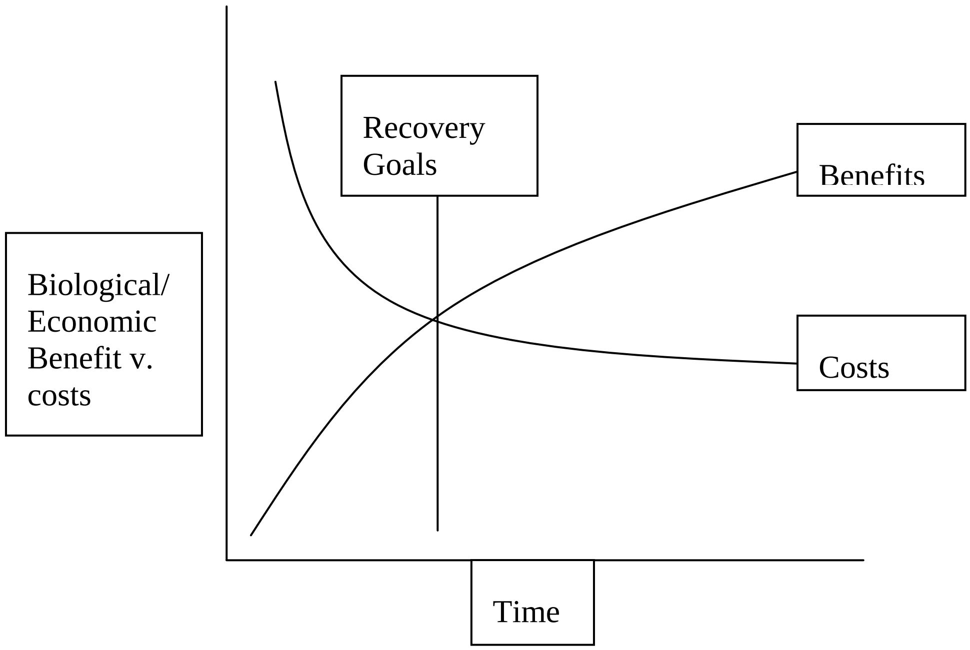


Figure 1. Benefits are amortized and describe how initial investments in salmon recovery's economic benefits accrue as initial recovery costs decline.

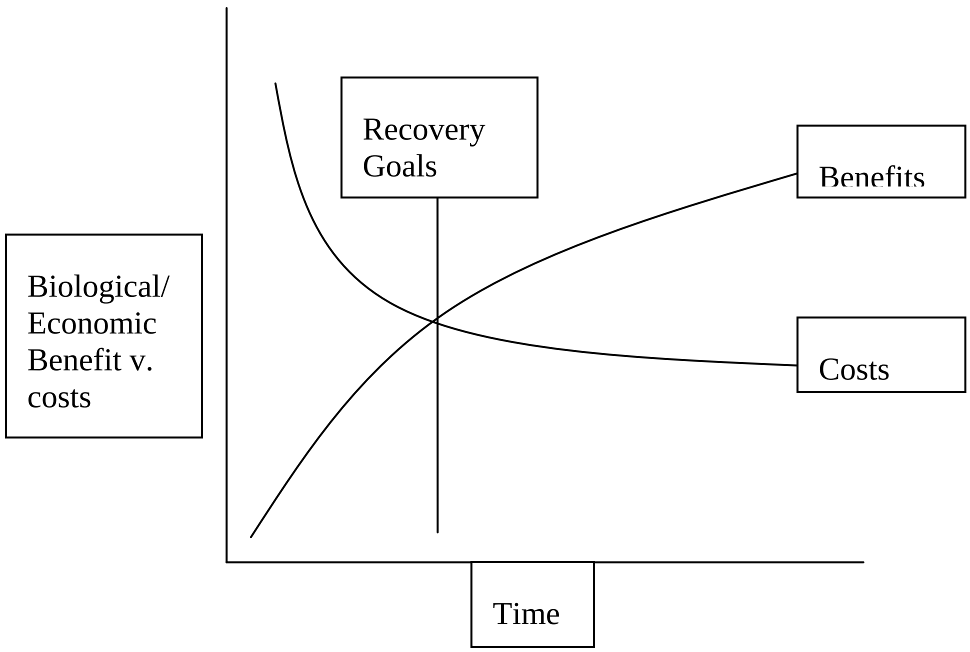
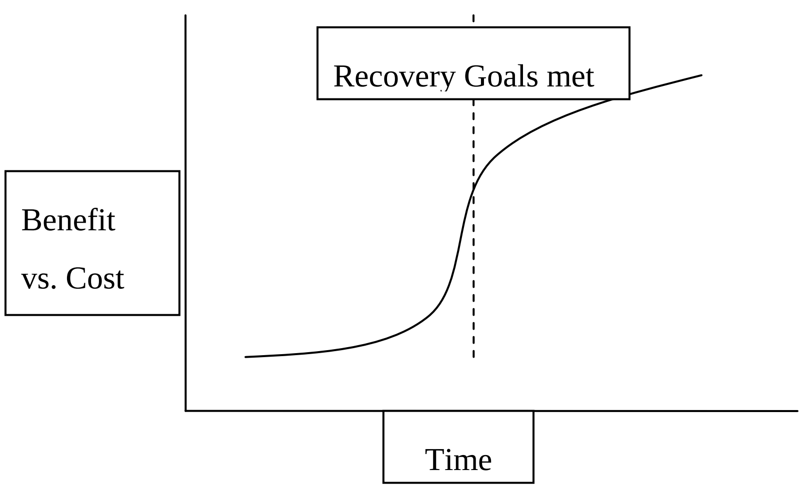


Figure 2: An informal benefit to cost ratio can be expressed in a simple graph showing how initially the benefit to cost ratio may be low (initial investment period) but as fish populations become stronger and recovery goals begin to be met, multiple benefits (beyond just "angling") accrue to the economy and the species at a higher rate.



The following sections on the economic benefits to recovery of a recreational salmon & steelhead fisheries in the Upper Columbia River basin has the primary objective of establishing best estimates of economic benefit based on available angler and landing data. Secondary objectives include highlights of significant research and a list of intangibles representing associated economic incentives and benefits to recreational salmon and steelhead fisheries recovery.

Estimates of Economic Benefits of Restored Salmon & Steelhead Fishing – Washington & Idaho Comparison

In deriving the most current and accurate estimates of economic benefits of restored salmon and steelhead fishing in the Upper Columbia River, we have incorporated multiple approaches. The first is to determine the potential economic impact to Washington State from the results of the comparative work done by Don C. Reading, of Ben Johnson Associates, on the potential economic impact of restored salmon and steelhead fishing in Idaho. Secondly, we used angler information to determine the economic impact specifically to the Upper Columbia River basin. Finally, we compared these estimates on the economic importance of salmonids in the Snake River Salmon Recovery Region which estimates 57 million dollars contributed annually to the local economy from angling associated expenditures. The Snake River region is similar in size and geography to the Upper Columbia, and thus, we believe the comparisons are reasonable.

For instance, in 2001, Washington state ranked 8th in the nation and ranked first in the Northwest in spending by sports anglers derived from 938,000 sports anglers fishing 12.8 million days, contributing **$854 million** that year to the state economy (USDI, 2003). This comports with estimates over multiple years from across the United States and corresponds with methods used and reported in pertinent literature and with the literature used and cited in this plan.

Table 1. Typical Expenditure Items: Angler Trip and Equipment Expenditures in the United States for 1996 (source: Texas Parks & Wildlife, 1996)

Expenditure Item	TOTAL
TRIP EXPENDITURES	
Food, Drink and Refreshments	$4,255,842,791
Lodging	$1,733,823,092

Public Transportation	$559,029,278
Private Transportation	$3,171,216,027
Boat Fuel	$1,339,584,467
Guide Fees, Pack Trip or Package Fees	$638,466,383
Public Land Use or Access Fees	$140,258,431
Private Land Use or Access Fees	$84,353,614
Boat Launching Fees	$201,377,081
Boat Mooring, Storage, Maintenance and Insurance	$1,398,154,895
Equipment Rental	$331,308,320
Bait (live, cut, prepared)	$1,084,661,194
Ice	$319,258,420
Heating and Cooking Fuel	$123,883,241
FISHING EQUIPMENT EXPENDITURES	
Rods, Reels, Poles and Rod Making Components	$2,331,835,635
Lines and Leaders	$490,917,008

Artificial Lures, Files, Baits and Dressing	$880,910,433
Hooks, Sinkers, Swivels, etc.	$376,671,950
Tackle Boxes	$128,193,348
Creels, Stringers, Fish Bags, Landing Nets and Gaff Hooks	$95,915,440
Minnow Traps, Seines and Bait Containers	$66,220,786
Depth Finders, Fish Finders and Other Electronic Fishing Devices	$395,926,970
Ice Fishing Equipment	$97,557,372
Other Fishing Equipment	$444,526,129
AUXILIARY PURCHASES FOR FISHING	
Camping Equipment	$501,711,047
Binoculars, Field Glasses, Telescopes, etc.	$46,757,879
Special Fishing Clothing, Foul Weather Gear, Boots, Waders, etc.	$312,636,188
SPECIAL EQUIPMENT PURCHASED FOR FISHING	
Bass Boat	$2,005,235,791
Other Motor Boat	$3,220,523,391

Canoe or Other Non-Motor Boat	$144,712,414
Boat Motor, Boat Trailer/Hitch or Other Boat Accessories	$981,703,104
Pickup, Camper, Van, Travel or Tent Trailer, Motor Home, House Trailer	$4,573,214,215
Cabin	$27,394,985
Trail Bike, Dune Buggy, 4x4 Vehicle, 4-Wheeler, Snowmobile	$1,129,232,231
Other Special Equipment Including Ice Chest	$746,301,786
OTHER EXPENDITURES	
Fishing License Fees	$519,060,780
Other Fees	$60,691,571
Owned or Leased Property	$2,340,344,488
Processing and Taxidermy Costs	$62,019,727
Books and Magazines	$169,546,449
Dues or Contributions to Organizations	$152,447,837
Other Purchases	$113,635,846
UNITED STATES TOTAL	**$37,797,062,032**

National Perspectives, local applicability

The national annual spending in the U.S., in 2001, by 35.2 million adult anglers, with approximately 626 million fishing days reported, amounting to **$37.8 billion** that year, with the average spending of about $1,100 per person per year (Texas Parks & Wildlife, ASA 2002). This amount closely approximates the national total of 34.1 million anglers (USDI, 2003). We note that this does not include the angler numbers from the combined "fishing and hunting" category and therefore consider this a conservative estimate.

Focusing on the data specific to salmon & steelhead in Washington (listed species in the Upper Columbia), of the 938,000 total anglers—freshwater and saltwater combined, a total of 367,000 fished for salmon and/or steelhead. The data report 156,000 steelhead anglers, and 211,000 salmon non tribal sport anglers respectively (USDI, 2003). We note that these estimates do not include any estimates of economic benefit from tribal fisheries, which unquestionably contribute to the state and local economy.

Of the 938,000 Washington State salmon and steelhead total anglers, 659,000 spent approximately 5.4 million angling days and $386 per trip with each trip lasting an average of 1.3 days (USDI 2003). However, total expenditures exceed $2,000 per fish harvested by including direct and indirect expenditures. Finally, because expenditures are incurred even when fish are not harvested, angling *trips*, whether fish are harvested or not, is the most appropriate metric in the economic equation and the final measure of economic benefit used in this plan.

Table 2. Freshwater anglers and days of fishing in Washington and Idaho, by type of fish: 2001 (table modified from USDI, 2003). (Note: WA state 2001 survey also has additional # anglers and # days attributed to saltwater salmon fishing which we did not include in the comparison to Idaho).

	WA	**ID**
# Anglers – steelhead	156,000	54,000
# Anglers – salmon	211,000	61,000
Total anglers	**367,000**	**115,000**
# Days – steelhead	2,483,000	475,000
# Days – salmon	2,908,000	448,000
Total Days	**5,391,000**	**923,000**

Table 3. Summary of Freshwater Fishing Trip & Equipment Expenditures in Washington, including National Averages, by U.S. Residents: 2001

Expenditure Type	**Amount (thousands of dollars)**		**Spenders (thousands)**		**Average per spender (dollars)**		**Average per angler (dollars)**	
ALL FRESHWATER	**WA**	**ID**	**WA**	**ID**	**WA**	**ID**	**WA**	**ID**
Total………………...	**310,668**	**164,261**	**668**	**398**	**465**	**412**	**463**	**391**
Food and lodging	83,020	53,463	516	325	161	165	126	129
Transportation	72,958	40,458	547	335	133	121	111	97
Other trip costs[1]	59,347	22,301	481	298	123	75	90	54
Equipment[2]	95,342	48,039	437	236	218	203	136	112

Note: These expenditures would be higher if additional expenditures from the "fishing and hunting" combined category and commercial non tribal and tribal fisheries were included.

[1] Other trip costs includes: Privilege and other fees (includes boat or equipment rental and fees for guides, pack trip (party and charter boats, etc.), public land use, and private land use; boating costs (includes boat launching, mooring, storage, maintenance, insurance, pump out fees and fuel); bait; Ice; and heating and cooking fuel.

[2] Equipment includes: Reels, rods, and rod making components; lines, hooks, sinkers, etc.; artificial lures & flies; creels, stringers, fish bags, landing nets, and gaff hooks; Minnow seines, traps, and bait containers; and other fishing equipment (includes electronic fishing devices; tackle boxes, ice fishing equipment, and others) modified from original USDI 2003 for Washington State.

Estimates of Economic Benefits of Restored Salmon & Steelhead Fishing – Snake River Basin & Upper Columbia Basin Comparison

To scale the potential economic benefit from national averages, to state and ultimately, to local assumptions, several economic analyses of salmon and steelhead fisheries for the Snake River Basin have been conducted in Idaho in recent years, and staff from the WDFW has reviewed these reports for use in estimating economic benefits for the Snake River Recovery Plan. We believe that these studies have reasonable applicability to the economics of fisheries in the Upper Columbia because of the similar geographical, river systems, size and comparable historic angler effort. The Idaho economic studies were paired with creel survey estimates of the amounts of angler effort and harvest in Idaho's salmon and steelhead fisheries and information for the Upper Columbia (1981-1999) has been provided by WDFW for context and comparison. Finally, we note that salmon and steelhead fisheries in the Upper Columbia in 2000-2004 have been near historical high levels and likely exceed the 1981-1999 average.

Direct expenditures and total economic value of Idaho's steelhead fisheries in 1992-93 were estimated at approximately $34.5 million and over $90 million, respectively (Reading 1996). These fisheries were responsible for approximately 2,700 jobs in the state as nearly 44,000 steelhead were harvested ($805 direct expenditures, $2045 total economic value, per harvested steelhead). In 2001, spring/summer Chinook fishing in Idaho contributed $46.1 million in direct expenditures and $89.9 million in total economic value to that state's economy (Ben Johnson and Assoc. 2003), with a harvest of 43,300 adult Chinook from 540,800 angler hours of effort ($887 direct expenditure, $2,076 total economic value, per Chinook salmon harvested). Just over 50% of the economic benefits accrued to river communities, with the remaining economic impact distributed over much of the rest of Idaho.

In Riggins, a salmon river community of about 400 people, the salmon fishery brought in about $10 million in total economic spending in two months and stimulated 23% of the town's annual sales. Riggins is similar in size to the towns of Riverside or Tonasket on the Okanogan River, Peshastin on the Wenatchee, the Entiat in total, Pateros on the mainstem Columbia River, and/or Winthrop on the Methow River. Direct expenditures alone accounted for 13% of Riggins annual sales, which compares to direct sales of 9.3% of the Riggins economy from agricultural and timber products (Ben Johnson and Assoc. 2003).

The most recent study in Idaho evaluated the potential economic benefits of salmon and steelhead fisheries if they were restored to sustainable, abundant and harvestable levels similar to those of the 1950s (Reading 2005). That study estimated that restored fisheries could contribute **$544.2** million per year of total economic value.

Using this method as a basis for estimating benefits to Washington State yields **$854 million per year of total economic value**. Localized estimates are reported below.

Table 4. Detailed economic value estimates of harvested salmon from the Upper Columbia based on 1981-1999. Estimates based on $1,065/harvest spring/summer Chinook direct expenditures and $2,076 per fish in total economic value from Idaho studies. (According to Reading 2005 these values could be increased by 3.9% to reflect 2004 dollars.

Subbasin or River Reach	**Year Reported**	**Landing Max/Min**	**Average # Salmon Landed**	**Direct Expenditures ($1065/fish)**	**Total economic value ($2076/fish)**
Chelan Lake	1990, 1993	22/12	17	$18,105	$**35,292**
Col. R. Upper		5678/4050	5107	$,438,955	$**10,602,132**
Entiat R.	1986, 1987	23/10	17	$18,105	$**35,292**
Icicle Cr.	1981-84	2063/35	699	$744,435	$**1,451,124**
Icicle R.	1996-1999	46	313	$333,345	$**649,788**
Lake Wenatchee	1984-85, 1987, 1990-93	6523/0	3426	$3,648,690	$**7,112,376**
McNary-Chief Joseph Dam	1981-1994	5916/414	3191	$3,648,690	$**6,624,516**
Methow R.	1987-88	0	0	$0	$**0**
Wenatchee R.	1984-86, 1988-94	1626/0	443	$471,795	$**919,668**

Table 5. Estimated economic values of harvested steelhead from the Upper Columbia based on 1981-1997. Estimates based on $805/steelhead direct expenditures and $2045 per fish in total economic value from Idaho studies (based on Reading's cost per fish estimates, 2005).

Subbasin or River Reach	Year Reported	Salmon Landing Year Av. Max/Min	Average # Salmon Landed	Direct Expenditures ($805/fish)	Total economic value ($2045/fish)
McNary to Hwy 12	1983-96	7099/107	2018	$1,624,490	$**4,126,810**
Hwy 12 to Priest Rapids - Col. R.	1983-96	5702/1510	3329	$2,679,845	$**6,807,805**
Above Priest Rapids Dam	1982-95	92/9	58	$46,690	$**118,610**
Priest Rapids Dam to Wanapum Dam	1996-97	21/12	17	$13,685	$**34,765**
Above Wanapum Dam	1982-95	337/0	94	$75,670	$**192,230**
Wanapum Dam to Rock Island Dam	1996-97	26/6	16	$12,880	$**32,720**
Above Rock Island Dam	1982-1995	1030/57	418	$336,490	$**854,810**
Rock Island Dam to Rocky Reach Dam	1996-97	308/78	193	$155,365	$**394,685**
Above Rocky Reach Dam	1982-95	882/47	275	$221,375	$**562,375**

Rocky Reach Dam to Wells Dam	1996-97	417/97	257	$205,885	**$525,565**
Above Wells Dam	1982-95	4972/258	1759	$1,415,995	**$3,597,155**
Wells Dam to Chief Joseph Dam	1996-97	798/231	515	$414,575	**$1,053,175**
Above Bonneville	1980-81	4808/3478	4143	$3,335,115	**$8,472,435**
Above McNary to Priest Rapids	1982		4669	$3,758,545	**$9,548,105**
Entiat River	1980-97	183/0	81	$65,205	**$165,645**
Methow River	1980-97	5824/166	1764	$1,420,020	**$3,607,380**
Okanagan River	1980-97	1193/2	265	$213,325	**$541,925**
Similkameen River	1980-97	746/0	167	$134,435	**$341,515**
Icicle Creek	1980-97	62/0	11	$8,855	**$22,495**
Wenatchee River	1980-97	1661/95	591	$475,755	**$1,208,595**

List of Intangible Benefits from Recovery of Listed Species:

In addition to the annual direct revenue and expenditures anticipated under a recovered Upper Columbia future, intangible benefits including:

1. **Intrinsic Quality of Life:** People like living and working in a healthy environment over a degraded one. For example, high value development occurs near parks, rivers, view-scapes etc. and property values in wilderness areas are higher than in areas with urban blight, industrial parks, denuded riparian areas etc.

2. **Reduced Regulatory Environment:** In addition to the quantified cost savings from reduced environmental review, permitting, assessments etc, absent ESA people and local governments can devote valuable time to other priorities such as improving public school systems, parks, public safety etc.

3. **Public and Civic Pride**: Numerous examples across the world, County and here in Washington state, exist. Take the City of Tonasket for example. The entire City Counsel from the mayor to the police administrator view salmon recovery as a source of pride and accomplishment. A ribbon cutting ceremony is scheduled for September 2005 to inaugurate a "Salmon Viewing and Information Platform" on the Okanogan River. The City estimates 500-600 people will attend.

4. **Visitors and Conventions:** In addition to the quantified benefits from increased tourism directly attributed to fishing etc., multidisciplinary and non-related conferences, conventions and overall visitation is higher of (and reported as a higher quality experience) when held in areas with high qualify natural resources. Compare Detroit Michigan to Aspen Colorado as a destination for conference-goers, tourists etc.

5. **Pubic/Private Partnerships:** The City of Wenatchee and East Wenatchee is a good example. The relationships formed between the public and say, the PUDs for example often converge around natural resources, their preservation and their celebration with parks, nature trails etc.

6. **Ecological Context:** Healthy fish populations have a direct linkage to other species and to the ecological integrity of river systems. A recent study shows that 137 species of birds, mammals, amphibians and reptiles are scavengers or predators of salmon, or have other attributes of their life cycle linked to the presence of salmon and/or steelhead populations (e.g., bear, cougar, birds, including certain river clam species) (Cederholm et al. 2000).

USDI 2001 Survey Highlights:

- 34.1 million U.S. residents 16 years and older fished.
- Sportspersons spent a total of $36 billion on fishing, and $14 billion on items used for both hunting and fishing.
- In 2001, 16% of the U.S. population 16 years old and older spent an average of 16 days fishing.
- Comparing results of the 2001 Survey and the 1996 Survey reveals that the number of all anglers declined 3% and overall fishing expenditures fell 17% - a 16% drop in trip and a 22% drop in equipment expenditures.
- From 1991 to 2001, the number of all anglers declined 4% and expenditures increased 14%.

- Activities in Idaho by U.S. residents: 416,000 anglers, 4 million days of fishing, Total expenditures $310,872,000. Activities in Oregon by U.S. residents: 687,000 anglers, 8.7 million days of fishing, total expenditures $601,780,000.

American Sportfishing Association, December 2002, Demographics & Economic Impact report:

- Sportfishing in 2001 accounted for $116 billion in the country's economy
- The data is derived from the U.S. Census Bureau survey of 30,000 American sportspersons, performed every 5 years since 1955
- The direct and indirect economic impacts demonstrated in the Pacific Northwest show that estimated economic impacts for Washington State exceed those estimated for either states of Idaho or Oregon.

WDFW, December 2002:

- The Columbia River spring Chinook fishery, alone, is estimated to generate a $15.4 million economic impact, according to the Northwest Sportfishing Association.

Don C. Reading 2005:

- This study utilized data on angling effort and fish abundance from the 1950s and early 2000s. Fisheries in the 1950s were exclusively derived from wild populations, whereas fisheries in the 2000s were made up of both wild and hatchery stocks.
- Total angler trips of 458,000, consist of an estimated 177,000 steelhead trips, 271,000 spring/summer Chinook, and 10,000 for fall Chinook (based on 2001 and 2002-2003 numbers multiplied by a 14% increase in effort).
- From the 1992-93 steelhead survey, anglers averaged 2 days per trip.
- According to Reading, under current Idaho regulations only salmon and steelhead of hatchery origin may be harvested. However, both wild and hatchery fish contribute numbers that influence angling effort and success.

Steven Edwards, November 1990, An Economics guide to Allocation of Fish Stocks between Commercial and Recreational Fisheries:

- To optimize the economic value of fish used for food and sport is one of the primary objectives of the Magnuson Fishery Conservation and Management Act.
- In the sport fishing sector, net economic value derived from direct effects "spread across primary and intermediate inputs from the entire economy, including labor, capital, and privately owned natural resources such as land and caught-fish. Also, often when recreational fishing is being evaluated, consumption of goods and services which are unrelated to fishing trips, such as meals and souvenirs, are

"direct" effects even when recreational fishing comprises only part of a vacation or trip.

- "Indirect" effects arise only after increased revenues and income are represented in the economy. Some examples include labor, boats, tackle, gasoline, rentals, ice, and other equipment.
- "Attributing all consumer surplus of sport fishing to the sport-caught fish would overestimate the value of sport-caught fish to anglers because other factors, including being outdoors and camaraderie, are also part of the fishing experience (Dawson & Wilkins 1981)

Table 6. Adapted from: Demographics & Economic Impact, American Sportfish Association, December 2002

	Retail Sales	Output	Wages & Salaries	Jobs	Sales/Fuel Taxes	State Income Tax	Federal Income Tax
Washington – Freshwater fishing	**$561,058,124**	**$994,368,756**	**$252,259,180**	**9536**	**$42,094,299**	**$0**	**$42,433,449**
Idaho – Freshwater fishing	$396,364,348	$657,461,318	$151,598,738	7,504	$22,697,010	$6,581,745	$15,254,668
Oregon – Freshwater fishing	$561,850,608	$991,779,210	#227,163,400	9,758	$15,339,886	$17,685,218	$34,902,374
National Total	$41,528,003,337	$116,064,518,700	$30,108,800,941	1,068,046	$1,913,373,871	$470,239,851	$4,885,011,975
WA – Saltwater fishing	$348,172,741	$617,214,306	$154,429,160	6,102	$25,074,428	$0	$25,229,231
Oregon – Saltwater fishing	$160,015,148	$289,176,767	$66,003,208	2,842	$1,970,044	$5136,583	$10,121,780
National Total	$11,318,249,621	$31,085,904,333	$8,138,400,181	296,898	$493,262,762	$85,456,389	$1,357,945,118
WA – All fishing	$932,431,598	$1,656,548,494	$417,164,967	15,965	$67,185,935	$0	$69,620,399
OR – All fishing	$733,412,813	$1,304,519,242	$298,749,523	12,776	$17,309,930	$23,274,649	$46,063,809
Idaho – All fishing	$409,453,451	$681,065,982	$157,402,757	7,773	$22,889,647	$6.846,807	$15,856,844
National – All fishing	$41,528,003,337	$116,064,518,700	$30,108,800,941	1,068,046	$1,913,373,871	$470,239,851	$4,885,011,975

Note: The U.S. total does not equal the sum of state data as economic activity across state borders are not included in the state totals, in addition to other factors.

Note: The expenditures reported are greater than those by the U.S. Fish and Wildlife Service. Sportsmen often attributed purchases to both fishing and hunting (especially vehicles and big-ticket items). These items were not included in the Service's fishing expenditure estimates. Such items were included above by prorating each item's cost based on each respondent's total days of hunting and fishing activity.

Analysis performed by Southwick Associates.

Note: The original tables have been modified to show only a summary of data pertinent to WA, OR, ID, and national estimates.

Dollar amounts will be adjusted using a consumer price index to 2005 $ estimates.

Appendix K2

Agricultural Impacts

NCW 2002 Wheat, Oats, Barley and Hay Sales
Source: 2002 Census of Agriculture

Compiled by R. Faini, WSU Extension, Chelan County

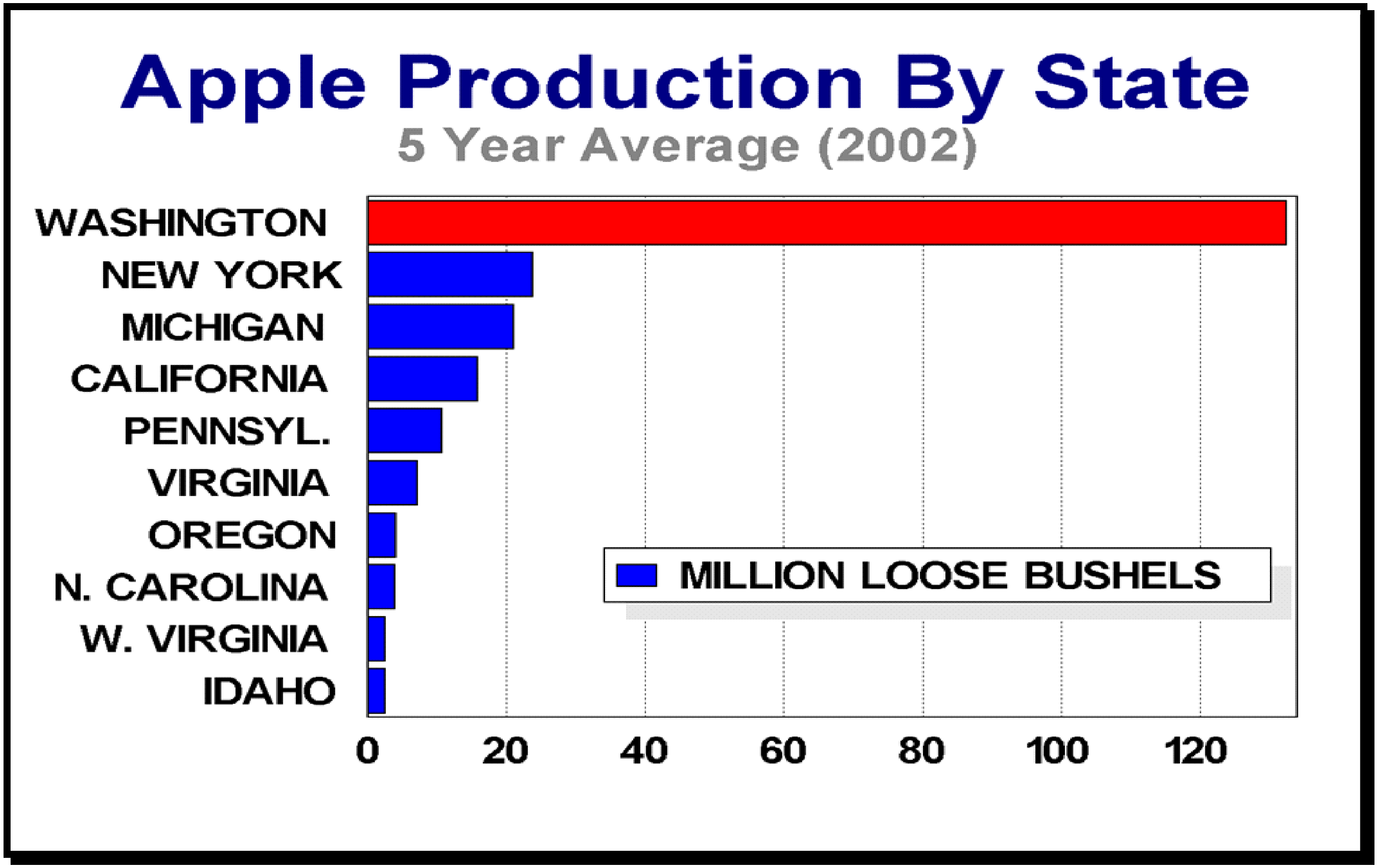
All Wheat	Acres	Yield (bu)	value
Douglas	184829	7122466	@3.25 = $23,148,014
Okanogan	9763	452682	= $1,471,266
			TOTAL VALUE: $24,619,230

All Oats	Acres	Yield (bu)	
Douglas	1632	65535	@2.00 = $131070.
Okanogan	2011	13933	= $27866
			TOTAL VALUE: $158,936

All Barley	Acres	Yield (bu)	
Douglas	3993	147327	@2.00 = $294654
Okanogan	318	11700	= $23400
			TOTAL VALUE: $318,054

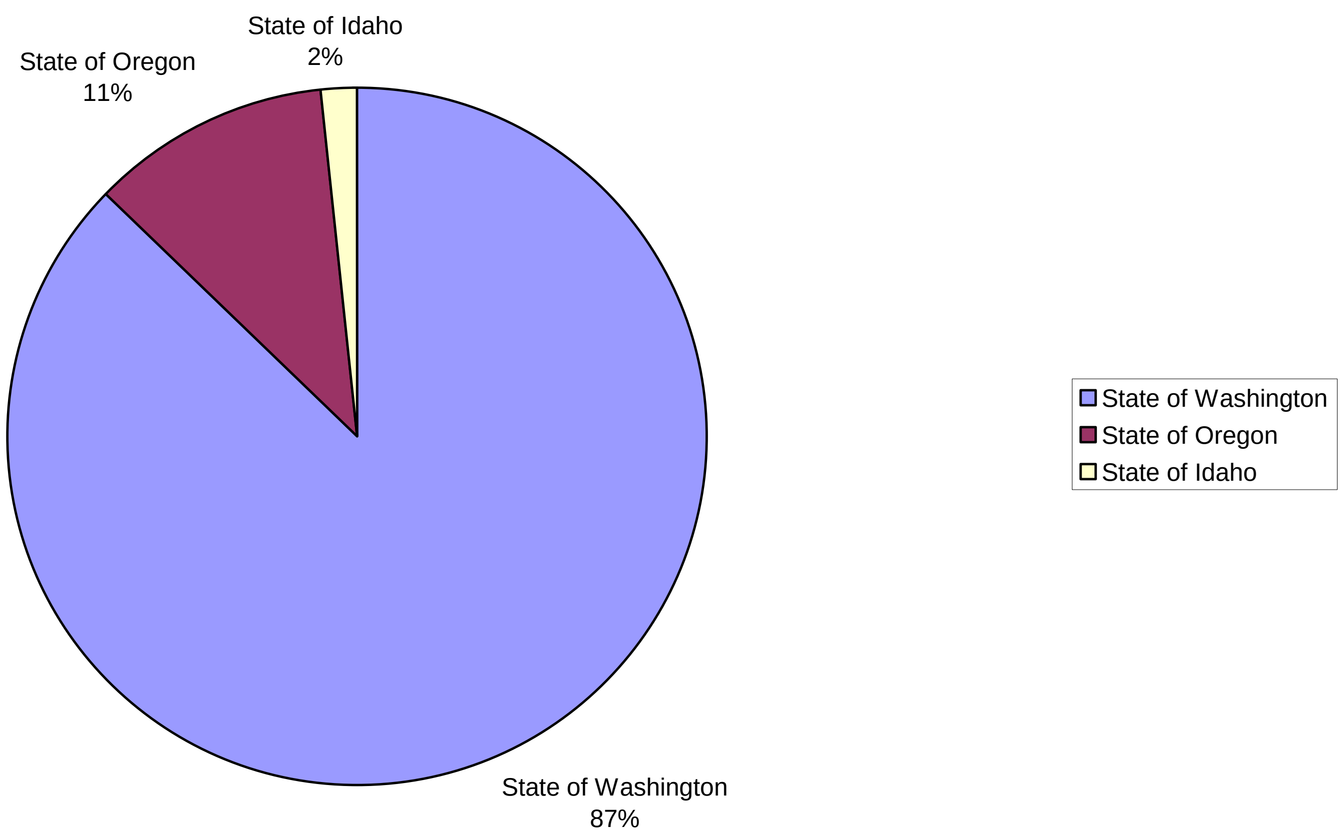
All Hay	Acres	tons	Value
Chelan	1823	3218	@120 = $386,160
Douglas	3654	16500	= $1,980,000
Okanogan	34138	85089	= $10,210,680
			TOTAL VALUE: $12,576,840

Totals Acres = 242,161
Value = $37,673,060



Source: Tim J. Smith

Chart 1 - Total Farmgate Values - Northwest States



Source: William S. Jensen, 2004

Tree Fruit Industry Impact on the North Central Region of Washington State

INCOME IMPACT RESULTS:

Direct and Indirect Purchases by Business Sectors	$154,473,468
Total Household Income of Owners and Employees	444,297,553
Local Business Sectors Impacted by Household Expenditures	199,728,201
Total Economic Income Impact to Region	$798,499,222

Local Sectors Impacted by Household Expenditures:

IMPLAN SECTOR	IMPLAN #	% of Local Consumer Expend.	Local $ Impact
Housing	mix	8.02	$28,102,108
Retail Trade	mix	3.63	$12,719,533
Health Care	mix	14.69	$51,473,812
Eating & Drinking Places	481	4.40	$15,417,616
Food Processing	mix	2.17	$7,603,688
Wholesale Trade	mix	3.47	$12,158,892
Utilities	mix	2.02	$7,078,087
Insurance	428	0.55	$1,927,202
Personal Services	mix	1.64	$5,746,566
Communications	mix	0.72	$2,522,883
Transportation Services	mix	1.34	$4,695,365
Motor Vehicle Operation	mix	4.80	$16,819,217
Banking/Credit Services	mix	2.53	$8,865,129
State/Local Services	mix	1.06	$3,714,244
Petroleum Products	mix	0.00	$0
Education	mix	0.83	$2,908,323
Recreational Activities	mix	1.26	$4,415,044
Hotels & Lodging	479	0.61	$2,137,442
Investments	426	0.35	$1,226,401
Civic/Religious Assoc.	mix	0.35	$1,226,401
Fabrics/Apparel	mix	0.01	$35,040
Publications/Paper	mix	0.04	$140,160
Business/Labor Assoc.	mix	0.35	$1,226,401
Household Furnishings	mix	0.61	$2,137,442
Household Industry	494	0.22	$770,881
U.S. Postal Service	398	0.08	$280,320
Other	mix	1.26	$4,415,044
Non-Local Purchases	mix	43.00	$150,672,152
Total Purchases		100.00	$350,400,353

ESTIMATED AVERAGE ANNUAL EMPLOYMENT **39,925**
(Assumes annual average income of $20,000)

Source: William S. Jensen, 2004

Tree Fruit Water Usage Calculations
Calculating the amount of water used by 1 acre of fruit trees per season
for cool, average and warm weather conditions in NCW.

	Water Use Per Day				**Water Use Per Season**		
	Acre Inches Used				Acre Inches Used		
	Cool	Average	Warm	days	**Cool**	**Average**	**Warm**
Early April	0.04	0.05	0.05	15	0.6	0.75	0.75
Late April	0.08	0.09	0.1	15	1.2	1.35	1.5
Early May	0.1	0.14	0.2	15	1.5	2.1	3
Late May	0.17	0.18	0.25	15	2.55	2.7	3.75
Early June	0.2	0.23	0.26	15	3	3.45	3.9
Late June	0.25	0.29	0.33	15	3.75	4.35	4.95
July	0.28	0.33	0.38	30	4.2	4.95	5.7
Early Aug	0.27	0.31	0.35	15	4.05	4.65	5.25
Late Aug	0.22	0.24	0.3	15	3.3	3.6	4.5
Early Sept	0.15	0.19	0.25	15	2.25	2.85	3.75
Late Sept	0.08	0.1	0.15	15	1.2	1.5	2.25
October	0.05	0.08	0.1	30	0.75	1.2	1.5
(Table calculations from Tim Smith, WSU Extension)							
	Total Season Use: Acre Inches				**28.35**	**33.45**	**40.8**

Converting ANNUAL water usage from "Acre inches" to "cfs"

A) 1 acre of land covered by 1 inch of water = 3630 cubic feet of water

B) Since there are 3630 cubic ft in 1 acre inch And 31,536,000 seconds in a year

C) Per acre we divide 3630 cubic ft by 31,536,000 seconds.= 0.0001151 cubic ft/sec/A for each acre inch applied.

D) To factor in irrigation inefficiencies, which range from 15% - 40%, additional water needed is calculated here:

* 15% = 1.15 x 0.0001151 ft3/sec = 0.0001323 ft3/sec per acre each year

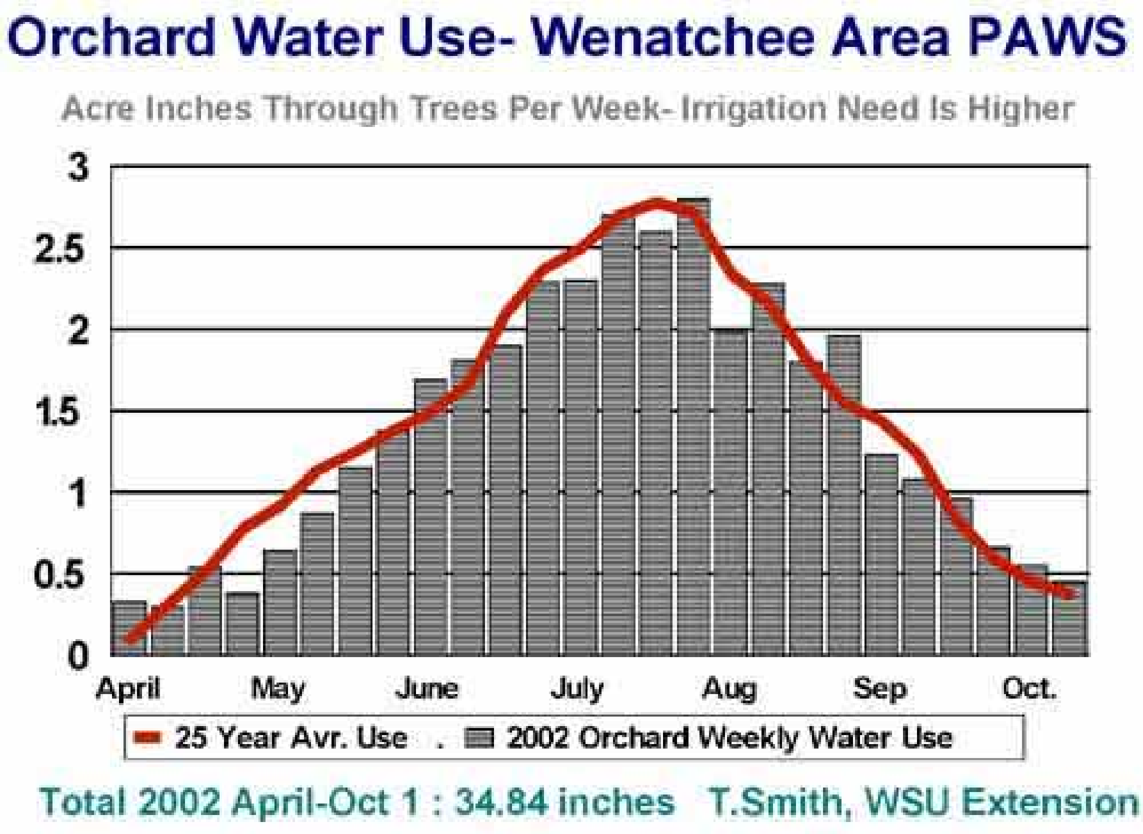
* 40% = 1.40 x 0.0001151 ft3/sec = 0.0001611 ft3/sec per acre each year[1]

E) For the average use noted above (33.45 Acre inches), **all nut & tree fruit acreage** in NCW (77,459) would use only 342.8 to 417.4 cfs per season from ALL RIVERS COMBINED in Chelan, Douglas and Okanogan Counties

[1] Calculations: A - D, Robert Simmons, WSU Water Quality Specialist

R. Faini, Director, WSU Extension Chelan County

Sources: T.J. Smith, R. Simmons, and R. Faini, 2006, 1968-1998


Orchard Water Use- Wenatchee Area PAWS
Acre Inches Through Trees Per Week- Irrigation Need Is Higher
3
2.5
2
1.5
1
0.5
0
April
May
June
July
Aug
Sep
Oct.
25 Year Avr. Use
2002 Orchard Weekly Water Use
Total 2002 April-Oct 1 : 34.84 inches T.Smith, WSU Extension

Tree Fruit Water Usage Calculations

Calculating the amount of water needed to irrigate 10,000 Acres
Showing Acre Feet, CFS and Average Streamflow
(Reference Table on p.5 for foundation of numbers used here.)

	Water Use Per day[1]	**CFS Needed***	**Average streamflow**
	Acre ft on 10,000 A, adding an inefficiency of 30% to the **Average** use	to Supply 10,000 Acres During Season	Wenatchee River at Monitor, WA[2] 1962-2004, in ft3/sec
Early April	54.2	27.31	
Late April	97.5	49.16	April: **4002 cfs**
Early May	151.7	76.47	
Late May	195.0	98.31	May**: 8004 cfs**
Early June	249.2	125.62	
Late June	314.2	158.39	June**: 8969 cfs**
July	357.5	180.24	July: **4440 cfs**
Early Aug	335.8	169.32	
Late Aug	260.0	131.08	August: **1495 cfs**
Early Sept	205.8	103.77	
Late Sept	108.3	54.62	September: **820 cfs**
October	86.7	43.69	October: **1091 cfs**

Table Calculations by Robert Simmons, WSU Water Quality Specialist

* A) 1 acre of land covered by 1 inch of water = 3630 cubic feet of water
*B) Since there are 3630 cubic ft in 1 acre inch and 86,400 seconds per day
*C) Per 10,000 acres we mulitply # Acre In used by 3630 cubic ft and divide by 86,400 seconds to get CFS Needed

[1] Multiply the Acre feet in this column by 12 to get Acre Inches
[2] Number shown is **after all prior depletions** (including domestic use and irrigation)
Source: USBR

R. Faini, Director
WSU Extension Chelan County

References

Faini, R.J. 2006. 2002 NCW Wheat, oats, barley and hay sales. 2002 Census of Agriculture. Chelan County, WA.

Faini, R.J., Simmons, R. and Smith, T.J. 2006, 1968-1998. Tree fruit water usage calculations: Calculating the amount of water needed to irrigate 10,000 acres. WSU Extenstion.

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Appendix L

Example of Prioritizing and Sequencing Recovery Actions in the Upper Columbia Region

INTRODUCTION

This appendix provides an example of implementing the framework for prioritizing and sequencing recovery actions in the Upper Columbia Basin. The framework is science and socio-economically based. The framework seeks to categorize projects based on multiple objectives and characteristics and establish a general model for selecting and implementing projects that will lead to recovery of spring Chinook, steelhead, and bull trout.

SELECTION OF ACTIONS

The framework is organized into four general tiers of priority as depicted in Figure 1**:**

I. Higher biological benefit; lower cost; higher feasibility

II. Higher biological benefit; higher cost; lower feasibility

III. Lower biological benefit; lower cost; higher feasibility

IV. Lower biological benefit; higher cost; lower feasibility

Projects that fall under Tier I would be implemented before projects.

Steps

1. The first step in prioritizing the suite of recommended strategies would be to assign a qualitative ranking of the biological benefit to each strategy (Table 1). This ranking would be based on how well each project addresses the VSP parameters.

2. The second step in prioritizing projects is to qualitatively rank the feasibility of the projects (Tables 1 and 2; Figure 2). Criteria used for ranking could range from input from professionals (e.g., biologist, engineers, etc.) and other stakeholders (e.g., land owner) to an in-depth feasibility study. It is important to define what “feasibility” means. In Table 2, we suggest some criteria that could be used, such as *time of implementation* and acceptance of the various projects by *local stakeholders* and *government*. As previously mentioned, the definition of feasibility should be evaluated for each subbasin within the Upper Columbia region.

3. Third, projects should then be ranked based on cost (Table 1; Figure 2). Various methods can be used to determine cost (eventually this would need solid information based on the feasibility study before a project is proposed for funding), but can at first be qualitatively assessed (i.e., order of magnitude). For example, building a storage reservoir to boost flows would cost more than water conservation measures.

After projects are ranked on feasibility and cost, they can then be compared to biological benefit (Figure 3). Those projects that show the least cost and are relatively highly ranked on feasibility and have high biological benefit will appear in tier I (Figure 1).

The highest priority projects would be grouped in the tier with lowest cost, highest feasibility and biological benefit; the second highest priority would be lower cost, moderate to high feasibility and high biological benefit, etc. (Table 3).

It is not the intent of this exercise to suggest final prioritization through the example below, since this would need to be coordinated with all stakeholders.

Table 1 Example table for ranking biological benefit, feasibility, and relative cost for actions suggested within the action class of “floodplain reconnection/restoration”

		Actions				
		Create diverse channel patterns	*Dike setback (where feasible)*	*Increase flood-prone areas (where feasible)*	*Restore/ reconnect floodplains*	*Decommission/ relocate roads (where feasible)*
Variable	**Rank**					
	1					
	1.5					
Biological Benefit	2					
	2.5					
	3		x	x		x
	3.5	x			x	
	1					
	1.5			x		
Feasibility	2	x	x			x
	2.5				x	
	3					
	3.5					

	1					
	1.5	x	x			
Relative cost	2			x	x	
	2.5					
	3					x
	3.5					

Note: Feasibility values are from Table 2. Relative cost values are inverted on the "x" axis (i.e., higher the value, the lower the cost; Figure 2). This is necessary so the tiers are in accord, e.g., low cost and high feasibility are in the same tier.

Table 2 Example of a matrix of criteria for defining feasibility

Criteria						
Action	Strategy #	Time to implement[1]	"Constructability"	Acceptance by local govt.	Acceptance from local stakeholders	Avg. score
Create diverse channel patterns	1	2	2.8	2	2	2.2
Dike setback (where feasible)	2	2	2.5	1.8	1.5	1.9
Increase flood-prone areas (where feasible)	3	1	2	1.5	1	1.4
Restore/reconnect floodplains	4	2	2.5	2.5	2.5	2.4
Decommission/relocate roads (where feasible)	5	3	3	1.5	1.5	2.3

[1]Values for time to implement are 1 = > 10 years; 2 = 5-10 years; 3 = < 5 years

Relative numbering: 1=low, 3=high

Table 3 Suggested prioritization of actions based on Figures 3 and 4

Action	Number (from graphs)	Tier
Increase flood-prone areas (where feasible)	3	**I**
Decommission/relocate roads (where feasible)	4	**I**
Create diverse channel patterns	1	**II**
Dike setback (where feasible)	2	**II**

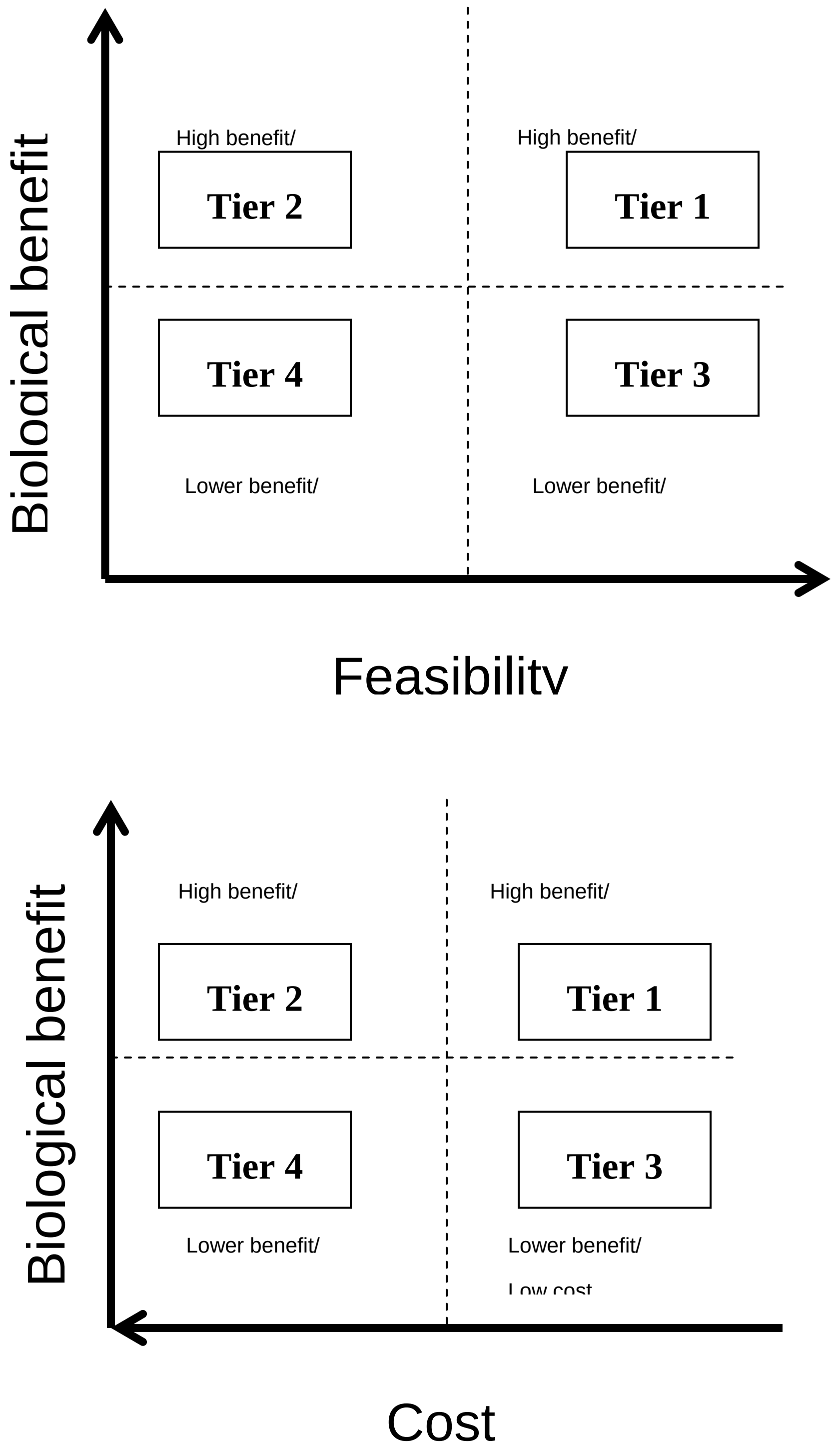

Figure 1 Comparison and prioritization categories.

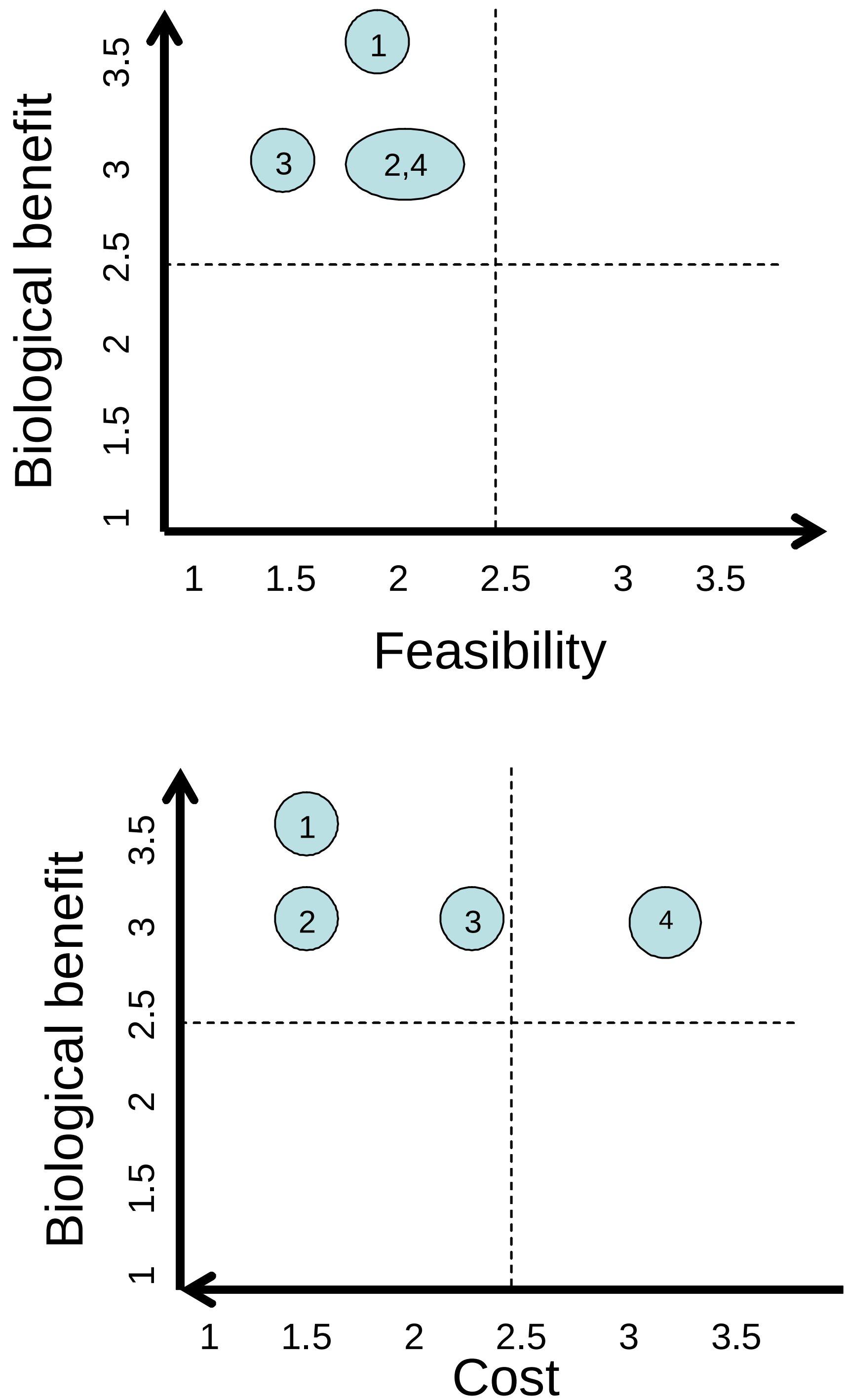

Figure 2 Individual category results (example) from matrix exercise.

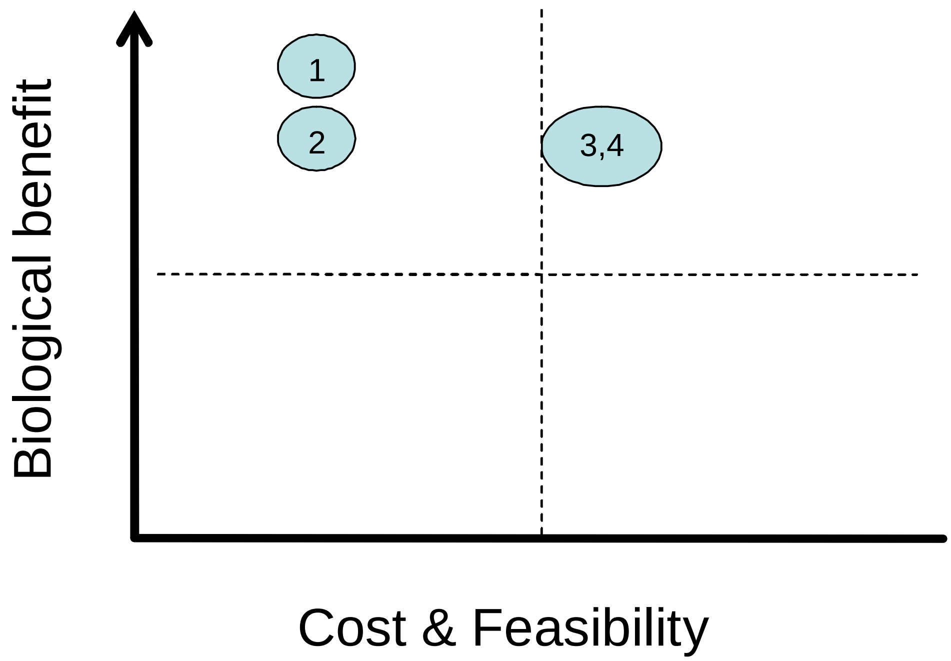

Figure 3 Relative cost and feasibility compared to biological benefit.

Id	Project Name	Status	Subbasin	Assessment Unit	Ecological Concern	2014	2015	2016	2017	2018	2019	2020	2022	Budget
17058	CCT Omak Creek Riparian Habitat Concept	Conceptual	Okanogan		4 Riparian Condition - Riparian Vegitation									$1,200,000.00
16285	CCT Aeneas Creek Spawning Development Concept	Completed	Okanogan		6 Channel Structure and Form - Bed and Channel Form									$100,000.00
16976	CCT Aeneas Creek Acquisition of 138 Acres	Completed	Okanogan		5 Peripheral and Transitional Habitats - Floodplain Condition									$545,000.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury									$175,000.00
17747	CCT Aeneas Creek Acquisition of 20 Acres	Completed	Okanogan		5 Peripheral and Transitional Habitats - Floodplain Condition									$56,000.00
16293	CCT Antoine Creek Diversion and Passage (2)	Completed	Okanogan	Antoine Creek from confluence with the Okanogan River to Rock Chute (RM 0 - 0.89)	1 Habitat Quantity - Anthropogenic Barriers	$200,000.00								$200,000.00
17063	CCT Antoine Creek Instream Flow Acquistions Concept	Active	Okanogan	Antoine Creek from confluence with the Okanogan River to Rock Chute (RM 0 - 0.89)	9 Water Quantity - Decreased Water Quantity			$2,000,000.00						$2,000,000.00
17064	CCT Antoine Creek Protection Concept	Active	Okanogan	Antoine Creek from confluence with the Okanogan River to Rock Chute (RM 0 - 0.89)	6 Channel Structure and Form - Bed and Channel Form			$5,000,000.00						$5,000,000.00
18892	CTT Antoine Creek Culvert Replacement	Completed	Okanogan	Antoine Creek from confluence with the Okanogan River to Rock Chute (RM 0 - 0.89)	1 Habitat Quantity - Anthropogenic Barriers	$40,000.00								$40,000.00
13254	CCT Antoine Creek Culvert Replacement	Completed	Okanogan	Antoine Creek from the Rock Chute to Fancher Dam (RM0.89 -11.9)	1 Habitat Quantity - Anthropogenic Barriers									$50,950.00
29722	CCFEG Ames - Mill Creek FFFPP	Active	Okanogan	Antoine Creek from the Rock Chute to Fancher Dam (RM0.89 -11.9)		$87,500.00								$87,500.00
13278	OCD Bonaparte Creek Livestock Exclusion	Completed	Okanogan		7 Sediment Conditions - Increased Sediment Quantity									$25,578.00
16909	CCT Bonaparte Creek Realignment Project	Completed	Okanogan		6 Channel Structure and Form - Bed and Channel Form									$120,000.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury									$175,000.00
13255	CCT McIntyre Dam Fish Passage	Completed	Okanogan	Canada Mainstem, Lakes and Tributaries	1 Habitat Quantity - Anthropogenic Barriers									$1,770,055.00
13256	CCT Okanogan River Restoration Initative (ORRI) Phase I & II	Completed	Okanogan	Canada Mainstem, Lakes and Tributaries										$1,100,000.00
17763	CCT Vaseux Creek Evaluation	Completed	Okanogan	Canada Mainstem, Lakes and Tributaries										$25,000.00
17765	CCT Lower Shuttleworth Creek Instream Flow Concept	Completed	Okanogan	Canada Mainstem, Lakes and Tributaries		$35,000.00								$35,000.00
17771	CCT Skaha Lake Barrier Concept	Conceptual	Okanogan	Canada Mainstem, Lakes and Tributaries										
17772	CCT Upper Shingle Creek Concept	Conceptual	Okanogan	Canada Mainstem, Lakes and Tributaries										
17775	CCT Lower Shingle Creek Barrier Concept	Completed	Okanogan	Canada Mainstem, Lakes and Tributaries										
17778	CCT Vaseux Creek Irrigation Diversions and Instream Flow Concepts	Conceptual	Okanogan	Canada Mainstem, Lakes and Tributaries										
17780	CCT Okanogan River in Canada Channel Structure and Form Concept	Conceptual	Okanogan	Canada Mainstem, Lakes and Tributaries										
17782	CCT Okanogan Lake Barriers Concept	Conceptual	Okanogan	Canada Mainstem, Lakes and Tributaries										
17783	CCT Ellis Creek Barriers Concept	Conceptual	Okanogan	Canada Mainstem, Lakes and Tributaries										
17784	CCT Lower Shuttleworth Creek Barriers Concept	Completed	Okanogan	Canada Mainstem, Lakes and Tributaries										
17790	CCT Vaseux Creek Barriers Concept	Conceptual	Okanogan	Canada Mainstem, Lakes and Tributaries										
17792	CCT Inkaneep Creek Barriers Concept	Conceptual	Okanogan	Canada Mainstem, Lakes and Tributaries										
17061	OCD Johnson Creek Riparian Planting Concept	Completed	Okanogan		4 Riparian Condition - Riparian Vegitation									$8,450.00
18667	TU-WWP: Johnson Creek Barrier Passage Projects	Dormant	Okanogan		1 Habitat Quantity - Anthropogenic Barriers	$195,000.00								$195,000.00
11008	CCT Loup Loup Creek Culverts	Completed	Okanogan	Loup-Loup Creek	1 Habitat Quantity - Anthropogenic Barriers									$636,237.00
17050	OCD Loup Loup Sediment Reduction Identification and Implementation Concept	Conceptual	Okanogan	Loup-Loup Creek	7 Sediment Conditions - Increased Sediment Quantity									$210,000.00
17055	CCT Loup Loup Water Lease	Active	Okanogan	Loup-Loup Creek	9 Water Quantity - Decreased Water Quantity								$300,000.00	$300,000.00
17081	CCT Loup Loup Acquisition 4.01 Acres	Completed	Okanogan	Loup-Loup Creek	5 Peripheral and Transitional Habitats - Floodplain Condition									$65,000.00
17788	CCT Loup Loup Creek Instream Flow Concept	Conceptual	Okanogan	Loup-Loup Creek	9 Water Quantity - Decreased Water Quantity									
16280	CCT Okanogan River BOR Side Channel Concept	Conceptual	Okanogan	Lower Middle Okanogan (Salmon Creek to Siwash Creek)	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$140,000.00
16948	CCT Okanogan River Riverside Acquisition 37.35 Acres	Completed	Okanogan	Lower Middle Okanogan (Salmon Creek to Siwash Creek)	8 Water Quality - Temperature									$125,000.00
16978	CCT Okanogan River Acquisition 72 Acres	Completed	Okanogan	Lower Middle Okanogan (Salmon Creek to Siwash Creek)	5 Peripheral and Transitional Habitats - Floodplain Condition									$900,000.00
17038	OCD Okanogan River Riparian Habitat Concept	Conceptual	Okanogan	Lower Middle Okanogan (Salmon Creek to Siwash Creek)	4 Riparian Condition - Riparian Vegitation									$372,000.00
17046	WDFW Okanogan River Fish Screening Inventory	Completed	Okanogan	Lower Middle Okanogan (Salmon Creek to Siwash Creek)										$174,000.00
17080	OCD Lower Middle Okanogan Sediment Identification and Implementation Concept	Conceptual	Okanogan	Lower Middle Okanogan (Salmon Creek to Siwash Creek)	7 Sediment Conditions - Increased Sediment Quantity									$550,000.00
17740	CCT Okanogan River Hwy 20 Acquisition	Completed	Okanogan	Lower Middle Okanogan (Salmon Creek to Siwash Creek)	4 Riparian Condition - Riparian Vegitation									$400,000.00
17742	CCT Okanogan River Shell Rock Point Acquisition	Completed	Okanogan	Lower Middle Okanogan (Salmon Creek to Siwash Creek)	5 Peripheral and Transitional Habitats - Floodplain Condition									$850,000.00
17079	OCD Lower Okanogan Irrigation Screens/Diversions Project	Completed	Okanogan	Lower Okanogan (Mouth to Salmon Creek)	2 Injury and Mortality - Mechanical Injury									
13243	CCT Salmon Creek Assessment 99	Completed	Okanogan	Lower Salmon Creek										$92,000.00
13280	CCT Salmon Creek - Low Flow Channel and Fish Passage at Confluence	Active	Okanogan	Lower Salmon Creek	6 Channel Structure and Form - Bed and Channel Form	$400,000.00								$400,000.00
13281	Salmon Creek Diversion Dam Design	Completed	Okanogan	Lower Salmon Creek										$51,500.00
13407	CCT Salmon Creek Instream Flow Agreement	Active	Okanogan	Lower Salmon Creek	9 Water Quantity - Decreased Water Quantity				$1,000,000.00					$1,000,000.00
16902	OCD Salmon Creek Well Development	Active	Okanogan	Lower Salmon Creek	9 Water Quantity - Decreased Water Quantity									$71,940.00
16950	CCT Lower Salmon Creek Acquisition 14 Acres	Completed	Okanogan	Lower Salmon Creek	5 Peripheral and Transitional Habitats - Floodplain Condition									$112,000.00
16951	CCT Lower Salmon Creek Acquisition 1 Acre	Completed	Okanogan	Lower Salmon Creek	5 Peripheral and Transitional Habitats - Floodplain Condition									$280,000.00
17051	CCT Salmon Creek Sediment Reduction Inventory and Implementation Concept	Conceptual	Okanogan	Lower Salmon Creek	7 Sediment Conditions - Increased Sediment Quantity									$0.00
17056	CCT Upper & Lower Salmon Creek Instream Flows Concept	Conceptual	Okanogan	Lower Salmon Creek	9 Water Quantity - Decreased Water Quantity									$375,000.00
18896	CCT Salmon Creek Acquisition	Completed	Okanogan	Lower Salmon Creek	10 Population Level Effects - Small Population Effects									$850,000.00
18896	CCT Salmon Creek Acquisition	Completed	Okanogan	Lower Salmon Creek	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$850,000.00
18897	CCT Salmon Creek Acquisition 2	Completed	Okanogan	Lower Salmon Creek	1 Habitat Quantity - HQ-Competition									$330,000.00
18897	CCT Salmon Creek Acquisition 2	Completed	Okanogan	Lower Salmon Creek	4 Riparian Condition - Riparian Vegitation									$330,000.00
18897	CCT Salmon Creek Acquisition 2	Completed	Okanogan	Lower Salmon Creek	5 Peripheral and Transitional Habitats - Floodplain Condition									$330,000.00
18898	CCT Okanogan River Dogleg Acquisition	Dormant	Okanogan	Lower Salmon Creek										$800,000.00
16953	CCT Nine Mile Creek Acquisition 3.83 Acres	Completed	Okanogan		5 Peripheral and Transitional Habitats - Floodplain Condition									$191,500.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury									$175,000.00
17082	CCT Nine Mile Acquisition 5.87 Acres	Completed	Okanogan		5 Peripheral and Transitional Habitats - Floodplain Condition									$176,000.00
18409	TU-WWP Ninemile Creek, In-Stream Flow Restoration Project	Completed	Okanogan		9 Water Quantity - Decreased Water Quantity									$225,000.00
18511	TU-WWP Ninemile Creek, Riparian Restoration and Passage Improvement	Completed	Okanogan		4 Riparian Condition - Riparian Vegitation									$165,783.00
18893	CCT Ninemile Acquisition	Completed	Okanogan		4 Riparian Condition - LWD Recruitment									$150,000.00
18893	CCT Ninemile Acquisition	Completed	Okanogan		4 Riparian Condition - Riparian Vegitation									$150,000.00
18893	CCT Ninemile Acquisition	Completed	Okanogan		6 Channel Structure and Form - Bed and Channel Form									$150,000.00
18893	CCT Ninemile Acquisition	Completed	Okanogan		6 Channel Structure and Form - Instream Structural Complexity									$150,000.00
16278	CCT Okanogan River Conservancy Island	Active	Okanogan	From Chiliwist Creek to Salmon Creek (RM 15.1-25.75)	1 Habitat Quantity - Anthropogenic Barriers		$200,000.00							$200,000.00
16278	CCT Okanogan River Conservancy Island	Active	Okanogan	From Chiliwist Creek to Salmon Creek (RM 15.1-25.75)	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions		$200,000.00							$200,000.00
16883	OCD Okanogan River Basin Fish Screen Replacements	Active	Okanogan	From Chiliwist Creek to Salmon Creek (RM 15.1-25.75)	2 Injury and Mortality - Mechanical Injury									$0.00
17071	OCD Lower Okanogan TMDL Implementation Concept	Conceptual	Okanogan	From Chiliwist Creek to Salmon Creek (RM 15.1-25.75)	8 Water Quality - Temperature									$0.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Chiliwist Creek to Salmon Creek (RM 15.1-25.75)	2 Injury and Mortality - Mechanical Injury		$165,000.00							$165,000.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From Salmon Creek to Omak Creek (RM 25.72-31.5)	2 Injury and Mortality - Mechanical Injury					$1,000,000.00				$1,000,000.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Salmon Creek to Omak Creek (RM 25.72-31.5)	2 Injury and Mortality - Mechanical Injury		$165,000.00							$165,000.00
16284	CCT Okanogan River Wanacut Creek Log Jam	Conceptual	Okanogan	From Omak Creek to Riverside (RM 31.5- 41.1)	6 Channel Structure and Form - Instream Structural Complexity					$100,000.00				$100,000.00
16906	CCT North Reservation Boundary Okanogan River Side Channel	Completed	Okanogan	From Omak Creek to Riverside (RM 31.5- 41.1)	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$20,000.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From Omak Creek to Riverside (RM 31.5- 41.1)	2 Injury and Mortality - Mechanical Injury					$1,000,000.00				$1,000,000.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Omak Creek to Riverside (RM 31.5- 41.1)	2 Injury and Mortality - Mechanical Injury		$165,000.00							$165,000.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From Riverside to Janis Bridge (RM 41.1 - 52.6)	2 Injury and Mortality - Mechanical Injury					$1,000,000.00				$1,000,000.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Riverside to Janis Bridge (RM 41.1 - 52.6)	2 Injury and Mortality - Mechanical Injury		$165,000.00							$165,000.00
18704	CCFEG Janis Rapids Side Channel - Okanogan Weir Removal Project	Active	Okanogan	From Riverside to Janis Bridge (RM 41.1 - 52.6)	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions			$35,500.00						$35,500.00
17701	OCD Okanogan Livestock and Water Quality	Proposed	Okanogan	From Janis Bridge to Siwash Creek (RM 52.6 – 57.3)	4 Riparian Condition - Riparian Vegitation									$248,506.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From Janis Bridge to Siwash Creek (RM 52.6 – 57.3)	2 Injury and Mortality - Mechanical Injury					$1,000,000.00				$1,000,000.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Janis Bridge to Siwash Creek (RM 52.6 – 57.3)	2 Injury and Mortality - Mechanical Injury		$165,000.00							$165,000.00
17701	OCD Okanogan Livestock and Water Quality	Proposed	Okanogan	From Siwash Creek to confluence with Similkameen (RM 57.3-74.3)	4 Riparian Condition - Riparian Vegitation									$248,506.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From Siwash Creek to confluence with Similkameen (RM 57.3-74.3)	2 Injury and Mortality - Mechanical Injury					$1,000,000.00				$1,000,000.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Siwash Creek to confluence with Similkameen (RM 57.3-74.3)	2 Injury and Mortality - Mechanical Injury		$165,000.00							$165,000.00
16904	CCT Driscoll Island Cross Channel Structure	Completed	Okanogan	From confluence with Similkameen to Zozel Dam (RM 74.3 -78.9)	6 Channel Structure and Form - Bed and Channel Form									$293,060.00
17701	OCD Okanogan Livestock and Water Quality	Proposed	Okanogan	From confluence with Similkameen to Zozel Dam (RM 74.3 -78.9)	4 Riparian Condition - Riparian Vegitation									$248,506.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From confluence with Similkameen to Zozel Dam (RM 74.3 -78.9)	2 Injury and Mortality - Mechanical Injury					$1,000,000.00				$1,000,000.00
1353	Omak Creek Bridge Replacement RM 1	Completed	Okanogan	Omak Creek from the confluence with the Okanogan River to Mission Falls (RM 0 – 5.6)	1 Habitat Quantity - Anthropogenic Barriers									$95,000.00
13246	CCT Omak Creek Mill Site Restoration RM 0.5	Completed	Okanogan	Omak Creek from the confluence with the Okanogan River to Mission Falls (RM 0 – 5.6)	1 Habitat Quantity - Anthropogenic Barriers									$1,100,000.00
16979	CCT Omak Creek Acquisition 120 Acres	Completed	Okanogan	Omak Creek from the confluence with the Okanogan River to Mission Falls (RM 0 – 5.6)	5 Peripheral and Transitional Habitats - Floodplain Condition									$132,000.00
17700	Omak Creek Bank Stabilization RM 2.9 to 4.7	Completed	Okanogan	Omak Creek from the confluence with the Okanogan River to Mission Falls (RM 0 – 5.6)	6 Channel Structure and Form - Bed and Channel Form									$147,000.00

13247	CCT Omak Creek Mission Falls Barriers RM 5.5	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	1 Habitat Quantity - Anthropogenic Barriers									$1,700,000.00
13249	CCT Omak Creek Road Decommissions	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$59,413.00
15789	CCT Omak Creek Lobe and Disautel Culvert Replacements (2) RM 15 & 17	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$216,372.65
15794	CCT Omak Creek Stapaloop Creek Culvert and Instream Structures	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$75,000.00
15800	CCT Omak Creek Grindstone Drainage Culverts (2)	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$75,000.00
15806	CCT Omak Creek Stapaloop Creek Culverts (3)	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$35,000.00
15807	CTT Omak Creek Camp Seven Creek Culverts (2)	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$120,000.00
15809	CCT Omak Creek Dutch Anderson Drainage Culvert	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$26,000.00
15810	CCT Omak (Upper) Creek Culvert Replacements (11)	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$455,000.00
15811	CCT Omak Creek Marchand & Sam Culvert Replacements (2) RM 19 & 19.5	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$150,000.00
16000	CTT Omak Creek Swimptkin Creek Culvert	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$6,000.00
16893	CCT Omak Creek Livestock Exclusion Fence Project	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$17,000.00
17060	CCT Omak Creek Culvert Replacements Concept	Conceptual	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									
17776	CCT Upper Omak Creek Barriers Phase II Concept	Conceptual	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	1 Habitat Quantity - Anthropogenic Barriers									
17969	CCT Clark Creek Culverts (2)	Completed	Okanogan	Upstream of Mission Falls (RM 5.6 -26.6)	7 Sediment Conditions - Increased Sediment Quantity									$35,000.00
13245	CCT Omak Creek Watershed Restoration and Sediment Reduction	Completed	Okanogan	Salmon Creek from OID to Conconully Dam (RM 4.5 -17.6)	7 Sediment Conditions - Increased Sediment Quantity									$189,621.00
15788	CCT Omak Creek Haley Culvert Replacement RM 8	Completed	Okanogan	Salmon Creek from OID to Conconully Dam (RM 4.5 -17.6)	7 Sediment Conditions - Increased Sediment Quantity									$140,000.00
16892	CCT Omak (Upper) Creek Spring Developments (3) Proposal	Proposed	Okanogan	Salmon Creek from OID to Conconully Dam (RM 4.5 -17.6)	7 Sediment Conditions - Increased Sediment Quantity									
19466	Salmon Creek Off Channel Habitat	Completed	Okanogan	Salmon Creek from OID to Conconully Dam (RM 4.5 -17.6)	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$80,000.00								$80,000.00
13297	CCFEG Similkameen-Okanogan Confluence Restoration Design	Completed	Okanogan	Similkameen										$177,750.00
13328	CCFEG Okanogan/Similkameen Assess/feasibility/preliminary design	Completed	Okanogan	Similkameen										$282,000.00
17052	OCD Similkameen Sediment Reduction Projects Concept	Conceptual	Okanogan	Similkameen	7 Sediment Conditions - Increased Sediment Quantity									$275,000.00
17067	CCT Similkameen Cool Water Refugia Concept	Conceptual	Okanogan	Similkameen										$600,000.00
17069	CCT Similkameen Protection Concept	Conceptual	Okanogan	Similkameen										$2,350,000.00
18646	OCD Similkameen RM 3.8 Habitat Design	Proposed	Okanogan	Similkameen	6 Channel Structure and Form - Bed and Channel Form		$200,000.00							$200,000.00
16884	CCFEG Driscoll Island Cold Water Refuge Design	Completed	Okanogan	From confluence with Okanogan River to Cross Channel (RM 0-3.7)	8 Water Quality - Temperature									$42,500.00
18450	CCFEG - Driscoll Island Riparian Planting	Completed	Okanogan	From confluence with Okanogan River to Cross Channel (RM 0-3.7)	4 Riparian Condition - Riparian Vegitation									$11,000.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury									$175,000.00
17762	CCT Siwash Creek Water Resource Inventory Concept	Completed	Okanogan											$65,000.00
18891	CCT Aeneas Creek Spring Headwaters Protection	Completed	Okanogan	Small Tributary Systems		$70,000.00								$70,000.00
18899	CCT Antoine Creek Corral Relocation	Completed	Okanogan	Small Tributary Systems	4 Riparian Condition - Riparian Vegitation									$80,000.00
18899	CCT Antoine Creek Corral Relocation	Completed	Okanogan	Small Tributary Systems	5 Peripheral and Transitional Habitats - Floodplain Condition									$80,000.00
18899	CCT Antoine Creek Corral Relocation	Completed	Okanogan	Small Tributary Systems	6 Channel Structure and Form - Bed and Channel Form									$80,000.00
18899	CCT Antoine Creek Corral Relocation	Completed	Okanogan	Small Tributary Systems	8 Water Quality - Toxic Contaminants									$80,000.00
13250	CCT Okanogan Basin Monitoring and Evaluation Program (OBMEP)	Active	Okanogan											
13251	CCT Okanogan Subbasin Habitat Implementation Program (OSHIP)	Active	Okanogan											
13258	CCT Okanogan Land and Water Acquisition Program	Active	Okanogan						$2,400,000.00					$2,400,000.00
13260	CCT Okanogan River Thermal & Lidar Image-Phase 1 & 2	Completed	Okanogan											$94,437.00
13262	WDFW Fish Screening Projects	Completed	Okanogan		2 Injury and Mortality - Mechanical Injury									
13273	OCD Okanogan County Fish Passage Barrier Survey	Completed	Okanogan											$224,183.00
13274	Okan Co. Salmon Habitat Enhancement	Completed	Okanogan											$200,000.00
13277	OCD Okanogan Livestock and Water Program	Completed	Okanogan											$68,438.00
13279	OCD Okanogan County Irrigation Water Concept	Conceptual	Okanogan		9 Water Quantity - Decreased Water Quantity									
17093	OCD Okanogan Conservation District Livestock Program	Active	Okanogan											$500,000.00
17703	OCD Okanogan & Methow Farm Assistance Concept	Conceptual	Okanogan		9 Water Quantity - Decreased Water Quantity									$185,196.00
17794	CCT Okanogan Subbasin Predation Assessment Concept	Conceptual	Okanogan											
17795	CCT Okanogan River Basin Riparian Concept	Conceptual	Okanogan		4 Riparian Condition - Riparian Vegitation									
16426	CCT Tonasket Creek Water Resource Inventory	Completed	Okanogan											$65,000.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury									$175,000.00
17714	TU-WWP Tonasket Creek Instream Flow Enhancements	Proposed	Okanogan		9 Water Quantity - Decreased Water Quantity	$120,000.00								$120,000.00
16427	CCT Tunk Creek Ground Water Study	Completed	Okanogan											$75,000.00
18501	CCFEG East Fork Tunk Creek Culvert Replacement	Completed	Okanogan		1 Habitat Quantity - Anthropogenic Barriers									$150,000.00
15805	WDFW Mclaughlin Falls Fish Habitat Acqusition	Completed	Okanogan	Upper Middle Okanogan, Siwash Creek to Okanogan/Similkameen Confl.	5 Peripheral and Transitional Habitats - Floodplain Condition									$700,000.00
17051	CCT Salmon Creek Sediment Reduction Inventory and Implementation Concept	Conceptual	Okanogan	Upper Middle Okanogan, Siwash Creek to Okanogan/Similkameen Confl.	7 Sediment Conditions - Increased Sediment Quantity									$0.00
17053	CCT Okanogan River Instream Flows for Temperature Reduction Concept	Conceptual	Okanogan	Upper Middle Okanogan, Siwash Creek to Okanogan/Similkameen Confl.	8 Water Quality - Temperature									$800,000.00
16890	CCT Okanogan River Cold Water Refugia Channel Creation Concept	Conceptual	Okanogan	Upper Okanogan	8 Water Quality - Temperature									$70,000.00
17045	OCD Okanogan River Riparian Habitat IV Concept	Conceptual	Okanogan	Upper Okanogan	4 Riparian Condition - Riparian Vegitation									$100,000.00
17049	OCD Upper Okanogan Sediment Reduction Project ID and Implementation Concept	Conceptual	Okanogan	Upper Okanogan	7 Sediment Conditions - Increased Sediment Quantity									$225,000.00
17745	CCT Okanogan River Basin Cold Water Refugia and Tributary Flow Restoration	Active	Okanogan	Upper Okanogan	9 Water Quantity - Increased Water Quantity					$4,000,000.00				$4,000,000.00
13253	CCT Wanacut Creek Livestock Management	Completed	Okanogan		7 Sediment Conditions - Increased Sediment Quantity									$40,000.00
16908	CCT Wanacut Creek Channel Rehabilitation	Completed	Okanogan		6 Channel Structure and Form - Bed and Channel Form									$60,991.00
18895	CCT Wanacut Creek Acquisition	Completed	Okanogan		7 Sediment Conditions - Increased Sediment Quantity									$60,000.00
17071	OCD Lower Okanogan TMDL Implementation Concept	Conceptual	Okanogan	From the confluence with the Columbia River to Chiliwist Creek (RM 0-15.1)	8 Water Quality - Temperature									$0.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From the confluence with the Columbia River to Chiliwist Creek (RM 0-15.1)	2 Injury and Mortality - Mechanical Injury		$165,000.00							$165,000.00
13252	CCT Wild Horse Springs Creek Restoration	Completed	Okanogan		1 Habitat Quantity - Anthropogenic Barriers									$80,000.00
16292	CCT Wild Horse Spring Creek McKinney Bridge	Completed	Okanogan		1 Habitat Quantity - Anthropogenic Barriers									$25,000.00
16430	CCT Wild Horse Spring Creek Hardened Rock Crossing II	Completed	Okanogan		7 Sediment Conditions - Increased Sediment Quantity									$3,000.00
16891	CCT Wild Horse Spring Creek Realignment	Completed	Okanogan		6 Channel Structure and Form - Bed and Channel Form									$25,000.00
16900	CCT Wild Horse Spring Creek Well Installation Proposal	Completed	Okanogan		9 Water Quantity - Decreased Water Quantity	$50,000.00								$50,000.00
16913	CCT Wild Horse Spring Creek Livestock Exclusion Phase I & II	Completed	Okanogan		4 Riparian Condition - Riparian Vegitation									$6,000.00
16915	CCT Wild Horse Spring Creek Culvert Replacements I & II	Completed	Okanogan		1 Habitat Quantity - Anthropogenic Barriers									$60,000.00
16947	CCT Wild Horse Spring Creek Hardened Rock Crossing	Completed	Okanogan		7 Sediment Conditions - Increased Sediment Quantity									$3,000.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury									$175,000.00
18894	CCT Wild Horse Spring Creek Culvert Replacement	Completed	Okanogan		1 Habitat Quantity - Anthropogenic Barriers									$60,000.00

Id	Project Name	Status	Subbasin	Assessment Unit	Ecological Concern	2014	2015	2016	2017	2018	2019	2020	2022	Budget
19400	TU-WWP Bear Creek Storage and Reconnection Feasibility Study	Conceptual	Methow		9 Water Quantity - Decreased Water Quantity									
29601	Barkley Irrigation Company: Under Pressure	Proposed	Methow				$700,000.00							$700,000.00
29604	Goat Creek Complexity for Confluentus	Proposed	Methow						$130,000.00					$130,000.00
29605	M2 Lewisia Floodplain Design	Proposed	Methow					$190,000.00						$190,000.00
29606	Methow Watershed Riparian Stewardship Program	Proposed	Methow						$77,300.00					$77,300.00
29607	Methow Watershed Beaver Reintroduction	Proposed	Methow						$211,000.00					$211,000.00
29721	CCFEG 25 Mile Creek Passage Improvement Project	Completed	Methow											$19,649.00
29723	CCFEG - Twisp to Carlton Reach Assessment	Active	Methow				$173,016.00							$173,016.00
13265	OCD Beaver Cr Coordinated Resource Mgt Plan	Completed	Methow	Beaver / Bear Creek										$81,464.00
13268	OCD Redshirt Barrier Removal	Completed	Methow	Beaver / Bear Creek	1 Habitat Quantity - Anthropogenic Barriers									$75,400.00
13269	OCD Thurlow Transfer Ditch Barrier and Piping Concept	Completed	Methow	Beaver / Bear Creek	9 Water Quantity - Decreased Water Quantity									$475,122.00
13271	OCD Beaver Creek Fish Passage Barriers (5)	Completed	Methow	Beaver / Bear Creek	1 Habitat Quantity - Anthropogenic Barriers									$30,000.00
13272	OCD Fort-Thurlow Lower Beaver Piping	Completed	Methow	Beaver / Bear Creek	9 Water Quantity - Decreased Water Quantity									$180,913.00
13276	OCD Marrachi Diversion	Completed	Methow	Beaver / Bear Creek	1 Habitat Quantity - Anthropogenic Barriers									$105,882.00
13332	MSRF Upper Beaver Creek Habitat Improvement Project	Active	Methow	Beaver / Bear Creek	6 Channel Structure and Form - Instream Structural Complexity							$740,000.00		$740,000.00
13334	MSRF Operskalski	Completed	Methow	Beaver / Bear Creek	6 Channel Structure and Form - Instream Structural Complexity									$31,588.92
17035	TU-WWP Beaver Creek, No. 2 Instream Flow Enhancement	Active	Methow	Beaver / Bear Creek	9 Water Quantity - Decreased Water Quantity		$225,000.00							$225,000.00
17655	MSRF Marrachi Phase II	Conceptual	Methow	Beaver / Bear Creek	1 Habitat Quantity - Anthropogenic Barriers									
17656	MSRF Fort/Thurlow Phase II	Active	Methow	Beaver / Bear Creek	1 Habitat Quantity - Anthropogenic Barriers	$50,000.00								$50,000.00
18408	TU-WWP Beaver Creek - 2012 Leases	Completed	Methow	Beaver / Bear Creek	9 Water Quantity - Decreased Water Quantity									$4,375.00
18527	YN Old Schoolhouse Fish Enhancement Project	Completed	Methow	Beaver / Bear Creek	4 Riparian Condition - LWD Recruitment									$250,000.00
18623	MSRF UBC Old Schoolhouse	Active	Methow	Beaver / Bear Creek	6 Channel Structure and Form - Instream Structural Complexity									
18624	MSRF UBC Campbell	Active	Methow	Beaver / Bear Creek	6 Channel Structure and Form - Instream Structural Complexity									
29499	MSRF Fine Riparian	Completed	Methow	Beaver / Bear Creek	4 Riparian Condition - Riparian Vegitation									$33,300.77
13236	Okan Co. Early Winters Ditch Diversion Structure	Completed	Methow	Early Winters / Lost River	1 Habitat Quantity - Anthropogenic Barriers									$128,521.00
13264	TPL Arrowleaf/Methow R Conservation	Completed	Methow	Early Winters / Lost River	5 Peripheral and Transitional Habitats - Floodplain Condition									$1,250,000.00
13305	WDFW Early Winter Canal Fish Screen	Completed	Methow	Early Winters / Lost River	2 Injury and Mortality - Mechanical Injury									$151,000.00
13323	MSRF Early Winters Creek Dike Removal	Completed	Methow	Early Winters / Lost River	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$168,859.00
13237	Okan Co. Fulton Ditch Lining Project	Completed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity									$18,415.00
13282	MSRF Chewuch Diversion	Completed	Methow	Lower Chewuch	1 Habitat Quantity - Anthropogenic Barriers									$149,381.00
13289	MC River Assessment Unit Acquisitions	Completed	Methow	Lower Chewuch	5 Peripheral and Transitional Habitats - Floodplain Condition		$225,000.00							$225,000.00
13291	MSRF Chewuch Canal & Fulton Canal Joint Study	Completed	Methow	Lower Chewuch										$61,591.00
13301	WDFW Fulton Canal Fish Screen	Completed	Methow	Lower Chewuch	2 Injury and Mortality - Mechanical Injury									$200,000.00
13307	MSRF Fulton Dam - Barrier Removal	Completed	Methow	Lower Chewuch	1 Habitat Quantity - Anthropogenic Barriers									$543,223.00
13315	MSRF Macpherson Side Channel	Completed	Methow	Lower Chewuch	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$43,629.38
13317	MSRF Chewuch Dam Modification	Completed	Methow	Lower Chewuch	1 Habitat Quantity - Anthropogenic Barriers									$272,091.00
13338	MSRF Pete Creek	Completed	Methow	Lower Chewuch	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$60,137.94
13340	MSRF Chewuch Basin Irrigator Efficiency	Completed	Methow	Lower Chewuch	9 Water Quantity - Increased Water Quantity									$294,000.00
13409	YN Chewuch Reach Assessment	Completed	Methow	Lower Chewuch										$167,000.00
15868	YN Chewuch River Mile 10 Fish Enhancement Project	Completed	Methow	Lower Chewuch	6 Channel Structure and Form - Instream Structural Complexity									$850,000.00
15870	YN Chewuch River 8 Mile Ranch Project	Completed	Methow	Lower Chewuch	6 Channel Structure and Form - Instream Structural Complexity									$750,000.00
16886	TU-WPP Fulton Ditch Instream Flow	Proposed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity			$1,300,000.00						$1,300,000.00
17008	USFS Chewuch Road Inventory and Minimum Roads Analysis Concept	Conceptual	Methow	Lower Chewuch										$60,000.00
17015	TU-WWP: Chewuch River No.3 Permanent Flow Enhancement,	Active	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity									$2,268,547.00
17031	MSRF Bulldog	Completed	Methow	Lower Chewuch	4 Riparian Condition - Riparian Vegitation									$34,927.24
17085	TU-WWP: Chewuch No. 2 Piping Project (Little Chewuch)	Completed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity									$150,000.00
17086	TU-WPP Little Barkley Piping	Completed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity									$131,219.50
17087	TU-WWP Chewuch No. 1, three year drought lease	Completed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity									$350,000.00
17088	USFS Upper Cub Creek Riparian Fencing Concept	Conceptual	Methow	Lower Chewuch	4 Riparian Condition - Riparian Vegitation									$25,000.00
17089	USFS Eightmile Creek Fish Barrier Assessment and Implementation Concept	Conceptual	Methow	Lower Chewuch	1 Habitat Quantity - Anthropogenic Barriers									$2,300,000.00
17731	YN Chewuch River Right	Proposed	Methow	Lower Chewuch	6 Channel Structure and Form - Instream Structural Complexity			$1,600,000.00						$1,600,000.00
17928	MSRF Lower Chewuch Watershed Beaver Restoration	Active	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity									
18709	TU-WWP Chewuch River Instream Flow Project	Proposed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity		$350,000.00							$350,000.00
19320	YN Chewuch Camp Ground	Conceptual	Methow	Lower Chewuch	4 Riparian Condition - LWD Recruitment			$1.00						$1.00
19320	YN Chewuch Camp Ground	Conceptual	Methow	Lower Chewuch	6 Channel Structure and Form - Instream Structural Complexity			$1.00						$1.00
29500	MSRF Satiqua Riparian	Completed	Methow	Lower Chewuch	4 Riparian Condition - Riparian Vegitation									$21,943.97
16973	WDFW Bridge 1 Riparian Acquisition	Proposed	Methow	Lower Methow	5 Peripheral and Transitional Habitats - Floodplain Condition									$305,000.00
17004	TU-WPP Lower Methow Irrigation Efficiencies & Instream Flow Enhancements	Active	Methow	Lower Methow	9 Water Quantity - Decreased Water Quantity	$525,000.00								$525,000.00
17707	TU-WPP Eightmile Creek Irrigation Efficiencies & Instream Flow Enhancements	Proposed	Methow	Lower Methow	9 Water Quantity - Decreased Water Quantity									
17708	TU-WWP: Twisp River POD Change & Instream Flow Enhancement	Active	Methow	Lower Methow	9 Water Quantity - Decreased Water Quantity									$100,000.00
17710	TU-WPP Beaver Creek No. 1, 2, 3- Late Season Instream Flow Projects	Completed	Methow	Lower Methow	9 Water Quantity - Decreased Water Quantity									$241,986.00
17711	TU-WPP Middle Methow River M2 Phase 3 Concept	Conceptual	Methow	Lower Methow	9 Water Quantity - Decreased Water Quantity									
13239	Okan Co. Airey/Risley Ditch Removal	Completed	Methow	Middle Methow	1 Habitat Quantity - Anthropogenic Barriers									$29,596.00
13283	MC Middle Methow River Assessment Unit Acquisitions	Completed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition		$2,307,579.00							$2,307,579.00
13299	WDFW Silver Side Channel Restoration and Conservation Easement	Completed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
13324	MSRF Methow Valley Irrigation District (MVID) East Irrigation Diversion	Completed	Methow	Middle Methow	1 Habitat Quantity - Anthropogenic Barriers									$917,440.00
13336	MSRF Winthrop Confluence Project Riparian	Completed	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation									$64,794.78
13336	MSRF Winthrop Confluence Project Riparian	Completed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition									$64,794.78
13337	BOR Middle Methow Reach Assessment	Completed	Methow	Middle Methow										$413,967.00
16473	MSRF Methow River Bird Island Acquisition	Completed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$0.00
16474	MSRF Middle Methow River Hoffman Acquisition	Completed	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation									$211,429.00
16475	MSRF Methow River Risley Acquisition	Completed	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation									$131,890.00
16995	MSRF Middle Methow Sugar Dike Reach Implementation	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition					$600,000.00				$600,000.00
16997	BOR Winthrop to Wolf Creek Reach Assessment	Completed	Methow	Middle Methow										$30,000.00
16998	BOR Middle Methow Silver Reach Assessment Concept	Conceptual	Methow	Middle Methow										
17018	TU-WPP Middle Methow instream flow enhancement	Proposed	Methow	Middle Methow	9 Water Quantity - Decreased Water Quantity	$1,150,000.00								$1,150,000.00
17023	MSRF Methow River Acquisition 2011 RM 48.9	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition			$68,800.00						$68,800.00
17024	MSRF M2 Whitefish Island	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$1,445,000.00								$1,445,000.00
17025	MSRF M2 WDFW Floodplain Restoration	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$0.00								$0.00
17026	MSRF M2 3R Concept	Conceptual	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions			$1,000,000.00						$1,000,000.00
17028	MSRF M2 Logjam Island Concept	Conceptual	Methow	Middle Methow	6 Channel Structure and Form - Instream Structural Complexity			$700,000.00						$700,000.00

17029	MSRF M2 Bear Creek Complexity	Conceptual	Methow	Middle Methow	6 Channel Structure and Form - Instream Structural Complexity					$500,000.00				$500,000.00
17030	MSRF M2 Complexity and Floodplain Restoration III	Conceptual	Methow	Middle Methow	6 Channel Structure and Form - Instream Structural Complexity					$2,500,000.00				$2,500,000.00
17721	TU-WWP Middle Methow Water Lease and/or In-basin Acquisition Concept	Conceptual	Methow	Middle Methow	9 Water Quantity - Decreased Water Quantity									
18004	MSRF WDFW Floodplain wetland easement (McIvor)	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
18537	CCFEG Methow Riparian Planting	Active	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation			$95,000.00						$95,000.00
18611	YN M2 Eagle Rocks Large Wood Enhancement	Completed	Methow	Middle Methow	6 Channel Structure and Form - Bed and Channel Form									$60,000.00
18625	MSRF M2 Amundsen Floodplain	Completed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
18626	MSRF Maltais	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition									
18703	CCFEG Silver Side Channel Revival	Active	Methow	Middle Methow				$900,000.00						$900,000.00
18707	TU-WWP: MVID Instream Flow Improvement Project	Active	Methow	Middle Methow	9 Water Quantity - Decreased Water Quantity			$500,000.00						$500,000.00
18708	MSRF M2 3R Project	Proposed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions		$250,000.00							$250,000.00
18730	CCFEG Twisp to Carlton Reach Assessment I	Proposed	Methow	Middle Methow				$200,000.00						$200,000.00
18848	YN M2 1890s Side Channel Enhancement Project	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions		$1,300,000.00							$1,300,000.00
18909	YN M2 Sugar Dike Large Wood Enhancement	Completed	Methow	Middle Methow	6 Channel Structure and Form - Instream Structural Complexity	$65,000.00								$65,000.00
18910	YN M2 Two Channels East Side Channel Project	Proposed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition									
18911	YN M2 Two Channels Large Wood Enhancement	Completed	Methow	Middle Methow	6 Channel Structure and Form - Instream Structural Complexity	$80,000.00								$80,000.00
19394	TU-WWP Barkley Diversion Reduction and Habitat Improvement	Active	Methow	Middle Methow	9 Water Quantity - Decreased Water Quantity									
29496	MSRF Witte Riparian	Completed	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation									$62,402.91
29498	MSRF 3R Riparian	Completed	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation									$68,286.96
13320	MSRF Methow Basin Riparian Enhancement Program	Completed	Methow		4 Riparian Condition - Riparian Vegitation									$608,639.00
13360	WDFW Methow Watershed Phase II	Completed	Methow		5 Peripheral and Transitional Habitats - Floodplain Condition									
14276	BOR Methow Subbasin Geomorphic Assessment	Completed	Methow											$220,060.00
17703	OCD Okanogan & Methow Farm Assistance Concept	Conceptual	Methow		9 Water Quantity - Decreased Water Quantity									$185,196.00
13231	Okan Co. Skyline Ditch Pipe Installation Phase 1 & 2	Completed	Methow	Upper Chewuch	9 Water Quantity - Decreased Water Quantity									$176,000.00
13306	WDFW Skyline Canal Fish Screen	Completed	Methow	Upper Chewuch	2 Injury and Mortality - Mechanical Injury									$165,000.00
17008	USFS Chewuch Road Inventory and Minimum Roads Analysis Concept	Conceptual	Methow	Upper Chewuch										$60,000.00
17015	TU-WWP: Chewuch River No.3 Permanent Flow Enhancement,	Active	Methow	Upper Chewuch	9 Water Quantity - Decreased Water Quantity									$2,268,547.00
18484	YN Chewuch River Mile 11.75-13 River Left Fish Enhancement Project	Active	Methow	Upper Chewuch	6 Channel Structure and Form - Instream Structural Complexity	$438,024.00								$438,024.00
19321	Chewuch RM 13-15.5	Conceptual	Methow	Upper Chewuch	4 Riparian Condition - LWD Recruitment									
13261	WDFW Methow River Basin Screening	Completed	Methow	Early Winters / Lost River	2 Injury and Mortality - Mechanical Injury									$229,667.00
13285	Upper Methow Assessment Unit MC Acquisitions	Completed	Methow	Early Winters / Lost River	5 Peripheral and Transitional Habitats - Floodplain Condition									$7,094,757.00
13318	CCFEG Rockview Diversion and Side Channel Restoration	Completed	Methow	Early Winters / Lost River	9 Water Quantity - Decreased Water Quantity									$154,500.00
13358	Private LO Weeman Bridge Side Channel Restoration	Completed	Methow	Early Winters / Lost River	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$54,000.00
17094	Whiteface Creek Culvert Replacement Concept	Conceptual	Methow	Early Winters / Lost River	1 Habitat Quantity - Anthropogenic Barriers									$160,000.00
17614	CCFEG Big Valley Wood and Floodplain	Conceptual	Methow	Early Winters / Lost River	6 Channel Structure and Form - Instream Structural Complexity		$330,000.00							$330,000.00
17657	? Suspension Bridge Habitat Complexity Project	Conceptual	Methow	Early Winters / Lost River	6 Channel Structure and Form - Instream Structural Complexity									
18610	YN Wolf Creek Road Bank Stabilization and Wood Enhancement Project	Completed	Methow	Early Winters / Lost River	6 Channel Structure and Form - Instream Structural Complexity									$90,000.00
29497	MSRF Wolfridge Riparian	Completed	Methow	Early Winters / Lost River	4 Riparian Condition - Riparian Vegitation									$115,835.26
13235	Okan Co. Eagle Creek Ditch Fish Screen	Completed	Methow	Upper Twisp	2 Injury and Mortality - Mechanical Injury									$23,225.00
17005	TU-WPP Twisp River Instream Flow Enhancement Concept	Completed	Methow	Upper Twisp	9 Water Quantity - Decreased Water Quantity	$99,200.00								$99,200.00
13313	MSRF Heath Phase II Install 2 Bridges	Completed	Methow	Methow river miles 51.5 to 61	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$80,181.85
13321	MSRF Fender Mill Floodplain Restoration	Completed	Methow	Methow river miles 51.5 to 61	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$2,693,249.00
13330	BOR Big Valley Reach Assessment	Completed	Methow	Methow river miles 51.5 to 61										$216,000.00
13335	MSRF Sletten and Green Habitat Complexity Projects	Completed	Methow	Methow river miles 51.5 to 61	6 Channel Structure and Form - Instream Structural Complexity									$30,000.00
17653	Wolf to Winthrop Complexity Project	Conceptual	Methow	Methow river miles 51.5 to 61	6 Channel Structure and Form - Instream Structural Complexity									
13233	Wolf Creek Channel Restoration	Completed	Methow	Wolf / Hancock Creeks	6 Channel Structure and Form - Bed and Channel Form									$20,000.00
13295	Wolf Creek Diversion/Patterson Mountain	Completed	Methow	Wolf / Hancock Creeks	1 Habitat Quantity - Anthropogenic Barriers									$275,373.00
13302	WDFW Wolf Creek Reclamation Dist Fish Screen	Completed	Methow	Wolf / Hancock Creeks	2 Injury and Mortality - Mechanical Injury									$140,000.00
13309	YN Hancock Springs Restoration Project Phase I	Completed	Methow	Wolf / Hancock Creeks	6 Channel Structure and Form - Instream Structural Complexity									$450,000.00
16971	CCFEG Wolf Creek Ditch and Fish Return improvement	Conceptual	Methow	Wolf / Hancock Creeks	2 Injury and Mortality - Mechanical Injury		$270,000.00							$270,000.00
18853	YN Hancock Creek Restoration Phase 3	Completed	Methow	Wolf / Hancock Creeks										$417,000.00
17712	TU-WPP Wolf Creek Piping & Diversion Enhancement	Proposed	Methow		9 Water Quantity - Decreased Water Quantity									
5425	MSRF Twisp Right Bank	Completed	Methow	Lower Twisp	4 Riparian Condition - Riparian Vegitation									$77,139.90
10301	MSRF Twisp River Conservation Acquisition 2	Completed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Floodplain Condition									$481,579.00
13234	Okan Co. Tourangeau Ditch to Well Conversion	Completed	Methow	Lower Twisp	9 Water Quantity - Decreased Water Quantity									$6,500.00
13238	Okan Co. Aspen Meadows Ditch Piping	Completed	Methow	Lower Twisp	9 Water Quantity - Decreased Water Quantity									$58,704.00
13240	Okan Co. Buttermilk Ditch Fish Screen	Completed	Methow	Lower Twisp	2 Injury and Mortality - Mechanical Injury									$37,557.00
13241	Okan Co. Little Bridge Creek Culvert	Completed	Methow	Lower Twisp	1 Habitat Quantity - Anthropogenic Barriers									$6,400.00
13275	OCD Hottell Intake Gate	Completed	Methow	Lower Twisp	2 Injury and Mortality - Mechanical Injury									$11,210.00
13287	MC Acquisitions Twisp River Assessment Unit	Completed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Floodplain Condition		$2,017,092.00							$2,017,092.00
13292	PWI - Assessment Twisp River Watershed	Completed	Methow	Lower Twisp										$185,626.00
13303	WDFW Twisp-Power Ditch Fish Screen	Completed	Methow	Lower Twisp	2 Injury and Mortality - Mechanical Injury									$130,000.00
13314	MSRF Channel Reconstruction/ Twisp side-channel	Completed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$92,000.00
13322	MSRF Elbow Coulee River Restoration	Completed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$54,060.76
13325	MSRF Poorman Creek Barrier Removal	Completed	Methow	Lower Twisp	1 Habitat Quantity - Anthropogenic Barriers									$106,805.50
13331	OCD Little Bridge Creek (Aspen Meadows)	Completed	Methow	Lower Twisp	1 Habitat Quantity - Anthropogenic Barriers									$108,400.00
13341	MSRF Twisp River Conservation Acquisition	Completed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Floodplain Condition									$200,835.00
16960	MSRF Twisp River Acquisitions 3	Active	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Floodplain Condition	$140,700.00								$140,700.00
17005	TU-WPP Twisp River Instream Flow Enhancement Concept	Completed	Methow	Lower Twisp	9 Water Quantity - Decreased Water Quantity	$99,200.00								$99,200.00
17032	MSRF Twisp Left Bank Complexity & Riparian	Completed	Methow	Lower Twisp	6 Channel Structure and Form - Instream Structural Complexity									$138,070.14
17649	MSRF Siberian Side-channel	Proposed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
17650	MSRF Poorman Creek Wetland Habitat	Active	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
17651	MSRF Elbow Coulee Phase II Rt/Lf Bank	Active	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions					$0.00				$0.00
17723	TU-WWP: Twisp River, Instream Flow Enhancement,	Proposed	Methow	Lower Twisp	9 Water Quantity - Decreased Water Quantity									
18614	YN Twisp Ponds Left Bank Large Wood Enhancement	Completed	Methow	Lower Twisp	6 Channel Structure and Form - Instream Structural Complexity									$80,000.00
18616	YN Twisp Ponds Left Bank Floodplain Restoration	Completed	Methow	Lower Twisp	4 Riparian Condition - Riparian Vegitation									$20,000.00
18618	YN Twisp Ponds Habitat Ponds Intake Ditch Repair	Completed	Methow	Lower Twisp	9 Water Quantity - Decreased Water Quantity									$60,000.00
18621	MSRF Twisp River - Hadfield	Active	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Floodplain Condition									
18622	MSRF Twisp River - Gann	Active	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
18908	YN Lower Twisp River Reach Assessment	Completed	Methow	Lower Twisp										$167,000.00
18912	YN Twisp River Poorman Creek Road Side Channel Project	Conceptual	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$60,000.00								$60,000.00
19324	YN Twisp River Mile 3 Fish Habitat Enhancement Project	Active	Methow	Lower Twisp	6 Channel Structure and Form - Instream Structural Complexity	$70,000.00								$70,000.00

19344	YN-Poorman Creek Road Large Wood Enhancement Project	Proposed	Methow	Lower Twisp	6 Channel Structure and Form - Instream Structural Complexity	$70,000.00								$70,000.00
29494	MSRF Daudon Riparian	Completed	Methow	Lower Twisp	4 Riparian Condition - Riparian Vegitation									$35,870.73
29495	MSRF TRPLLC Riparian	Completed	Methow	Lower Twisp	4 Riparian Condition - Riparian Vegitation									$95,629.59

Id	Project Name	Status	Subbasin	Assessment Unit	Ecological Concern	2014	2015	2016	2017	2018	2019	2020	2022	Budget
29742	CCFEG - Stormy Creek Barrier Removals	Active	Entiat											
1785	CCNRD Harrison Side Channel	Completed	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$177,454.93
1786	CCNRD & CCD Hanan Detwiler Instream Structures	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity									$91,000.00
1892	CCD Bridge to Bridge Phase I	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Bed and Channel Form									$185,000.00
1894	CCNRD & CCD Milne Entiat Instream Structures	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity									$97,000.00
5562	CCD Roaring Creek Flow Enhancement & Barrier Removal	Completed	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity									$147,069.00
5563	CCD Entiat PUD Canal System Conversion Concept	Conceptual	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity									$496,584.00
7501	CCD Below the Keystone Bridge	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity									$594,000.00
8521	CCD 2008 Lower Entiat Riparian Restoration	Completed	Entiat	Lower Entiat	4 Riparian Condition - Riparian Vegitation									$43,600.00
10293	CCD Tillicum Creek Fencing	Completed	Entiat	Lower Entiat	4 Riparian Condition - Riparian Vegitation									$80,000.00
10318	CCD 2007 Entiat Riparian Enhancement/Restoration	Completed	Entiat	Lower Entiat	4 Riparian Condition - Riparian Vegitation									$31,500.00
10695	CCD Entiat Canal Log Boom Installation	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity									$7,160.00
10700	CCD Entiat Demo Instream Rock Weirs	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity									
10710	CCD HD Wells Project	Completed	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity									
10754	CCD Knapp-Wham Hanan Detwiler Consolidation	Completed	Entiat	Lower Entiat	2 Injury and Mortality - Mechanical Injury									$552,912.00
10784	ICTU Entiat River Off-Channel Rearing Habitat	Completed	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$201,096.00
10786	ICTU Jon Small Off-Channel Rearing Pond	Completed	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$195,842.00
13556	CCD Entiat Intensively Monitored Watershed	Active	Entiat	Lower Entiat										
14308	at National Fish Hatchery Levee Removal and Restoration Project	Completed	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Floodplain Condition									$312,940.00
14452	CCNRD Entiat River Floodplain Reconnection	Active	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Floodplain Condition	$208,592.00								$208,592.00
15956	CCD 2010 Lower Entiat Riparian Restoration	Completed	Entiat	Lower Entiat	4 Riparian Condition - Riparian Vegitation									$70,412.00
16128	CCD Entiat ARRA Surface to Wells Conversion	Completed	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity									$487,200.00
16129	CCD Ecology Surface to Wells Conversions	Active	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity									
16130	CCD McKenzie Ditch Project	Conceptual	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$400,000.00
16149	CCD Entiat Fish Screen Project	Conceptual	Entiat	Lower Entiat	2 Injury and Mortality - Mechanical Injury									
16150	CCD Bridge to Bridge Phase III	Conceptual	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity									$650,000.00
16151	CCD Habitat Farming	Conceptual	Entiat	Lower Entiat										
16152	CCD-USFS Road Management	Conceptual	Entiat	Lower Entiat										
16920	BOR Lower Entiat Reach Assessment	Completed	Entiat	Lower Entiat										$111,000.00
17488	CCD 2011 Lower Entiat Riparian Restoration	Completed	Entiat	Lower Entiat	4 Riparian Condition - Riparian Vegitation									$85,590.08
17925	CCD Lower Entiat RM 0.8 - 2.3 Restoration	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity	$254,807.00								$254,807.00
17996	CCD Entiat PUD Canal System Conversion Phase II	Active	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity		$204,000.00							$204,000.00
18076	CCD Lower Entiat Off-Channel Restoration	Conceptual	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
18082	CCD Entiat National Fish Hatchery Restoration Phase II	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity	$254,654.00								$254,654.00
18710	U-WWP Roaring Crk Flow Restoration & Diversion Removal	Proposed	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity		$85,000.00							$85,000.00
18736	YN Keystone Habitat Complexity Project	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity									$90,000.00
19356	YN - Entiat River RM 2.6-3.5 Habitat Enhancement Project	Proposed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity	$397,000.00								$397,000.00
10293	CCD Tillicum Creek Fencing	Completed	Entiat	Mad River	4 Riparian Condition - Riparian Vegitation									$80,000.00
13556	CCD Entiat Intensively Monitored Watershed	Active	Entiat	Mad River										
10318	CCD 2007 Entiat Riparian Enhancement/Restoration	Completed	Entiat	Middle Entiat (Stillwater's)	4 Riparian Condition - Riparian Vegitation									$31,500.00
11914	BOR Stormy Reach Assessment	Completed	Entiat	Middle Entiat (Stillwater's)										$28,000.00
11916	BOR Preston Reach Assessment	Completed	Entiat	Middle Entiat (Stillwater's)										$138,000.00
13556	CCD Entiat Intensively Monitored Watershed	Active	Entiat	Middle Entiat (Stillwater's)										
14916	CDLT Entiat River Troy Acquisition	Completed	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition									$3,822,667.00
14919	CDLT Entiat River Tyee Ranch Conservation Easement Planning	Completed	Entiat	Middle Entiat (Stillwater's)										$39,600.00
14980	CDLT Entiat River Nava Acquisition	Completed	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition									$41,381.59
14981	CDLT Entiat River Dill Creek Acquisition	Completed	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition									$73,587.85
14982	CDLT Entiat River Beatley Acquisition	Completed	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition									$131,848.99
14983	CDLT Entiat River Stormy Creek Frank Thomas Acquisition	Completed	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition									$197,159.04
14991	CDLT Entiat River Cottonwood Flats Owen-Ritchie Acquisition	Completed	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition									$272,293.27
14992	CDLT Entiat River Brennegan Creek John Malone Acquisition	Completed	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition									$134,877.80
14994	CDLT Entiat River Grandma Creek Acquisition	Completed	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition									$1,280,832.67
15023	CCNRD Entiat Dillwater Engineered Log Structures	Completed	Entiat	Middle Entiat (Stillwater's)	6 Channel Structure and Form - Instream Structural Complexity									$347,500.00
15024	? Upper Preston Reach Habitat Complexity project	Completed	Entiat	Middle Entiat (Stillwater's)	6 Channel Structure and Form - Instream Structural Complexity									$406,800.00
15076	CDLT Entiat River Bancroft Conservation Easement	Completed	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition									$0.00
15842	CCD Entiat RM 21.5 LWD and Riparian Restoration	Completed	Entiat	Middle Entiat (Stillwater's)	6 Channel Structure and Form - Instream Structural Complexity									$535,000.00
15867	CCD Entiat River Tyee Ranch Restoration	Completed	Entiat	Middle Entiat (Stillwater's)	6 Channel Structure and Form - Instream Structural Complexity									$1,800,000.00
15880	BOR Entiat Tributary Assessment	Completed	Entiat	Middle Entiat (Stillwater's)										$400,000.00
15956	CCD 2010 Lower Entiat Riparian Restoration	Completed	Entiat	Middle Entiat (Stillwater's)	4 Riparian Condition - Riparian Vegitation									$70,412.00
16002	YN 3-D Habitat Enhancement Project	Completed	Entiat	Middle Entiat (Stillwater's)	6 Channel Structure and Form - Instream Structural Complexity									$2,200,000.00
16941	CDLT Entiat River Stormy Reach Acquisition Phase 2	Completed	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition									$336,000.00
17429	YN 3-D Reach Assessment	Completed	Entiat	Middle Entiat (Stillwater's)										$47,000.00
17982	CCNRD Cottonwood Flats Bridge Removal	Active	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition				$400,000.00					$400,000.00
18664	CDLT Entiat Gray Reach Acquisitions	Active	Entiat	Middle Entiat (Stillwater's)	5 Peripheral and Transitional Habitats - Floodplain Condition		$449,625.00							$449,625.00
17255	Large Wood Coordination	Conceptual	Entiat											
17507	CCD 2010/2011 Entiat River Appreciation	Completed	Entiat		4 Riparian Condition - Riparian Vegitation									$13,000.00
17876	TU-WWP Beaver Reintroduction and Flow Augmentation Project	Proposed	Entiat		9 Water Quantity - Decreased Water Quantity					$250,000.00				$250,000.00
18188	Lamprey	Conceptual	Entiat											
18662	WDFW Wenatchee-Entiat Rivers Screen Inventory & Design	Proposed	Entiat				$100,000.00							$100,000.00
13556	CCD Entiat Intensively Monitored Watershed	Active	Entiat	Upper Entiat										

Id	Project Name	Status	Subbasin	Assessment Unit	Ecological Concern	2014	2015	2016	2017	2018	2019	2020	2022	Budget
29598	Skinney Creek Floodplain Restoration Design	Proposed	Wenatchee					$75,000.00						$75,000.00
29602	Upper Peshastin Migration Barrier Design	Proposed	Wenatchee					$65,000.00						$65,000.00
1890	CCNRD Alder Creek Culvert #1 and 2	Completed	Wenatchee	Chiwawa River	1 Habitat Quantity - Anthropogenic Barriers									$315,774.01
1893	CCNRD Clear Creek Culvert Replacements	Completed	Wenatchee	Chiwawa River	1 Habitat Quantity - Anthropogenic Barriers									$216,840.00
10322	USFS Chiwawa Recreation Restoration	Completed	Wenatchee	Chiwawa River	4 Riparian Condition - Riparian Vegitation									$135,500.00
10332	USFS Chikamin Pumice Mine and Road Restoration Project	Completed	Wenatchee	Chiwawa River	7 Sediment Conditions - Increased Sediment Quantity									$140,000.00
10707	CCD & CCPW Chiwawa Loop Road Wetland Mitigation	Completed	Wenatchee	Chiwawa River	4 Riparian Condition - Riparian Vegitation									$34,000.00
15028	CCNRD Wenatchee Chiwawa Irrigation District Efficiences	Conceptual	Wenatchee	Chiwawa River										$170,000.00
16925	USFS Chiwawa River Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	Chiwawa River			$25,000.00							$25,000.00
18503	CCFEG Wenatchee Nutrient Assessment	Completed	Wenatchee	Chiwawa River	3 Food - Altered Primary Productivity	$256,828.00								$256,828.00
18702	CCFEG Chiwawa Nutrient Enhancement	Proposed	Wenatchee	Chiwawa River	3 Food - Altered Primary Productivity						$300,000.00			$300,000.00
29720	CCFEG Clear Creek Riparian Planting	Completed	Wenatchee	Chiwawa River	4 Riparian Condition - Riparian Vegitation									$400.00
1701	CCD Chumstick Fish Passage Complex	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers									$240,600.00
1769	CCNRD Chumstick/Eagle Riparian Restoration 2007	Completed	Wenatchee	Chumstick Creek	4 Riparian Condition - Riparian Vegitation									$73,283.64
10712	CCD McDevitt Diversion Project	Completed	Wenatchee	Chumstick Creek	2 Injury and Mortality - Mechanical Injury									$2,000.00
10783	CCNRD Wenatchee Instream Flow Habitat Project	Completed	Wenatchee	Chumstick Creek										$187,469.01
10791	CCNRD Chumstick 2009 North Road Culvert Replacement	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers									$1,818,779.00
11921	CCNRD Chumstick Creek Culvert Replacement 2009 Projects	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers									$2,513,324.23
15866	CCD Freund Canyon Barrier Removal	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers									$148,000.00
15957	CCNRD Chumstick Creek Culvert Replacement 2010 Project	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers									$60,000.00
15958	CCNRD Chumstick Creek Culvert Replacement 2011 Project	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers									$161,829.72
16142	TU-WWP Chumstick Creek Water Quantity Projects	Conceptual	Wenatchee	Chumstick Creek	9 Water Quantity - Decreased Water Quantity	$260,000.00								$260,000.00
16922	USFS Chumstick Creek Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	Chumstick Creek			$25,000.00							$25,000.00
16929	CCNRD Chumstick Creek Culvert Replacement 2012 Project	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers									$618,412.00
17508	CCD 2011 Chumstick Clean-up and Riparian Restoration	Completed	Wenatchee	Chumstick Creek	4 Riparian Condition - Riparian Vegitation									$16,000.00
17872	TU-WWP Lower Chumstick Flow Enhancement	Completed	Wenatchee	Chumstick Creek	9 Water Quantity - Decreased Water Quantity	$4,800.00								$4,800.00
19113	CCD Old Barn Farm Restoration	Completed	Wenatchee	Chumstick Creek	4 Riparian Condition - Riparian Vegitation									$3,500.00
1636	USFWS LNH Icicle Creek Restoration Project	Active	Wenatchee	Icicle Creek	1 Habitat Quantity - Anthropogenic Barriers		$5,700,000.00							$5,700,000.00
1653	ICTU Icicle Creek Reach Level Analysis	Completed	Wenatchee	Icicle Creek										$47,500.00
1764	CCNRD Icicle Revegetation Fromm 7	Completed	Wenatchee	Icicle Creek	4 Riparian Condition - Riparian Vegitation									$21,114.00
10783	CCNRD Wenatchee Instream Flow Habitat Project	Completed	Wenatchee	Icicle Creek										$187,469.01
10796	CDLT Lower Icicle Creek Habitat Conservation	Completed	Wenatchee	Icicle Creek	5 Peripheral and Transitional Habitats - Floodplain Condition									$420,000.00
10797	CDLT Icicle Creek Conservation Opportunities Outreach	Completed	Wenatchee	Icicle Creek										$30,500.00
13396	CCNRD Lower Icicle Riparian Initiative	Completed	Wenatchee	Icicle Creek	4 Riparian Condition - Riparian Vegitation									$40,749.00
16143	TU-WWP Icicle Creek Alternatives Analysis	Conceptual	Wenatchee	Icicle Creek	9 Water Quantity - Decreased Water Quantity				$176,000.00					$176,000.00
16429	CDLT Icicle Creek Copper Notch Conservation Easement	Completed	Wenatchee	Icicle Creek	5 Peripheral and Transitional Habitats - Floodplain Condition									$0.00
16924	USFS Icicle Creek Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	Icicle Creek			$25,000.00							$25,000.00
18087	CCNRD Icicle Irrigation District Efficiencies	Proposed	Wenatchee	Icicle Creek										
18143	CDLT Lower Wenatchee Leavenworth Audubon Center Acquisition	Completed	Wenatchee	Icicle Creek	5 Peripheral and Transitional Habitats - Floodplain Condition									$0.00
18204	TU-WWP - Icicle Creek Boulder Field Assessment	Completed	Wenatchee	Icicle Creek	1 Habitat Quantity - Anthropogenic Barriers	$123,854.00								$123,854.00
18500	CCFEG Salmon Lifecycle Landscape	Completed	Wenatchee	Icicle Creek										$10,000.00
18714	TU-WWP Icicle Boulder Field Passage Design	Proposed	Wenatchee	Icicle Creek			$185,000.00							$185,000.00
16565	CCNRD Lake Wenatchee Water Quality Monitoring	Completed	Wenatchee											$44,000.00
16926	USFS Little Wenatchee River Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	Little Wenatchee River			$25,000.00							$25,000.00
18503	CCFEG Wenatchee Nutrient Assessment	Completed	Wenatchee	Little Wenatchee River	3 Food - Altered Primary Productivity	$256,828.00								$256,828.00
1630	CCD & CCPW Sleepy Hollow Bridge Restoration Project	Completed	Wenatchee	Lower Wenatchee	6 Channel Structure and Form - Instream Structural Complexity									$16,500.00
1649	CCNRD FLIR Assessment	Completed	Wenatchee	Lower Wenatchee										$65,317.00
1655	CCD Jones-Shotwell Screen & Diversion Enhancement	Completed	Wenatchee	Lower Wenatchee	2 Injury and Mortality - Mechanical Injury									$303,091.00
1665	CCNRD Wenatchee Revegetation Leavenworth Golf Course	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation									$24,427.88
1684	CCD Riparian Revegetation on Wenatchee River 02	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation									$2,000.00
1688	CCNRD Irwin Riparian Restoration RM 24.3	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation									$99,932.00
1696	CCNRD Lower Wenatchee Channel Migration Zone Study	Completed	Wenatchee	Lower Wenatchee										$233,142.00
1735	CCNRD CMZ 20	Completed	Wenatchee	Lower Wenatchee	6 Channel Structure and Form - Instream Structural Complexity									$169,932.00
1792	CCNRD CMZ 11	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$427,573.08
1794	CCNRD CMZ 12 & 13	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$225,649.16
1889	CCNRD CMZ 10 Gagnon	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$513,775.00
7102	CCNRD Cashmere Pond Off-Channel Habitat	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$433,992.11
7103	YN Goodfellow/Chotzen Floodplain Reconnection	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$360,000.00
10639	PRCC Blackbird Island Side Channel Habitat Complexity	Completed	Wenatchee	Lower Wenatchee	6 Channel Structure and Form - Instream Structural Complexity									$150,000.00
10701	CCD Cummings Restoration Project	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation									$42,400.00
10751	WSDOT CMZ 6 US 2/97 Monitor Flats Channel Enhancement	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
10755	ICTU Blackbird Island Kids Fishing /Steelhead Acclimatization Pond	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$300,000.00
10758	ICTU & WDFW Blackbird Island Riparian Planting Project	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$250,000.00
10785	PUD Chelan Dryden Fish Enhancement CMZ Project	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$179,750.39
10788	ICTU Blackbird Island Channel Development	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$350,000.00
13373	CCNRD Wenatchee River Riparian Enhancement RM 11	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation									$60,088.27
13375	CCNRD Wenatchee River Riparian Enhancement RM 15.1	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation									$37,852.73
14464	CCNRD CMZ 6 Side Channel	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$120,451.67
14555	TU-WWP Lower Wenatchee River Instream Flow Enhancement Project	Completed	Wenatchee	Lower Wenatchee	9 Water Quantity - Decreased Water Quantity									$3,467,842.00
15012	CCD CMZ 2 Lower Sleepy Hollow Island Riparian Restoration	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation									$52,000.00
15025	CCNRD Lower Wenatchee River Leavenworth Boat Launch Off-channel Reconnection	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$149,500.00
16001	YN Sunnyslope ELJ	Completed	Wenatchee	Lower Wenatchee	6 Channel Structure and Form - Instream Structural Complexity									$400,000.00
16298	CCNRD Wenatchee River Riparian Enhancement RM 1.4	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation									$43,372.92
16300	CCNRD Wenatchee River Riparian Enhancement RM 13.6	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation									$39,474.05

16928	USFS Wenatchee River mainstem Minimum Roads Analysis and Road System Improvement	Proposed	Wenatchee	Lower Wenatchee			$25,000.00						$25,000.00
16938	CCNRD Old Peshastin Mill Riparian Enhancement	Active	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation		$86,285.00						$86,285.00
17985	CDLT Wenatchee River Lower Sleepy Hollow Floodplain Conservation Easements	Proposed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Floodplain Condition								$545,000.00
18091	CCNRD Lower Wenatchee Levee Removal	Active	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Floodplain Condition	$68,000.00							$68,000.00
19319	UCSRB Joy Creek Fish Passage Project	Active	Wenatchee	Lower Wenatchee	1 Habitat Quantity - Anthropogenic Barriers		$100,000.00						$100,000.00
1694	CCD Lower Mission Creek Planting Project	Completed	Wenatchee	Mission Creek	4 Riparian Condition - Riparian Vegitation								$110,000.00
1698	CCNRD Brender Creek Habitat Development	Completed	Wenatchee	Mission Creek	6 Channel Structure and Form - Bed and Channel Form								$46,931.00
1768	CCNRD Mission Creek Riparian Restoration 2007	Completed	Wenatchee	Mission Creek	4 Riparian Condition - Riparian Vegitation								$20,014.44
8523	CCD Mission Creek Diversion/Screens 2008	Completed	Wenatchee	Mission Creek	6 Channel Structure and Form - Instream Structural Complexity								$25,000.00
10315	CCD & CCPW Yaksum Creek-Horner Restoration Project	Completed	Wenatchee	Mission Creek	4 Riparian Condition - Riparian Vegitation								$36,900.00
10709	CCD Brender Creek Pond	Completed	Wenatchee	Mission Creek	4 Riparian Condition - Riparian Vegitation								$5,000.00
10711	CCD Mission Creek Habitat Restoration and Streambank Stabilization Project	Completed	Wenatchee	Mission Creek	6 Channel Structure and Form - Bed and Channel Form								$32,600.00
14458	CCD Yaksum Creek Riparian Enhancement	Completed	Wenatchee	Mission Creek	6 Channel Structure and Form - Instream Structural Complexity								$25,000.00
16132	TU-WWP Mission Creek Water Quantity Projects	Conceptual	Wenatchee	Mission Creek	9 Water Quantity - Decreased Water Quantity								$260,000.00
16923	USFS Mission Creek Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	Mission Creek			$25,000.00						$25,000.00
1888	CCNRD Nason Creek 2007 Oxbow Reconnection	Completed	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Floodplain Condition								$800,000.00
7174	Nason Creek Kahler Design	Proposed	Wenatchee	Wenatchee - Nason Creek	6 Channel Structure and Form - Instream Structural Complexity			$175,000.00					$175,000.00
10645	WSDOT Mill Creek Culvert Replacement	Completed	Wenatchee	Wenatchee - Nason Creek	1 Habitat Quantity - Anthropogenic Barriers								$1,300,000.00
10747	BOR Nason Creek Assessments	Completed	Wenatchee	Wenatchee - Nason Creek									$414,000.00
10752	PUD Grant - Nason Creek Godwin Parcel Purchase	Completed	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Floodplain Condition								
10783	CCNRD Wenatchee Instream Flow Habitat Project	Completed	Wenatchee	Wenatchee - Nason Creek									$187,469.01
10792	CCNRD BNSF Railroad and Wenatchee Basin Coordination	Completed	Wenatchee	Wenatchee - Nason Creek									$54,125.00
13410	CCNRD Nason N4 oxbow reconnection	Completed	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions								$791,300.50
14462	CCNRD Nason Creek Lower White Pine Reconnection Project	Completed	Wenatchee	Wenatchee - Nason Creek	1 Habitat Quantity - Anthropogenic Barriers								$99,166.00
14463	CCNRD Nason Creek Upper White Pine Reach 2 Restoration	Active	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions		$225,000.00						$225,000.00
15026	CCNRD Nason N1-KDIZ3 Floodplain Reconnection	Active	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions		$107,300.00						$107,300.00
16127	USFS Nason Creek Minimum Roads Analysis	Completed	Wenatchee	Wenatchee - Nason Creek									$25,000.00
16258	YN Nason Creek Inner Zone Project Identification	Completed	Wenatchee	Wenatchee - Nason Creek									$15,000.00
16921	USFS Upper Peshastin Creek Roads Inventory	Active	Wenatchee	Wenatchee - Nason Creek							$100,000.00		$100,000.00
16939	CCNRD Nason Creek Coulter Creek Barrier Replacement	Active	Wenatchee	Wenatchee - Nason Creek	1 Habitat Quantity - Anthropogenic Barriers	$169,134.00							$169,134.00
16994	CDLT Nason Creek Lower White Pine Alcove Acquisition	Completed	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Floodplain Condition	$294,700.00							$294,700.00
18503	CCFEG Wenatchee Nutrient Assessment	Completed	Wenatchee	Wenatchee - Nason Creek	3 Food - Altered Primary Productivity	$256,828.00							$256,828.00
18665	CDLT Nason Creek UWP Horseshoe Bend Acquisitions	Active	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Floodplain Condition		$379,700.00						$379,700.00
29743	1st Bend Nason LWP Habitat Restoration Project	Completed	Wenatchee	Wenatchee - Nason Creek	4 Riparian Condition - Riparian Vegitation								$378,428.00
29743	1st Bend Nason LWP Habitat Restoration Project	Completed	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Nearshore Conditions								$378,428.00
29743	1st Bend Nason LWP Habitat Restoration Project	Completed	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions								$378,428.00
29743	1st Bend Nason LWP Habitat Restoration Project	Completed	Wenatchee	Wenatchee - Nason Creek	6 Channel Structure and Form - Bed and Channel Form								$378,428.00
29743	1st Bend Nason LWP Habitat Restoration Project	Completed	Wenatchee	Wenatchee - Nason Creek	6 Channel Structure and Form - Instream Structural Complexity								$378,428.00
29746	Upper White Pine Sub-Reaches 3&4 Habitat Restoration Project	Proposed	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Nearshore Conditions								
29746	Upper White Pine Sub-Reaches 3&4 Habitat Restoration Project	Proposed	Wenatchee	Wenatchee - Nason Creek	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions								
1731	Longview Fibre Culvert Conversion (7)	Completed	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers								
1791	CCNRD Peshastin Irrigation Pipeline Schedule A	Completed	Wenatchee		9 Water Quantity - Decreased Water Quantity								$906,622.00
10317	CCD Mill Creek Ditch Fish Passage Improvement Project	Completed	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers								$35,000.00
10321	USFS Sand Creek and Little Camas Creek Culvert Replacement	Completed	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers								$150,000.00
10748	YN Peshastin Creek Reach Assessment	Completed	Wenatchee										$160,000.00
10757	ICTU & WDFW Brender Creek Riparian Planting Project	Completed	Wenatchee		4 Riparian Condition - Riparian Vegitation								$55,000.00
10780	CCNRD Peshastin Creek Fishway	Completed	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers								$237,950.31
10783	CCNRD Wenatchee Instream Flow Habitat Project	Completed	Wenatchee										$187,469.01
14449	CCNRD Peshastin Creek Reconnection Alternatives Analysis (RM 3.9)	Completed	Wenatchee		5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions								$98,102.00
15027	CCNRD Peshastin Irrigation District Pump Exchange	Active	Wenatchee		9 Water Quantity - Decreased Water Quantity								
16093	CCNRD Peshastin Irrigation Pipeline Schedule B	Completed	Wenatchee		9 Water Quantity - Decreased Water Quantity								$304,960.86
16133	TU-WWP Peshastin Creek Water Quantity Projects	Conceptual	Wenatchee		9 Water Quantity - Decreased Water Quantity								$45,000.00
16937	CCNRD Mill Creek Culvert Replacement Mountain Home Ranch Rd	Active	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers	$390,081.00							$390,081.00
17929	CCNRD Peshastin BRG Side Channel	Active	Wenatchee		5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions			$199,000.00					$199,000.00
17983	CCNRD Upper Peshastin Creek Reach Assessment	Conceptual	Wenatchee										$135,000.00
17984	CCNRD Ruby Creek barrier replacement	Conceptual	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers								$100,000.00
18711	CCNRD Camas Creek Fish Passage	Conceptual	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers								
18716	Restore Lower Peshastin Creek - Design	Proposed	Wenatchee		5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions		$140,000.00						$140,000.00
18737	YN Peshastin Creek RM 0.8	Completed	Wenatchee		5 Peripheral and Transitional Habitats - Floodplain Condition								$160,000.00
18738	YN Peshastin Fishway	Conceptual	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers								$130,000.00
17255	Large Wood Coordination	Conceptual	Wenatchee										
17876	TU-WWP Beaver Reintroduction and Flow Augmentation Project	Proposed	Wenatchee		9 Water Quantity - Decreased Water Quantity					$250,000.00			$250,000.00
18188	Lamprey	Conceptual	Wenatchee										
18662	WDFW Wenatchee-Entiat Rivers Screen Inventory & Design	Proposed	Wenatchee				$100,000.00						$100,000.00
1706	CCNRD Beaver Creek #1, 2 & 3	Completed	Wenatchee	Upper Wenatchee (Lake to Tumwater) and Chiwaukum Creek	1 Habitat Quantity - Anthropogenic Barriers								$235,676.55
1763	CCNRD Upper Skinney Creek Culvert	Completed	Wenatchee	Upper Wenatchee (Lake to Tumwater) and Chiwaukum Creek	1 Habitat Quantity - Anthropogenic Barriers								$75,991.00
10646	WSDOT Skinney Creek Culvert Replacements (3)	Completed	Wenatchee	Upper Wenatchee (Lake to Tumwater) and Chiwaukum Creek	1 Habitat Quantity - Anthropogenic Barriers								$1,300,000.00
10783	CCNRD Wenatchee Instream Flow Habitat Project	Completed	Wenatchee	Upper Wenatchee (Lake to Tumwater) and Chiwaukum Creek									$187,469.01
15022	USFS Skinney Creek Restoration	Proposed	Wenatchee	Upper Wenatchee (Lake to Tumwater) and Chiwaukum Creek									$125,000.00

16028	CCNRD Ponderosa Community Riparian Assessment and Planting	Completed	Wenatchee	Upper Wenatchee (Lake to Tumwater) and Chiwaukum Creek										$25,077.00
16353	YN Upper Wenatchee Stream Corridor Assessment and Habitat Restoration Strategy	Completed	Wenatchee	Upper Wenatchee (Lake to Tumwater) and Chiwaukum Creek										$300,000.00
16928	USFS Wenatchee River mainstem Minimum Roads Analysis and Road System Improvement	Proposed	Wenatchee	Upper Wenatchee (Lake to Tumwater) and Chiwaukum Creek			$25,000.00							$25,000.00
17879	TU-WWP Beaver Creek Diversion Conversion	Conceptual	Wenatchee	Upper Wenatchee (Lake to Tumwater) and Chiwaukum Creek	9 Water Quantity - Decreased Water Quantity									
29683	CCFEG - Thomson Creek Culvert Replacement	Completed	Wenatchee	Upper Wenatchee (Lake to Tumwater) and Chiwaukum Creek	1 Habitat Quantity - Anthropogenic Barriers									
1651	CDLT White River Martin Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$170,000.00
10328	USFS White River Log Jam	Completed	Wenatchee	White River	6 Channel Structure and Form - Instream Structural Complexity									$80,000.00
10330	USFS White River Oxbow Restoration Project	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
14507	CDLT White River Nason View Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$684,000.00
14508	CDLT White River Tall Timber Ranch Conservation Easement	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$583,810.00
15032	CDLT White River Kasparek Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$35,955.39
15035	CDLT White River Bjorgen Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$96,333.01
15036	CDLT White River Kincaid Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$112,408.13
15038	CDLT White River Two Rivers Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$587,544.99
15044	CDLT White River RM 9 Conservation Easement	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$440,000.00
15045	CDLT White River RM 8.5 Conservation Easement	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$194,000.00
15048	CDLT White River Quintana-Leon Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$259,184.13
15051	CDLT White River Quintana-Leon II Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$315,000.00
15959	CDLT White River Tiegel Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition									$199,500.00
16927	USFS White River Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	White River			$25,000.00							$25,000.00
16940	CCFEG Large Wood Atonement White River	Active	Wenatchee	White River	6 Channel Structure and Form - Instream Structural Complexity	$352,392.00								$352,392.00
17926	CDLT White River Tall Timber Ranch Conservation Easement Phase 2	Active	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition	$229,500.00								$229,500.00
18495	CCFEG Napeequa and White River Riparian Planting	Completed	Wenatchee	White River	4 Riparian Condition - Riparian Vegitation									$47,400.00
18503	CCFEG Wenatchee Nutrient Assessment	Completed	Wenatchee	White River	3 Food - Altered Primary Productivity	$256,828.00								$256,828.00

UC Mainstem Tributaries, Regionwide, and other areas Implementaiton Schedule

Id	Project Name	Status	Subbasin	Assessment Unit	Ecological Concern	2014	2015	2016	2017	2018	2019	2020	2022	Budget
19188	Test 2 RM 2	Active												
19395	TU-WWP Jones-Shotwell Irrigation Efficiency Upgrade	Active												
29603	Burns-Garrity Floodplain Enhance - Implementation	Proposed								$185,000.00				$185,000.00
10643	YN Upper Columbia Habitat Restoration	Active	Mainstem Tributaries	Chelan Co Tribs						$0.00				$0.00
10793	CCNRD Chelan County Fish Barrier Inventory	Completed	Mainstem Tributaries	Chelan Co Tribs										$75,004.31
11908	CCNRD Wenatchee Watershed Planning	Completed	Mainstem Tributaries	Chelan Co Tribs										
11911	WSDOT SR 971 First Creek Culvert Replacement	Completed	Mainstem Tributaries	Chelan Co Tribs	1 Habitat Quantity - Anthropogenic Barriers									$200,000.00
15030	CCFEG Assessing Nutrient Enhancement Logistics - Upper Columbia	Completed	Mainstem Tributaries	Chelan Co Tribs										$9,875.00
15836	Chelan Co. Knotweed inventory and control	Active	Mainstem Tributaries	Chelan Co Tribs	4 Riparian Condition - Riparian Vegitation		$80,000.00							$80,000.00
16091	Chelan County Watershed Outreach Plan	Completed	Mainstem Tributaries	Chelan Co Tribs										$8,000.00
16183	BOR Project Reviews	Active	Mainstem Tributaries	Chelan Co Tribs										
10781	ICTU Beebe Creek Channel Reconfiguration	Completed	Mainstem Tributaries	Columbia Mainstem	6 Channel Structure and Form - Bed and Channel Form									$399,948.00
13248	CCT Abell - Barnaby Creek Culvert Replacement	Completed	Mainstem Tributaries	Columbia Mainstem	1 Habitat Quantity - Anthropogenic Barriers									$68,560.00
1356	East Foster Creek Sediment Control Structure #1	Completed	Mainstem Tributaries	Douglas Co Tribs	7 Sediment Conditions - Increased Sediment Quantity									$135,000.00
2708	Sand Canyon Creek Clean-Up Spring 2008- Phase 1	Completed	Mainstem Tributaries	Douglas Co Tribs	5 Peripheral and Transitional Habitats - Floodplain Condition									$12,040.00
3032	East Foster Creek Sediment Control Structure #2	Completed	Mainstem Tributaries	Douglas Co Tribs	7 Sediment Conditions - Increased Sediment Quantity									
3036	Planning and Assessment Projects 2006-2010	Active	Mainstem Tributaries	Douglas Co Tribs										
3039	Riparian Roads Survey	Completed	Mainstem Tributaries	Douglas Co Tribs	4 Riparian Condition - Riparian Vegitation									
3041	Foster Creek Slope Stabilization	Completed	Mainstem Tributaries	Douglas Co Tribs	7 Sediment Conditions - Increased Sediment Quantity									
3043	Voluntary Regional Agreement (VRA) Feasibility Study- Columbia River	Active	Mainstem Tributaries	Douglas Co Tribs										
3044	Stream Monitoring and Water Quality	Active	Mainstem Tributaries	Douglas Co Tribs										
3053	r Coulee and Rock Island Creek Surface Water Storage Feasability Study	Proposed	Mainstem Tributaries	Douglas Co Tribs										$93,750.00
3056	Feasibility of Rearing Ponds near Chief Joseph Dam	Proposed	Mainstem Tributaries	Douglas Co Tribs										
3057	Bridgeport Bar Water System Consolidation	Proposed	Mainstem Tributaries	Douglas Co Tribs										
13052	Sand Canyon Creek Clean-Up Fall 2008- Phase 2	Completed	Mainstem Tributaries	Douglas Co Tribs	5 Peripheral and Transitional Habitats - Floodplain Condition									$2,300.00
13056	Bridgeport High School Senior Projects	Completed	Mainstem Tributaries	Douglas Co Tribs	4 Riparian Condition - Riparian Vegitation									
13058	Lower Moses Coulee Recharge Basin	Completed	Mainstem Tributaries	Douglas Co Tribs	9 Water Quantity - Altered Flow Timing									$42,500.00
15014	West Foster Creek Headcut Repair	Proposed	Mainstem Tributaries	Douglas Co Tribs	7 Sediment Conditions - Increased Sediment Quantity									$250,000.00
15015	West Foster Creek Stream Restoration	Proposed	Mainstem Tributaries	Douglas Co Tribs										$150,000.00
15016	Continued Operation and Maintenance of East Foster projects	Active	Mainstem Tributaries	Douglas Co Tribs										
15020	Wetlands and Ponds Assessment, Douglas County	Proposed	Mainstem Tributaries	Douglas Co Tribs										$350,000.00
15021	Volunteer Monitoring Program at Rock Island Lakes	Proposed	Mainstem Tributaries	Douglas Co Tribs										$30,000.00
15835	Lower Moses Coulee Shallow Aquifer Recharge Feasibility Study	Proposed	Mainstem Tributaries	Douglas Co Tribs										$167,500.00
17277	Livestock Access Project	Active	Mainstem Tributaries	Douglas Co Tribs	7 Sediment Conditions - Increased Sediment Quantity									$35,500.00
18010	Lower Foster Creek Steelhead Habitat Enhancement	Proposed	Mainstem Tributaries	Douglas Co Tribs	6 Channel Structure and Form - Instream Structural Complexity									$92,000.00
13257	CCT Colville Confederated Tribes Action Agency MOA	Active	Regionwide											
13308	YN Yakama Nations Action Agency MOA	Active	Regionwide											
16907	Witnessing Change	Conceptual	Regionwide											

17058	CCT Omak Creek Riparian Habitat Concept	Conceptual	Okanogan		4 Riparian Condition - Riparian Vegitation	$1,200,000.00									$1,200,000.00
19188	Test 2 RM 2	Active													
19395	TU-WWP Jones-Shotwell Irrigation Efficiency Upgrade	Active													
19400	TU-WWP Bear Creek Storage and Reconnection Feasibility Study	Conceptual	Methow		9 Water Quantity - Decreased Water Quantity										
29598	Skinney Creek Floodplain Restoration Design	Proposed	Wenatchee						$75,000.00						$75,000.00
29601	Barkley Irrigation Company: Under Pressure	Proposed	Methow					$700,000.00							$700,000.00
29602	Upper Peshastin Migration Barrier Design	Proposed	Wenatchee						$65,000.00						$65,000.00
29603	Burns-Garrity Floodplain Enhance - Implementation	Proposed									$185,000.00				$185,000.00
29604	Goat Creek Complexity for Confluentus	Proposed	Methow							$130,000.00					$130,000.00
29605	M2 Lewisia Floodplain Design	Proposed	Methow						$190,000.00						$190,000.00
29606	Methow Watershed Riparian Stewardship Program	Proposed	Methow							$77,300.00					$77,300.00
29607	Methow Watershed Beaver Reintroduction	Proposed	Methow							$211,000.00					$211,000.00
29721	CCFEG 25 Mile Creek Passage Improvement Project	Completed	Methow			$19,649.00									$19,649.00
29723	CCFEG - Twisp to Carlton Reach Assessment	Active	Methow					$173,016.00							$173,016.00
29742	CCFEG - Stormy Creek Barrier Removals	Active	Entiat												
1785	CCNRD Harrison Side Channel	Completed	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$177,454.93
1786	CCNRD & CCD Hanan Detwiler Instream Structures	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity										$91,000.00
1892	CCD Bridge to Bridge Phase I	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Bed and Channel Form										$185,000.00
1894	CCNRD & CCD Milne Entiat Instream Structures	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity										$97,000.00
5562	CCD Roaring Creek Flow Enhancement & Barrier Removal	Completed	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity										$147,069.00
5563	CCD Entiat PUD Canal System Conversion Concept	Conceptual	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity										$496,584.00
7501	CCD Below the Keystone Bridge	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity										$594,000.00
8521	CCD 2008 Lower Entiat Riparian Restoration	Completed	Entiat	Lower Entiat	4 Riparian Condition - Riparian Vegitation										$43,600.00
10293	CCD Tillicum Creek Fencing	Completed	Entiat	Lower Entiat	4 Riparian Condition - Riparian Vegitation										$80,000.00
10318	CCD 2007 Entiat Riparian Enhancement/Restoration	Completed	Entiat	Lower Entiat	4 Riparian Condition - Riparian Vegitation										$31,500.00
10695	CCD Entiat Canal Log Boom Installation	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity										$7,160.00
10700	CCD Entiat Demo Instream Rock Weirs	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity										
10710	CCD HD Wells Project	Completed	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity										
10754	CCD Knapp-Wham Hanan Detwiler Consolidation	Completed	Entiat	Lower Entiat	2 Injury and Mortality - Mechanical Injury										$552,912.00
10784	ICTU Entiat River Off-Channel Rearing Habitat	Completed	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$201,096.00
10786	ICTU Jon Small Off-Channel Rearing Pond	Completed	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$195,842.00
13556	CCD Entiat Intensively Monitored Watershed	Active	Entiat	Lower Entiat											
14308	CCD Entiat National Fish Hatchery Levee Removal and Restoration Project	Completed	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Floodplain Condition										$312,940.00
14452	CCNRD Entiat River Floodplain Reconnection	Active	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Floodplain Condition		$208,592.00								$208,592.00
15956	CCD 2010 Lower Entiat Riparian Restoration	Completed	Entiat	Lower Entiat	4 Riparian Condition - Riparian Vegitation										$70,412.00
16128	CCD Entiat ARRA Surface to Wells Conversion	Completed	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity										$487,200.00
16129	CCD Ecology Surface to Wells Conversions	Active	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity										
16130	CCD McKenzie Ditch Project	Conceptual	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$400,000.00
16149	CCD Entiat Fish Screen Project	Conceptual	Entiat	Lower Entiat	2 Injury and Mortality - Mechanical Injury										
16150	CCD Bridge to Bridge Phase III	Conceptual	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity										$650,000.00
16151	CCD Habitat Farming	Conceptual	Entiat	Lower Entiat											
16152	CCD-USFS Road Management	Conceptual	Entiat	Lower Entiat											
16920	BOR Lower Entiat Reach Assessment	Completed	Entiat	Lower Entiat											$111,000.00
17488	CCD 2011 Lower Entiat Riparian Restoration	Completed	Entiat	Lower Entiat	4 Riparian Condition - Riparian Vegitation										$85,590.08
17925	CCD Lower Entiat RM 0.8 - 2.3 Restoration	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity		$254,807.00								$254,807.00
17996	CCD Entiat PUD Canal System Conversion Phase II	Active	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity			$204,000.00							$204,000.00
18076	CCD Lower Entiat Off-Channel Restoration	Conceptual	Entiat	Lower Entiat	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										
18082	CCD Entiat National Fish Hatchery Restoration Phase II	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity		$254,654.00								$254,654.00
18710	TU-WWP Roaring Crk Flow Restoration & Diversion Removal	Proposed	Entiat	Lower Entiat	9 Water Quantity - Decreased Water Quantity			$85,000.00							$85,000.00
18736	YN Keystone Habitat Complexity Project	Completed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity										$90,000.00
19356	YN - Entiat River RM 2.6-3.5 Habitat Enhancement Project	Proposed	Entiat	Lower Entiat	6 Channel Structure and Form - Instream Structural Complexity		$397,000.00								$397,000.00
10293	CCD Tillicum Creek Fencing	Completed	Entiat	Mad River	4 Riparian Condition - Riparian Vegitation										$80,000.00
13556	CCD Entiat Intensively Monitored Watershed	Active	Entiat	Mad River											
10318	CCD 2007 Entiat Riparian Enhancement/Restoration	Completed	Entiat	Middle Entiat (Stillwa	4 Riparian Condition - Riparian Vegitation										$31,500.00
11914	BOR Stormy Reach Assessment	Completed	Entiat	Middle Entiat (Stillwa											$28,000.00
11916	BOR Preston Reach Assessment	Completed	Entiat	Middle Entiat (Stillwa											$138,000.00
13556	CCD Entiat Intensively Monitored Watershed	Active	Entiat	Middle Entiat (Stillwa											
14916	CDLT Entiat River Troy Acquisition	Completed	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition										$3,822,667.00
14919	CDLT Entiat River Tyee Ranch Conservation Easement Planning	Completed	Entiat	Middle Entiat (Stillwa											$39,600.00
14980	CDLT Entiat River Nava Acquisition	Completed	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition										$41,381.59
14981	CDLT Entiat River Dill Creek Acquisition	Completed	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition										$73,587.85
14982	CDLT Entiat River Beatley Acquisition	Completed	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition										$131,848.99
14983	CDLT Entiat River Stormy Creek Frank Thomas Acquisition	Completed	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition										$197,159.04
14991	CDLT Entiat River Cottonwood Flats Owen-Ritchie Acquisition	Completed	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition										$272,293.27
14992	CDLT Entiat River Brennegan Creek John Malone Acquisition	Completed	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition										$134,877.80
14994	CDLT Entiat River Grandma Creek Acquisition	Completed	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition										$1,280,832.67
15023	CCNRD Entiat Dillwater Engineered Log Structures	Completed	Entiat	Middle Entiat (Stillwa	6 Channel Structure and Form - Instream Structural Complexity										$347,500.00
15024	? Upper Preston Reach Habitat Complexity project	Completed	Entiat	Middle Entiat (Stillwa	6 Channel Structure and Form - Instream Structural Complexity										$406,800.00
15076	CDLT Entiat River Bancroft Conservation Easement	Completed	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition										$0.00
15842	CCD Entiat RM 21.5 LWD and Riparian Restoration	Completed	Entiat	Middle Entiat (Stillwa	6 Channel Structure and Form - Instream Structural Complexity										$535,000.00
15867	CCD Entiat River Tyee Ranch Restoration	Completed	Entiat	Middle Entiat (Stillwa	6 Channel Structure and Form - Instream Structural Complexity	$1,800,000.00									$1,800,000.00
15880	BOR Entiat Tributary Assessment	Completed	Entiat	Middle Entiat (Stillwa											$400,000.00
15956	CCD 2010 Lower Entiat Riparian Restoration	Completed	Entiat	Middle Entiat (Stillwa	4 Riparian Condition - Riparian Vegitation										$70,412.00

16002	YN 3-D Habitat Enhancement Project	Completed	Entiat	Middle Entiat (Stillwa	6 Channel Structure and Form - Instream Structural Complexity										$2,200,000.00
16941	CDLT Entiat River Stormy Reach Acquisition Phase 2	Completed	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition										$336,000.00
17429	YN 3-D Reach Assessment	Completed	Entiat	Middle Entiat (Stillwa											$47,000.00
17982	CCNRD Cottonwood Flats Bridge Removal	Active	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition					$400,000.00					$400,000.00
18664	CDLT Entiat Gray Reach Acquisitions	Active	Entiat	Middle Entiat (Stillwa	5 Peripheral and Transitional Habitats - Floodplain Condition			$449,625.00							$449,625.00
17255	Large Wood Coordination	Conceptual	Entiat												
17507	CCD 2010/2011 Entiat River Appreciation	Completed	Entiat		4 Riparian Condition - Riparian Vegitation										$13,000.00
17876	TU-WWP Beaver Reintroduction and Flow Augmentation Project	Proposed	Entiat		9 Water Quantity - Decreased Water Quantity						$250,000.00				$250,000.00
18188	Lamprey	Conceptual	Entiat												
18662	WDFW Wenatchee-Entiat Rivers Screen Inventory & Design	Proposed	Entiat					$100,000.00							$100,000.00
13556	CCD Entiat Intensively Monitored Watershed	Active	Entiat	Upper Entiat											
10643	YN Upper Columbia Habitat Restoration	Active	Mainstem Tributaries	Chelan Co Tribs							$0.00				$0.00
10793	CCNRD Chelan County Fish Barrier Inventory	Completed	Mainstem Tributaries	Chelan Co Tribs											$75,004.31
11908	CCNRD Wenatchee Watershed Planning	Completed	Mainstem Tributaries	Chelan Co Tribs											
11911	WSDOT SR 971 First Creek Culvert Replacement	Completed	Mainstem Tributaries	Chelan Co Tribs	1 Habitat Quantity - Anthropogenic Barriers										$200,000.00
15030	CCFEG Assessing Nutrient Enhancement Logistics - Upper Columbia	Completed	Mainstem Tributaries	Chelan Co Tribs											$9,875.00
15836	Chelan Co. Knotweed inventory and control	Active	Mainstem Tributaries	Chelan Co Tribs	4 Riparian Condition - Riparian Vegitation			$80,000.00							$80,000.00
16091	Chelan County Watershed Outreach Plan	Completed	Mainstem Tributaries	Chelan Co Tribs											$8,000.00
16183	BOR Project Reviews	Active	Mainstem Tributaries	Chelan Co Tribs											
10781	ICTU Beebe Creek Channel Reconfiguration	Completed	Mainstem Tributaries	Columbia Mainstem	6 Channel Structure and Form - Bed and Channel Form										$399,948.00
13248	CCT Abell - Barnaby Creek Culvert Replacement	Completed	Mainstem Tributaries	Columbia Mainstem	1 Habitat Quantity - Anthropogenic Barriers										$68,560.00
1356	East Foster Creek Sediment Control Structure #1	Completed	Mainstem Tributaries	Douglas Co Tribs	7 Sediment Conditions - Increased Sediment Quantity										$135,000.00
2708	Sand Canyon Creek Clean-Up Spring 2008- Phase 1	Completed	Mainstem Tributaries	Douglas Co Tribs	5 Peripheral and Transitional Habitats - Floodplain Condition										$12,040.00
3032	East Foster Creek Sediment Control Structure #2	Completed	Mainstem Tributaries	Douglas Co Tribs	7 Sediment Conditions - Increased Sediment Quantity										
3036	Planning and Assessment Projects 2006-2010	Active	Mainstem Tributaries	Douglas Co Tribs											
3039	Riparian Roads Survey	Completed	Mainstem Tributaries	Douglas Co Tribs	4 Riparian Condition - Riparian Vegitation										
3041	Foster Creek Slope Stabilization	Completed	Mainstem Tributaries	Douglas Co Tribs	7 Sediment Conditions - Increased Sediment Quantity										
3043	Voluntary Regional Agreement (VRA) Feasibility Study- Columbia River	Active	Mainstem Tributaries	Douglas Co Tribs											
3044	Stream Monitoring and Water Quality	Active	Mainstem Tributaries	Douglas Co Tribs											
3053	Foster Coulee and Rock Island Creek Surface Water Storage Feasability Study	Proposed	Mainstem Tributaries	Douglas Co Tribs											$93,750.00
3056	Feasibility of Rearing Ponds near Chief Joseph Dam	Proposed	Mainstem Tributaries	Douglas Co Tribs											
3057	Bridgeport Bar Water System Consolidation	Proposed	Mainstem Tributaries	Douglas Co Tribs											
13052	Sand Canyon Creek Clean-Up Fall 2008- Phase 2	Completed	Mainstem Tributaries	Douglas Co Tribs	5 Peripheral and Transitional Habitats - Floodplain Condition										$2,300.00
13056	Bridgeport High School Senior Projects	Completed	Mainstem Tributaries	Douglas Co Tribs	4 Riparian Condition - Riparian Vegitation										
13058	Lower Moses Coulee Recharge Basin	Completed	Mainstem Tributaries	Douglas Co Tribs	9 Water Quantity - Altered Flow Timing										$42,500.00
15014	West Foster Creek Headcut Repair	Proposed	Mainstem Tributaries	Douglas Co Tribs	7 Sediment Conditions - Increased Sediment Quantity										$250,000.00
15015	West Foster Creek Stream Restoration	Proposed	Mainstem Tributaries	Douglas Co Tribs		$150,000.00									$150,000.00
15016	Continued Operation and Maintenance of East Foster projects	Active	Mainstem Tributaries	Douglas Co Tribs											
15020	Wetlands and Ponds Assessment, Douglas County	Proposed	Mainstem Tributaries	Douglas Co Tribs		$350,000.00									$350,000.00
15021	Volunteer Monitoring Program at Rock Island Lakes	Proposed	Mainstem Tributaries	Douglas Co Tribs											$30,000.00
15835	Lower Moses Coulee Shallow Aquifer Recharge Feasibility Study	Proposed	Mainstem Tributaries	Douglas Co Tribs											$167,500.00
17277	Livestock Access Project	Active	Mainstem Tributaries	Douglas Co Tribs	7 Sediment Conditions - Increased Sediment Quantity										$35,500.00
18010	Lower Foster Creek Steelhead Habitat Enhancement	Proposed	Mainstem Tributaries	Douglas Co Tribs	6 Channel Structure and Form - Instream Structural Complexity	$92,000.00									$92,000.00
13265	OCD Beaver Cr Coordinated Resource Mgt Plan	Completed	Methow	Beaver / Bear Creek											$81,464.00
13268	OCD Redshirt Barrier Removal	Completed	Methow	Beaver / Bear Creek	1 Habitat Quantity - Anthropogenic Barriers										$75,400.00
13269	OCD Thurlow Transfer Ditch Barrier and Piping Concept	Completed	Methow	Beaver / Bear Creek	9 Water Quantity - Decreased Water Quantity										$475,122.00
13271	OCD Beaver Creek Fish Passage Barriers (5)	Completed	Methow	Beaver / Bear Creek	1 Habitat Quantity - Anthropogenic Barriers										$30,000.00
13272	OCD Fort-Thurlow Lower Beaver Piping	Completed	Methow	Beaver / Bear Creek	9 Water Quantity - Decreased Water Quantity										$180,913.00
13276	OCD Marrachi Diversion	Completed	Methow	Beaver / Bear Creek	1 Habitat Quantity - Anthropogenic Barriers										$105,882.00
13332	MSRF Upper Beaver Creek Habitat Improvement Project	Active	Methow	Beaver / Bear Creek	6 Channel Structure and Form - Instream Structural Complexity								$740,000.00		$740,000.00
13334	MSRF Operskalski	Completed	Methow	Beaver / Bear Creek	6 Channel Structure and Form - Instream Structural Complexity	$31,588.92									$31,588.92
17035	TU-WWP Beaver Creek, No. 2 Instream Flow Enhancement	Active	Methow	Beaver / Bear Creek	9 Water Quantity - Decreased Water Quantity			$225,000.00							$225,000.00
17655	MSRF Marrachi Phase II	Conceptual	Methow	Beaver / Bear Creek	1 Habitat Quantity - Anthropogenic Barriers										
17656	MSRF Fort/Thurlow Phase II	Active	Methow	Beaver / Bear Creek	1 Habitat Quantity - Anthropogenic Barriers		$50,000.00								$50,000.00
18408	TU-WWP Beaver Creek - 2012 Leases	Completed	Methow	Beaver / Bear Creek	9 Water Quantity - Decreased Water Quantity										$4,375.00
18527	YN Old Schoolhouse Fish Enhancement Project	Completed	Methow	Beaver / Bear Creek	4 Riparian Condition - LWD Recruitment	$250,000.00									$250,000.00
18623	MSRF UBC Old Schoolhouse	Active	Methow	Beaver / Bear Creek	6 Channel Structure and Form - Instream Structural Complexity										
18624	MSRF UBC Campbell	Active	Methow	Beaver / Bear Creek	6 Channel Structure and Form - Instream Structural Complexity										
29499	MSRF Fine Riparian	Completed	Methow	Beaver / Bear Creek	4 Riparian Condition - Riparian Vegitation	$33,300.77									$33,300.77
13236	Okan Co. Early Winters Ditch Diversion Structure	Completed	Methow	Early Winters / Lost	1 Habitat Quantity - Anthropogenic Barriers										$128,521.00
13264	TPL Arrowleaf/Methow R Conservation	Completed	Methow	Early Winters / Lost	5 Peripheral and Transitional Habitats - Floodplain Condition										$1,250,000.00
13305	WDFW Early Winter Canal Fish Screen	Completed	Methow	Early Winters / Lost	2 Injury and Mortality - Mechanical Injury										$151,000.00
13323	MSRF Early Winters Creek Dike Removal	Completed	Methow	Early Winters / Lost	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$168,859.00
13237	Okan Co. Fulton Ditch Lining Project	Completed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity										$18,415.00
13282	MSRF Chewuch Diversion	Completed	Methow	Lower Chewuch	1 Habitat Quantity - Anthropogenic Barriers										$149,381.00
13289	MC River Assessment Unit Acquisitions	Completed	Methow	Lower Chewuch	5 Peripheral and Transitional Habitats - Floodplain Condition			$225,000.00							$225,000.00
13291	MSRF Chewuch Canal & Fulton Canal Joint Study	Completed	Methow	Lower Chewuch											$61,591.00
13301	WDFW Fulton Canal Fish Screen	Completed	Methow	Lower Chewuch	2 Injury and Mortality - Mechanical Injury										$200,000.00
13307	MSRF Fulton Dam - Barrier Removal	Completed	Methow	Lower Chewuch	1 Habitat Quantity - Anthropogenic Barriers										$543,223.00
13315	MSRF Macpherson Side Channel	Completed	Methow	Lower Chewuch	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$43,629.38									$43,629.38
13317	MSRF Chewuch Dam Modification	Completed	Methow	Lower Chewuch	1 Habitat Quantity - Anthropogenic Barriers										$272,091.00
13338	MSRF Pete Creek	Completed	Methow	Lower Chewuch	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$60,137.94									$60,137.94
13340	MSRF Chewuch Basin Irrigator Efficiency	Completed	Methow	Lower Chewuch	9 Water Quantity - Increased Water Quantity										$294,000.00
13409	YN Chewuch Reach Assessment	Completed	Methow	Lower Chewuch											$167,000.00

15868	YN Chewuch River Mile 10 Fish Enhancement Project	Completed	Methow	Lower Chewuch	6 Channel Structure and Form - Instream Structural Complexity									$850,000.00
15870	YN Chewuch River 8 Mile Ranch Project	Completed	Methow	Lower Chewuch	6 Channel Structure and Form - Instream Structural Complexity									$750,000.00
16886	TU-WPP Fulton Ditch Instream Flow	Proposed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity				$1,300,000.00					$1,300,000.00
17008	USFS Chewuch Road Inventory and Minimum Roads Analysis Concept	Conceptual	Methow	Lower Chewuch		$60,000.00								$60,000.00
17015	TU-WWP: Chewuch River No.3 Permanent Flow Enhancement,	Active	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity	$2,268,547.00								$2,268,547.00
17031	MSRF Bulldog	Completed	Methow	Lower Chewuch	4 Riparian Condition - Riparian Vegitation	$34,927.24								$34,927.24
17085	TU-WWP: Chewuch No. 2 Piping Project (Little Chewuch)	Completed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity									$150,000.00
17086	TU-WPP Little Barkley Piping	Completed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity									$131,219.50
17087	TU-WWP Chewuch No. 1, three year drought lease	Completed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity									$350,000.00
17088	USFS Upper Cub Creek Riparian Fencing Concept	Conceptual	Methow	Lower Chewuch	4 Riparian Condition - Riparian Vegitation									$25,000.00
17089	USFS Eightmile Creek Fish Barrier Assessment and Implementation Concept	Conceptual	Methow	Lower Chewuch	1 Habitat Quantity - Anthropogenic Barriers	$2,300,000.00								$2,300,000.00
17731	YN Chewuch River Right	Proposed	Methow	Lower Chewuch	6 Channel Structure and Form - Instream Structural Complexity				$1,600,000.00					$1,600,000.00
17928	MSRF Lower Chewuch Watershed Beaver Restoration	Active	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity									
18709	TU-WWP Chewuch River Instream Flow Project	Proposed	Methow	Lower Chewuch	9 Water Quantity - Decreased Water Quantity			$350,000.00						$350,000.00
19320	YN Chewuch Camp Ground	Conceptual	Methow	Lower Chewuch	4 Riparian Condition - LWD Recruitment				$1.00					$1.00
19320	YN Chewuch Camp Ground	Conceptual	Methow	Lower Chewuch	6 Channel Structure and Form - Instream Structural Complexity				$1.00					$1.00
29500	MSRF Satiqua Riparian	Completed	Methow	Lower Chewuch	4 Riparian Condition - Riparian Vegitation	$21,943.97								$21,943.97
16973	WDFW Bridge 1 Riparian Acquisition	Proposed	Methow	Lower Methow	5 Peripheral and Transitional Habitats - Floodplain Condition									$305,000.00
17004	TU-WPP Lower Methow Irrigation Efficiencies & Instream Flow Enhancements	Active	Methow	Lower Methow	9 Water Quantity - Decreased Water Quantity		$525,000.00							$525,000.00
17707	TU-WPP Eightmile Creek Irrigation Efficiencies & Instream Flow Enhancements	Proposed	Methow	Lower Methow	9 Water Quantity - Decreased Water Quantity									
17708	TU-WWP: Twisp River POD Change & Instream Flow Enhancement	Active	Methow	Lower Methow	9 Water Quantity - Decreased Water Quantity	$100,000.00								$100,000.00
17710	TU-WPP Beaver Creek No. 1, 2, 3- Late Season Instream Flow Projects	Completed	Methow	Lower Methow	9 Water Quantity - Decreased Water Quantity									$241,986.00
17711	TU-WPP Middle Methow River M2 Phase 3 Concept	Conceptual	Methow	Lower Methow	9 Water Quantity - Decreased Water Quantity									
13239	Okan Co. Airey/Risley Ditch Removal	Completed	Methow	Middle Methow	1 Habitat Quantity - Anthropogenic Barriers									$29,596.00
13283	MC Middle Methow River Assessment Unit Acquisitions	Completed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition			$2,307,579.00						$2,307,579.00
13299	WDFW Silver Side Channel Restoration and Conservation Easement	Completed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
13324	MSRF Methow Valley Irrigation District (MVID) East Irrigation Diversion	Completed	Methow	Middle Methow	1 Habitat Quantity - Anthropogenic Barriers									$917,440.00
13336	MSRF Winthrop Confluence Project Riparian	Completed	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation	$64,794.78								$64,794.78
13336	MSRF Winthrop Confluence Project Riparian	Completed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition	$64,794.78								$64,794.78
13337	BOR Middle Methow Reach Assessment	Completed	Methow	Middle Methow										$413,967.00
16473	MSRF Methow River Bird Island Acquisition	Completed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									$0.00
16474	MSRF Middle Methow River Hoffman Acquisition	Completed	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation									$211,429.00
16475	MSRF Methow River Risley Acquisition	Completed	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation									$131,890.00
16995	MSRF Middle Methow Sugar Dike Reach Implementation	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition						$600,000.00			$600,000.00
16997	BOR Winthrop to Wolf Creek Reach Assessment	Completed	Methow	Middle Methow		$30,000.00								$30,000.00
16998	BOR Middle Methow Silver Reach Assessment Concept	Conceptual	Methow	Middle Methow										
17018	TU-WPP Middle Methow instream flow enhancement	Proposed	Methow	Middle Methow	9 Water Quantity - Decreased Water Quantity		$1,150,000.00							$1,150,000.00
17023	MSRF Methow River Acquisition 2011 RM 48.9	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition				$68,800.00					$68,800.00
17024	MSRF M2 Whitefish Island	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions		$1,445,000.00							$1,445,000.00
17025	MSRF M2 WDFW Floodplain Restoration	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions		$0.00							$0.00
17026	MSRF M2 3R Concept	Conceptual	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions				$1,000,000.00					$1,000,000.00
17028	MSRF M2 Logjam Island Concept	Conceptual	Methow	Middle Methow	6 Channel Structure and Form - Instream Structural Complexity				$700,000.00					$700,000.00
17029	MSRF M2 Bear Creek Complexity	Conceptual	Methow	Middle Methow	6 Channel Structure and Form - Instream Structural Complexity						$500,000.00			$500,000.00
17030	MSRF M2 Complexity and Floodplain Restoration III	Conceptual	Methow	Middle Methow	6 Channel Structure and Form - Instream Structural Complexity						$2,500,000.00			$2,500,000.00
17721	TU-WWP Middle Methow Water Lease and/or In-basin Acquisition Concept	Conceptual	Methow	Middle Methow	9 Water Quantity - Decreased Water Quantity									
18004	MSRF WDFW Floodplain wetland easement (McIvor)	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
18537	CCFEG Methow Riparian Planting	Active	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation				$95,000.00					$95,000.00
18611	YN M2 Eagle Rocks Large Wood Enhancement	Completed	Methow	Middle Methow	6 Channel Structure and Form - Bed and Channel Form									$60,000.00
18625	MSRF M2 Amundsen Floodplain	Completed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions									
18626	MSRF Maltais	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition									
18703	CCFEG Silver Side Channel Revival	Active	Methow	Middle Methow					$900,000.00					$900,000.00
18707	TU-WWP: MVID Instream Flow Improvement Project	Active	Methow	Middle Methow	9 Water Quantity - Decreased Water Quantity				$500,000.00					$500,000.00
18708	MSRF M2 3R Project	Proposed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions			$250,000.00						$250,000.00
18730	CCFEG Twisp to Carlton Reach Assessment I	Proposed	Methow	Middle Methow					$200,000.00					$200,000.00
18848	YN M2 1890s Side Channel Enhancement Project	Active	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions			$1,300,000.00						$1,300,000.00
18909	YN M2 Sugar Dike Large Wood Enhancement	Completed	Methow	Middle Methow	6 Channel Structure and Form - Instream Structural Complexity		$65,000.00							$65,000.00
18910	YN M2 Two Channels East Side Channel Project	Proposed	Methow	Middle Methow	5 Peripheral and Transitional Habitats - Floodplain Condition									
18911	YN M2 Two Channels Large Wood Enhancement	Completed	Methow	Middle Methow	6 Channel Structure and Form - Instream Structural Complexity		$80,000.00							$80,000.00
19394	TU-WWP Barkley Diversion Reduction and Habitat Improvement	Active	Methow	Middle Methow	9 Water Quantity - Decreased Water Quantity									
29496	MSRF Witte Riparian	Completed	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation	$62,402.91								$62,402.91
29498	MSRF 3R Riparian	Completed	Methow	Middle Methow	4 Riparian Condition - Riparian Vegitation	$68,286.96								$68,286.96
13320	MSRF Methow Basin Riparian Enhancement Program	Completed	Methow		4 Riparian Condition - Riparian Vegitation									$608,639.00
13360	WDFW Methow Watershed Phase II	Completed	Methow		5 Peripheral and Transitional Habitats - Floodplain Condition									
14276	BOR Methow Subbasin Geomorphic Assessment	Completed	Methow											$220,060.00
17703	OCD Okanogan & Methow Farm Assistance Concept	Conceptual	Methow		9 Water Quantity - Decreased Water Quantity	$185,196.00								$185,196.00
13231	Okan Co. Skyline Ditch Pipe Installation Phase 1 & 2	Completed	Methow	Upper Chewuch	9 Water Quantity - Decreased Water Quantity									$176,000.00
13306	WDFW Skyline Canal Fish Screen	Completed	Methow	Upper Chewuch	2 Injury and Mortality - Mechanical Injury									$165,000.00
17008	USFS Chewuch Road Inventory and Minimum Roads Analysis Concept	Conceptual	Methow	Upper Chewuch		$60,000.00								$60,000.00
17015	TU-WWP: Chewuch River No.3 Permanent Flow Enhancement,	Active	Methow	Upper Chewuch	9 Water Quantity - Decreased Water Quantity	$2,268,547.00								$2,268,547.00
18484	YN Chewuch River Mile 11.75-13 River Left Fish Enhancement Project	Active	Methow	Upper Chewuch	6 Channel Structure and Form - Instream Structural Complexity		$438,024.00							$438,024.00
19321	Chewuch RM 13-15.5	Conceptual	Methow	Upper Chewuch	4 Riparian Condition - LWD Recruitment									
13261	WDFW Methow River Basin Screening	Completed	Methow	Early Winters / Lost I	2 Injury and Mortality - Mechanical Injury									$229,667.00
13285	Upper Methow Assessment Unit MC Acquisitions	Completed	Methow	Early Winters / Lost I	5 Peripheral and Transitional Habitats - Floodplain Condition									$7,094,757.00
13318	CCFEG Rockview Diversion and Side Channel Restoration	Completed	Methow	Early Winters / Lost I	9 Water Quantity - Decreased Water Quantity									$154,500.00

13358	Private LO Weeman Bridge Side Channel Restoration	Completed	Methow	Early Winters / Lost	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$54,000.00
17094	Whiteface Creek Culvert Replacement Concept	Conceptual	Methow	Early Winters / Lost	1 Habitat Quantity - Anthropogenic Barriers										$160,000.00
17614	CCFEG Big Valley Wood and Floodplain	Conceptual	Methow	Early Winters / Lost	6 Channel Structure and Form - Instream Structural Complexity			$330,000.00							$330,000.00
17657	? Suspension Bridge Habitat Complexity Project	Conceptual	Methow	Early Winters / Lost	6 Channel Structure and Form - Instream Structural Complexity										
18610	YN Wolf Creek Road Bank Stabilization and Wood Enhancement Project	Completed	Methow	Early Winters / Lost	6 Channel Structure and Form - Instream Structural Complexity										$90,000.00
29497	MSRF Wolfridge Riparian	Completed	Methow	Early Winters / Lost	4 Riparian Condition - Riparian Vegitation	$115,835.26									$115,835.26
13235	Okan Co. Eagle Creek Ditch Fish Screen	Completed	Methow	Upper Twisp	2 Injury and Mortality - Mechanical Injury										$23,225.00
17005	TU-WPP Twisp River Instream Flow Enhancement Concept	Completed	Methow	Upper Twisp	9 Water Quantity - Decreased Water Quantity		$99,200.00								$99,200.00
13313	MSRF Heath Phase II Install 2 Bridges	Completed	Methow	Methow river miles	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$80,181.85									$80,181.85
13321	MSRF Fender Mill Floodplain Restoration	Completed	Methow	Methow river miles	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$2,693,249.00
13330	BOR Big Valley Reach Assessment	Completed	Methow	Methow river miles											$216,000.00
13335	MSRF Sletten and Green Habitat Complexity Projects	Completed	Methow	Methow river miles	6 Channel Structure and Form - Instream Structural Complexity										$30,000.00
17653	Wolf to Winthrop Complexity Project	Conceptual	Methow	Methow river miles	6 Channel Structure and Form - Instream Structural Complexity										
13233	Wolf Creek Channel Restoration	Completed	Methow	Wolf / Hancock Cree	6 Channel Structure and Form - Bed and Channel Form										$20,000.00
13295	Wolf Creek Diversion/Patterson Mountain	Completed	Methow	Wolf / Hancock Cree	1 Habitat Quantity - Anthropogenic Barriers										$275,373.00
13302	WDFW Wolf Creek Reclamation Dist Fish Screen	Completed	Methow	Wolf / Hancock Cree	2 Injury and Mortality - Mechanical Injury										$140,000.00
13309	YN Hancock Springs Restoration Project Phase I	Completed	Methow	Wolf / Hancock Cree	6 Channel Structure and Form - Instream Structural Complexity										$450,000.00
16971	CCFEG Wolf Creek Ditch and Fish Return improvement	Conceptual	Methow	Wolf / Hancock Cree	2 Injury and Mortality - Mechanical Injury			$270,000.00							$270,000.00
18853	YN Hancock Creek Restoration Phase 3	Completed	Methow	Wolf / Hancock Cree											$417,000.00
17712	TU-WPP Wolf Creek Piping & Diversion Enhancement	Proposed	Methow		9 Water Quantity - Decreased Water Quantity										
5425	MSRF Twisp Right Bank	Completed	Methow	Lower Twisp	4 Riparian Condition - Riparian Vegitation	$77,139.90									$77,139.90
10301	MSRF Twisp River Conservation Acquisition 2	Completed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Floodplain Condition										$481,579.00
13234	Okan Co. Tourangeau Ditch to Well Conversion	Completed	Methow	Lower Twisp	9 Water Quantity - Decreased Water Quantity										$6,500.00
13238	Okan Co. Aspen Meadows Ditch Piping	Completed	Methow	Lower Twisp	9 Water Quantity - Decreased Water Quantity										$58,704.00
13240	Okan Co. Buttermilk Ditch Fish Screen	Completed	Methow	Lower Twisp	2 Injury and Mortality - Mechanical Injury										$37,557.00
13241	Okan Co. Little Bridge Creek Culvert	Completed	Methow	Lower Twisp	1 Habitat Quantity - Anthropogenic Barriers										$6,400.00
13275	OCD Hottell Intake Gate	Completed	Methow	Lower Twisp	2 Injury and Mortality - Mechanical Injury										$11,210.00
13287	MC Acquisitions Twisp River Assessment Unit	Completed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Floodplain Condition			$2,017,092.00							$2,017,092.00
13292	PWI - Assessment Twisp River Watershed	Completed	Methow	Lower Twisp											$185,626.00
13303	WDFW Twisp-Power Ditch Fish Screen	Completed	Methow	Lower Twisp	2 Injury and Mortality - Mechanical Injury										$130,000.00
13314	MSRF Channel Reconstruction/ Twisp side-channel	Completed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$92,000.00
13322	MSRF Elbow Coulee River Restoration	Completed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$54,060.76									$54,060.76
13325	MSRF Poorman Creek Barrier Removal	Completed	Methow	Lower Twisp	1 Habitat Quantity - Anthropogenic Barriers	$106,805.50									$106,805.50
13331	OCD Little Bridge Creek (Aspen Meadows)	Completed	Methow	Lower Twisp	1 Habitat Quantity - Anthropogenic Barriers										$108,400.00
13341	MSRF Twisp River Conservation Acquisition	Completed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Floodplain Condition										$200,835.00
16960	MSRF Twisp River Acquisitions 3	Active	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Floodplain Condition		$140,700.00								$140,700.00
17005	TU-WPP Twisp River Instream Flow Enhancement Concept	Completed	Methow	Lower Twisp	9 Water Quantity - Decreased Water Quantity		$99,200.00								$99,200.00
17032	MSRF Twisp Left Bank Complexity & Riparian	Completed	Methow	Lower Twisp	6 Channel Structure and Form - Instream Structural Complexity	$138,070.14									$138,070.14
17649	MSRF Siberian Side-channel	Proposed	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										
17650	MSRF Poorman Creek Wetland Habitat	Active	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										
17651	MSRF Elbow Coulee Phase II Rt/Lf Bank	Active	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions						$0.00				$0.00
17723	TU-WWP: Twisp River, Instream Flow Enhancement,	Proposed	Methow	Lower Twisp	9 Water Quantity - Decreased Water Quantity										
18614	YN Twisp Ponds Left Bank Large Wood Enhancement	Completed	Methow	Lower Twisp	6 Channel Structure and Form - Instream Structural Complexity										$80,000.00
18616	YN Twisp Ponds Left Bank Floodplain Restoration	Completed	Methow	Lower Twisp	4 Riparian Condition - Riparian Vegitation										$20,000.00
18618	YN Twisp Ponds Habitat Ponds Intake Ditch Repair	Completed	Methow	Lower Twisp	9 Water Quantity - Decreased Water Quantity										$60,000.00
18621	MSRF Twisp River - Hadfield	Active	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Floodplain Condition										
18622	MSRF Twisp River - Gann	Active	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										
18908	YN Lower Twisp River Reach Assessment	Completed	Methow	Lower Twisp											$167,000.00
18912	YN Twisp River Poorman Creek Road Side Channel Project	Conceptual	Methow	Lower Twisp	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions		$60,000.00								$60,000.00
19324	YN Twisp River Mile 3 Fish Habitat Enhancement Project	Active	Methow	Lower Twisp	6 Channel Structure and Form - Instream Structural Complexity		$70,000.00								$70,000.00
19344	YN-Poorman Creek Road Large Wood Enhancement Project	Proposed	Methow	Lower Twisp	6 Channel Structure and Form - Instream Structural Complexity		$70,000.00								$70,000.00
29494	MSRF Daudon Riparian	Completed	Methow	Lower Twisp	4 Riparian Condition - Riparian Vegitation	$35,870.73									$35,870.73
29495	MSRF TRPLLC Riparian	Completed	Methow	Lower Twisp	4 Riparian Condition - Riparian Vegitation	$95,629.59									$95,629.59
16285	CCT Aeneas Creek Spawning Development Concept	Completed	Okanogan		6 Channel Structure and Form - Bed and Channel Form	$100,000.00									$100,000.00
16976	CCT Aeneas Creek Acquisition of 138 Acres	Completed	Okanogan		5 Peripheral and Transitional Habitats - Floodplain Condition										$545,000.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury	$175,000.00									$175,000.00
17747	CCT Aeneas Creek Acquisition of 20 Acres	Completed	Okanogan		5 Peripheral and Transitional Habitats - Floodplain Condition										$56,000.00
16293	CCT Antoine Creek Diversion and Passage (2)	Completed	Okanogan	Antoine Creek from	1 Habitat Quantity - Anthropogenic Barriers		$200,000.00								$200,000.00
17063	CCT Antoine Creek Instream Flow Acquistions Concept	Active	Okanogan	Antoine Creek from	9 Water Quantity - Decreased Water Quantity				$2,000,000.00						$2,000,000.00
17064	CCT Antoine Creek Protection Concept	Active	Okanogan	Antoine Creek from	6 Channel Structure and Form - Bed and Channel Form				$5,000,000.00						$5,000,000.00
18892	CTT Antoine Creek Culvert Replacement	Completed	Okanogan	Antoine Creek from	1 Habitat Quantity - Anthropogenic Barriers		$40,000.00								$40,000.00
13254	CCT Antoine Creek Culvert Replacement	Completed	Okanogan	Antoine Creek from	1 Habitat Quantity - Anthropogenic Barriers										$50,950.00
29722	CCFEG Ames - Mill Creek FFFPP	Active	Okanogan	Antoine Creek from			$87,500.00								$87,500.00
13278	OCD Bonaparte Creek Livestock Exclusion	Completed	Okanogan		7 Sediment Conditions - Increased Sediment Quantity										$25,578.00
16909	CCT Bonaparte Creek Realignment Project	Completed	Okanogan		6 Channel Structure and Form - Bed and Channel Form										$120,000.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury	$175,000.00									$175,000.00
13255	CCT McIntyre Dam Fish Passage	Completed	Okanogan	Canada Mainstem, L	1 Habitat Quantity - Anthropogenic Barriers										$1,770,055.00
13256	CCT Okanogan River Restoration Initative (ORRI) Phase I & II	Completed	Okanogan	Canada Mainstem, L											$1,100,000.00
17763	CCT Vaseux Creek Evaluation	Completed	Okanogan	Canada Mainstem, L											$25,000.00
17765	CCT Lower Shuttleworth Creek Instream Flow Concept	Completed	Okanogan	Canada Mainstem, L			$35,000.00								$35,000.00
17771	CCT Skaha Lake Barrier Concept	Conceptual	Okanogan	Canada Mainstem, L											
17772	CCT Upper Shingle Creek Concept	Conceptual	Okanogan	Canada Mainstem, L											
17775	CCT Lower Shingle Creek Barrier Concept	Completed	Okanogan	Canada Mainstem, L											
17778	CCT Vaseux Creek Irrigation Diversions and Instream Flow Concepts	Conceptual	Okanogan	Canada Mainstem, L											

17780	CCT Okanogan River in Canada Channel Structure and Form Concept	Conceptual	Okanogan	Canada Mainstem, L											
17782	CCT Okanogan Lake Barriers Concept	Conceptual	Okanogan	Canada Mainstem, L											
17783	CCT Ellis Creek Barriers Concept	Conceptual	Okanogan	Canada Mainstem, L											
17784	CCT Lower Shuttleworth Creek Barriers Concept	Completed	Okanogan	Canada Mainstem, L											
17790	CCT Vaseux Creek Barriers Concept	Conceptual	Okanogan	Canada Mainstem, L											
17792	CCT Inkaneep Creek Barriers Concept	Conceptual	Okanogan	Canada Mainstem, L											
17061	OCD Johnson Creek Riparian Planting Concept	Completed	Okanogan		4 Riparian Condition - Riparian Vegitation										$8,450.00
18667	TU-WWP: Johnson Creek Barrier Passage Projects	Dormant	Okanogan		1 Habitat Quantity - Anthropogenic Barriers		$195,000.00								$195,000.00
11008	CCT Loup Loup Creek Culverts	Completed	Okanogan	Loup-Loup Creek	1 Habitat Quantity - Anthropogenic Barriers										$636,237.00
17050	OCD Loup Loup Sediment Reduction Identification and Implementation Concept	Conceptual	Okanogan	Loup-Loup Creek	7 Sediment Conditions - Increased Sediment Quantity										$210,000.00
17055	CCT Loup Loup Water Lease	Active	Okanogan	Loup-Loup Creek	9 Water Quantity - Decreased Water Quantity									$300,000.00	$300,000.00
17081	CCT Loup Loup Acquisition 4.01 Acres	Completed	Okanogan	Loup-Loup Creek	5 Peripheral and Transitional Habitats - Floodplain Condition										$65,000.00
17788	CCT Loup Loup Creek Instream Flow Concept	Conceptual	Okanogan	Loup-Loup Creek	9 Water Quantity - Decreased Water Quantity										
16280	CCT Okanogan River BOR Side Channel Concept	Conceptual	Okanogan	Lower Middle Okanc	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$140,000.00
16948	CCT Okanogan River Riverside Acquisition 37.35 Acres	Completed	Okanogan	Lower Middle Okanc	8 Water Quality - Temperature										$125,000.00
16978	CCT Okanogan River Acquisition 72 Acres	Completed	Okanogan	Lower Middle Okanc	5 Peripheral and Transitional Habitats - Floodplain Condition										$900,000.00
17038	OCD Okanogan River Riparian Habitat Concept	Conceptual	Okanogan	Lower Middle Okanc	4 Riparian Condition - Riparian Vegitation	$372,000.00									$372,000.00
17046	WDFW Okanogan River Fish Screening Inventory	Completed	Okanogan	Lower Middle Okanc											$174,000.00
17080	OCD Lower Middle Okanogan Sediment Identification and Implementation Concept	Conceptual	Okanogan	Lower Middle Okanc	7 Sediment Conditions - Increased Sediment Quantity	$550,000.00									$550,000.00
17740	CCT Okanogan River Hwy 20 Acquisition	Completed	Okanogan	Lower Middle Okanc	4 Riparian Condition - Riparian Vegitation										$400,000.00
17742	CCT Okanogan River Shell Rock Point Acquisition	Completed	Okanogan	Lower Middle Okanc	5 Peripheral and Transitional Habitats - Floodplain Condition										$850,000.00
17079	OCD Lower Okanogan Irrigation Screens/Diversions Project	Completed	Okanogan	Lower Okanogan (M	2 Injury and Mortality - Mechanical Injury										
13243	CCT Salmon Creek Assessment 99	Completed	Okanogan	Lower Salmon Creek											$92,000.00
13280	CCT Salmon Creek - Low Flow Channel and Fish Passage at Confluence	Active	Okanogan	Lower Salmon Creek	6 Channel Structure and Form - Bed and Channel Form		$400,000.00								$400,000.00
13281	Salmon Creek Diversion Dam Design	Completed	Okanogan	Lower Salmon Creek											$51,500.00
13407	CCT Salmon Creek Instream Flow Agreement	Active	Okanogan	Lower Salmon Creek	9 Water Quantity - Decreased Water Quantity					$1,000,000.00					$1,000,000.00
16902	OCD Salmon Creek Well Development	Active	Okanogan	Lower Salmon Creek	9 Water Quantity - Decreased Water Quantity										$71,940.00
16950	CCT Lower Salmon Creek Acquisition 14 Acres	Completed	Okanogan	Lower Salmon Creek	5 Peripheral and Transitional Habitats - Floodplain Condition										$112,000.00
16951	CCT Lower Salmon Creek Acquisition 1 Acre	Completed	Okanogan	Lower Salmon Creek	5 Peripheral and Transitional Habitats - Floodplain Condition										$280,000.00
17051	CCT Salmon Creek Sediment Reduction Inventory and Implementation Concept	Conceptual	Okanogan	Lower Salmon Creek	7 Sediment Conditions - Increased Sediment Quantity	$0.00									$0.00
17056	CCT Upper & Lower Salmon Creek Instream Flows Concept	Conceptual	Okanogan	Lower Salmon Creek	9 Water Quantity - Decreased Water Quantity	$375,000.00									$375,000.00
18896	CCT Salmon Creek Acquisition	Completed	Okanogan	Lower Salmon Creek	10 Population Level Effects - Small Population Effects	$850,000.00									$850,000.00
18896	CCT Salmon Creek Acquisition	Completed	Okanogan	Lower Salmon Creek	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$850,000.00									$850,000.00
18897	CCT Salmon Creek Acquisition 2	Completed	Okanogan	Lower Salmon Creek	1 Habitat Quantity - HQ-Competition	$330,000.00									$330,000.00
18897	CCT Salmon Creek Acquisition 2	Completed	Okanogan	Lower Salmon Creek	4 Riparian Condition - Riparian Vegitation	$330,000.00									$330,000.00
18897	CCT Salmon Creek Acquisition 2	Completed	Okanogan	Lower Salmon Creek	5 Peripheral and Transitional Habitats - Floodplain Condition	$330,000.00									$330,000.00
18898	CCT Okanogan River Dogleg Acquisition	Dormant	Okanogan	Lower Salmon Creek		$800,000.00									$800,000.00
16953	CCT Nine Mile Creek Acquisition 3.83 Acres	Completed	Okanogan		5 Peripheral and Transitional Habitats - Floodplain Condition										$191,500.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury	$175,000.00									$175,000.00
17082	CCT Nine Mile Acquisition 5.87 Acres	Completed	Okanogan		5 Peripheral and Transitional Habitats - Floodplain Condition										$176,000.00
18409	TU-WWP Ninemile Creek, In-Stream Flow Restoration Project	Completed	Okanogan		9 Water Quantity - Decreased Water Quantity										$225,000.00
18511	TU-WWP Ninemile Creek, Riparian Restoration and Passage Improvement	Completed	Okanogan		4 Riparian Condition - Riparian Vegitation	$165,783.00									$165,783.00
18893	CCT Ninemile Acquisition	Completed	Okanogan		4 Riparian Condition - LWD Recruitment	$150,000.00									$150,000.00
18893	CCT Ninemile Acquisition	Completed	Okanogan		4 Riparian Condition - Riparian Vegitation	$150,000.00									$150,000.00
18893	CCT Ninemile Acquisition	Completed	Okanogan		6 Channel Structure and Form - Bed and Channel Form	$150,000.00									$150,000.00
18893	CCT Ninemile Acquisition	Completed	Okanogan		6 Channel Structure and Form - Instream Structural Complexity	$150,000.00									$150,000.00
16278	CCT Okanogan River Conservancy Island	Active	Okanogan	From Chiliwist Creek	1 Habitat Quantity - Anthropogenic Barriers			$200,000.00							$200,000.00
16278	CCT Okanogan River Conservancy Island	Active	Okanogan	From Chiliwist Creek	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions			$200,000.00							$200,000.00
16883	OCD Okanogan River Basin Fish Screen Replacements	Active	Okanogan	From Chiliwist Creek	2 Injury and Mortality - Mechanical Injury										$0.00
17071	OCD Lower Okanogan TMDL Implementation Concept	Conceptual	Okanogan	From Chiliwist Creek	8 Water Quality - Temperature	$0.00									$0.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Chiliwist Creek	2 Injury and Mortality - Mechanical Injury			$165,000.00							$165,000.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From Salmon Creek	2 Injury and Mortality - Mechanical Injury						$1,000,000.00				$1,000,000.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Salmon Creek	2 Injury and Mortality - Mechanical Injury			$165,000.00							$165,000.00
16284	CCT Okanogan River Wanacut Creek Log Jam	Conceptual	Okanogan	From Omak Creek to	6 Channel Structure and Form - Instream Structural Complexity						$100,000.00				$100,000.00
16906	CCT North Reservation Boundary Okanogan River Side Channel	Completed	Okanogan	From Omak Creek to	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$20,000.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From Omak Creek to	2 Injury and Mortality - Mechanical Injury						$1,000,000.00				$1,000,000.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Omak Creek to	2 Injury and Mortality - Mechanical Injury			$165,000.00							$165,000.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From Riverside to Ja	2 Injury and Mortality - Mechanical Injury						$1,000,000.00				$1,000,000.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Riverside to Ja	2 Injury and Mortality - Mechanical Injury			$165,000.00							$165,000.00
18704	CCFEG Janis Rapids Side Channel - Okanogan Weir Removal Project	Active	Okanogan	From Riverside to Ja	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions				$35,500.00						$35,500.00
17701	OCD Okanogan Livestock and Water Quality	Proposed	Okanogan	From Janis Bridge to	4 Riparian Condition - Riparian Vegitation										$248,506.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From Janis Bridge to	2 Injury and Mortality - Mechanical Injury						$1,000,000.00				$1,000,000.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Janis Bridge to	2 Injury and Mortality - Mechanical Injury			$165,000.00							$165,000.00
17701	OCD Okanogan Livestock and Water Quality	Proposed	Okanogan	From Siwash Creek t	4 Riparian Condition - Riparian Vegitation										$248,506.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From Siwash Creek t	2 Injury and Mortality - Mechanical Injury						$1,000,000.00				$1,000,000.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From Siwash Creek t	2 Injury and Mortality - Mechanical Injury			$165,000.00							$165,000.00
16904	CCT Driscoll Island Cross Channel Structure	Completed	Okanogan	From confluence wit	6 Channel Structure and Form - Bed and Channel Form										$293,060.00
17701	OCD Okanogan Livestock and Water Quality	Proposed	Okanogan	From confluence wit	4 Riparian Condition - Riparian Vegitation										$248,506.00
17739	CCT OCD Okanogan River Diversion Screening	Active	Okanogan	From confluence wit	2 Injury and Mortality - Mechanical Injury						$1,000,000.00				$1,000,000.00
1353	Omak Creek Bridge Replacement RM 1	Completed	Okanogan	Omak Creek from th	1 Habitat Quantity - Anthropogenic Barriers										$95,000.00
13246	CCT Omak Creek Mill Site Restoration RM 0.5	Completed	Okanogan	Omak Creek from th	1 Habitat Quantity - Anthropogenic Barriers										$1,100,000.00
16979	CCT Omak Creek Acquisition 120 Acres	Completed	Okanogan	Omak Creek from th	5 Peripheral and Transitional Habitats - Floodplain Condition										$132,000.00
17700	Omak Creek Bank Stabilization RM 2.9 to 4.7	Completed	Okanogan	Omak Creek from th	6 Channel Structure and Form - Bed and Channel Form										$147,000.00
13247	CCT Omak Creek Mission Falls Barriers RM 5.5	Completed	Okanogan	Upstream of Missior	1 Habitat Quantity - Anthropogenic Barriers										$1,700,000.00

13249	CCT Omak Creek Road Decommissions	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$59,413.00
15789	CCT Omak Creek Lobe and Disautel Culvert Replacements (2) RM 15 & 17	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$216,372.65
15794	CCT Omak Creek Stapaloop Creek Culvert and Instream Structures	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$75,000.00
15800	CCT Omak Creek Grindstone Drainage Culverts (2)	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$75,000.00
15806	CCT Omak Creek Stapaloop Creek Culverts (3)	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$35,000.00
15807	CTT Omak Creek Camp Seven Creek Culverts (2)	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$120,000.00
15809	CCT Omak Creek Dutch Anderson Drainage Culvert	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$26,000.00
15810	CCT Omak (Upper) Creek Culvert Replacements (11)	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$455,000.00
15811	CCT Omak Creek Marchand & Sam Culvert Replacements (2) RM 19 & 19.5	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$150,000.00
16000	CTT Omak Creek Swimptkin Creek Culvert	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$6,000.00
16893	CCT Omak Creek Livestock Exclusion Fence Project	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$17,000.00
17060	CCT Omak Creek Culvert Replacements Concept	Conceptual	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										
17776	CCT Upper Omak Creek Barriers Phase ll Concept	Conceptual	Okanogan	Upstream of Missior	1 Habitat Quantity - Anthropogenic Barriers										
17969	CCT Clark Creek Culverts (2)	Completed	Okanogan	Upstream of Missior	7 Sediment Conditions - Increased Sediment Quantity										$35,000.00
13245	CCT Omak Creek Watershed Restoration and Sediment Reduction	Completed	Okanogan	Salmon Creek from (	7 Sediment Conditions - Increased Sediment Quantity										$189,621.00
15788	CCT Omak Creek Haley Culvert Replacement RM 8	Completed	Okanogan	Salmon Creek from (	7 Sediment Conditions - Increased Sediment Quantity										$140,000.00
16892	CCT Omak (Upper) Creek Spring Developments (3) Proposal	Proposed	Okanogan	Salmon Creek from (	7 Sediment Conditions - Increased Sediment Quantity										
19466	Salmon Creek Off Channel Habitat	Completed	Okanogan	Salmon Creek from (	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions		$80,000.00								$80,000.00
13297	CCFEG Similkameen-Okanogan Confluence Restoration Design	Completed	Okanogan	Similkameen											$177,750.00
13328	CCFEG Okanogan/Similkameen Assess/feasibility/preliminary design	Completed	Okanogan	Similkameen											$282,000.00
17052	OCD Similkameen Sediment Reduction Projects Concept	Conceptual	Okanogan	Similkameen	7 Sediment Conditions - Increased Sediment Quantity	$275,000.00									$275,000.00
17067	CCT Similkameen Cool Water Refugia Concept	Conceptual	Okanogan	Similkameen		$600,000.00									$600,000.00
17069	CCT Similkameen Protection Concept	Conceptual	Okanogan	Similkameen		$2,350,000.00									$2,350,000.00
18646	OCD Similkameen RM 3.8 Habitat Design	Proposed	Okanogan	Similkameen	6 Channel Structure and Form - Bed and Channel Form			$200,000.00							$200,000.00
16884	CCFEG Driscoll Island Cold Water Refuge Design	Completed	Okanogan	From confluence wit	8 Water Quality - Temperature	$42,500.00									$42,500.00
18450	CCFEG - Driscoll Island Riparian Planting	Completed	Okanogan	From confluence wit	4 Riparian Condition - Riparian Vegitation										$11,000.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury	$175,000.00									$175,000.00
17762	CCT Siwash Creek Water Resource Inventory Concept	Completed	Okanogan												$65,000.00
18891	CCT Aeneas Creek Spring Headwaters Protection	Completed	Okanogan	Small Tributary Syste			$70,000.00								$70,000.00
18899	CCT Antoine Creek Corral Relocation	Completed	Okanogan	Small Tributary Syste	4 Riparian Condition - Riparian Vegitation	$80,000.00									$80,000.00
18899	CCT Antoine Creek Corral Relocation	Completed	Okanogan	Small Tributary Syste	5 Peripheral and Transitional Habitats - Floodplain Condition	$80,000.00									$80,000.00
18899	CCT Antoine Creek Corral Relocation	Completed	Okanogan	Small Tributary Syste	6 Channel Structure and Form - Bed and Channel Form	$80,000.00									$80,000.00
18899	CCT Antoine Creek Corral Relocation	Completed	Okanogan	Small Tributary Syste	8 Water Quality - Toxic Contaminants	$80,000.00									$80,000.00
13250	CCT Okanogan Basin Monitoring and Evaluation Program (OBMEP)	Active	Okanogan												
13251	CCT Okanogan Subbasin Habitat Implementation Program (OSHIP)	Active	Okanogan												
13258	CCT Okanogan Land and Water Acquisition Program	Active	Okanogan							$2,400,000.00					$2,400,000.00
13260	CCT Okanogan River Thermal & Lidar Image-Phase 1 & 2	Completed	Okanogan												$94,437.00
13262	WDFW Fish Screening Projects	Completed	Okanogan		2 Injury and Mortality - Mechanical Injury										
13273	OCD Okanogan County Fish Passage Barrier Survey	Completed	Okanogan												$224,183.00
13274	Okan Co. Salmon Habitat Enhancement	Completed	Okanogan												$200,000.00
13277	OCD Okanogan Livestock and Water Program	Completed	Okanogan												$68,438.00
13279	OCD Okanogan County Irrigation Water Concept	Conceptual	Okanogan		9 Water Quantity - Decreased Water Quantity										
17093	OCD Okanogan Conservation District Livestock Program	Active	Okanogan												$500,000.00
17703	OCD Okanogan & Methow Farm Assistance Concept	Conceptual	Okanogan		9 Water Quantity - Decreased Water Quantity	$185,196.00									$185,196.00
17794	CCT Okanogan Subbasin Predation Assessment Concept	Conceptual	Okanogan												
17795	CCT Okanogan River Basin Riparian Concept	Conceptual	Okanogan		4 Riparian Condition - Riparian Vegitation										
16426	CCT Tonasket Creek Water Resource Inventory	Completed	Okanogan												$65,000.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury	$175,000.00									$175,000.00
17714	TU-WWP Tonasket Creek Instream Flow Enhancements	Proposed	Okanogan		9 Water Quantity - Decreased Water Quantity		$120,000.00								$120,000.00
16427	CCT Tunk Creek Ground Water Study	Completed	Okanogan												$75,000.00
18501	CCFEG East Fork Tunk Creek Culvert Replacement	Completed	Okanogan		1 Habitat Quantity - Anthropogenic Barriers	$150,000.00									$150,000.00
15805	WDFW Mclaughlin Falls Fish Habitat Acqusition	Completed	Okanogan	Upper Middle Okanc	5 Peripheral and Transitional Habitats - Floodplain Condition										$700,000.00
17051	CCT Salmon Creek Sediment Reduction Inventory and Implementation Concept	Conceptual	Okanogan	Upper Middle Okanc	7 Sediment Conditions - Increased Sediment Quantity	$0.00									$0.00
17053	CCT Okanogan River Instream Flows for Temperature Reduction Concept	Conceptual	Okanogan	Upper Middle Okanc	8 Water Quality - Temperature	$800,000.00									$800,000.00
16890	CCT Okanogan River Cold Water Refugia Channel Creation Concept	Conceptual	Okanogan	Upper Okanogan	8 Water Quality - Temperature										$70,000.00
17045	OCD Okanogan River Riparian Habitat IV Concept	Conceptual	Okanogan	Upper Okanogan	4 Riparian Condition - Riparian Vegitation	$100,000.00									$100,000.00
17049	OCD Upper Okanogan Sediment Reduction Project ID and Implementation Concept	Conceptual	Okanogan	Upper Okanogan	7 Sediment Conditions - Increased Sediment Quantity	$225,000.00									$225,000.00
17745	CCT Okanogan River Basin Cold Water Refugia and Tributary Flow Restoration	Active	Okanogan	Upper Okanogan	9 Water Quantity - Increased Water Quantity						$4,000,000.00				$4,000,000.00
13253	CCT Wanacut Creek Livestock Management	Completed	Okanogan		7 Sediment Conditions - Increased Sediment Quantity										$40,000.00
16908	CCT Wanacut Creek Channel Rehabilitation	Completed	Okanogan		6 Channel Structure and Form - Bed and Channel Form										$60,991.00
18895	CCT Wanacut Creek Acquisition	Completed	Okanogan		7 Sediment Conditions - Increased Sediment Quantity	$60,000.00									$60,000.00
17071	OCD Lower Okanogan TMDL Implementation Concept	Conceptual	Okanogan	From the confluence	8 Water Quality - Temperature	$0.00									$0.00
18660	OCD Okanogan River Fish Screen Implementation Ph II	Proposed	Okanogan	From the confluence	2 Injury and Mortality - Mechanical Injury			$165,000.00							$165,000.00
13252	CCT Wild Horse Springs Creek Restoration	Completed	Okanogan		1 Habitat Quantity - Anthropogenic Barriers										$80,000.00
16292	CCT Wild Horse Spring Creek McKinney Bridge	Completed	Okanogan		1 Habitat Quantity - Anthropogenic Barriers										$25,000.00
16430	CCT Wild Horse Spring Creek Hardened Rock Crossing II	Completed	Okanogan		7 Sediment Conditions - Increased Sediment Quantity										$3,000.00
16891	CCT Wild Horse Spring Creek Realignment	Completed	Okanogan		6 Channel Structure and Form - Bed and Channel Form										$25,000.00
16900	CCT Wild Horse Spring Creek Well Installation Proposal	Completed	Okanogan		9 Water Quantity - Decreased Water Quantity		$50,000.00								$50,000.00
16913	CCT Wild Horse Spring Creek Livestock Exclusion Phase I & II	Completed	Okanogan		4 Riparian Condition - Riparian Vegitation										$6,000.00
16915	CCT Wild Horse Spring Creek Culvert Replacements I & II	Completed	Okanogan		1 Habitat Quantity - Anthropogenic Barriers										$60,000.00
16947	CCT Wild Horse Spring Creek Hardened Rock Crossing	Completed	Okanogan		7 Sediment Conditions - Increased Sediment Quantity										$3,000.00
17062	CCT Okanogan Small Tributary Systems Fish Screening Concept	Dormant	Okanogan		2 Injury and Mortality - Mechanical Injury	$175,000.00									$175,000.00
18894	CCT Wild Horse Spring Creek Culvert Replacement	Completed	Okanogan		1 Habitat Quantity - Anthropogenic Barriers	$60,000.00									$60,000.00
13257	CCT Colville Confederated Tribes Action Agency MOA	Active	Regionwide												

13308	YN Yakama Nations Action Agency MOA	Active	Regionwide												
16907	Witnessing Change	Conceptual	Regionwide												
1890	CCNRD Alder Creek Culvert #1 and 2	Completed	Wenatchee	Chiwawa River	1 Habitat Quantity - Anthropogenic Barriers										$315,774.01
1893	CCNRD Clear Creek Culvert Replacements	Completed	Wenatchee	Chiwawa River	1 Habitat Quantity - Anthropogenic Barriers										$216,840.00
10322	USFS Chiwawa Recreation Restoration	Completed	Wenatchee	Chiwawa River	4 Riparian Condition - Riparian Vegitation										$135,500.00
10332	USFS Chikamin Pumice Mine and Road Restoration Project	Completed	Wenatchee	Chiwawa River	7 Sediment Conditions - Increased Sediment Quantity										$140,000.00
10707	CCD & CCPW Chiwawa Loop Road Wetland Mitigation	Completed	Wenatchee	Chiwawa River	4 Riparian Condition - Riparian Vegitation										$34,000.00
15028	CCNRD Wenatchee Chiwawa Irrigation District Efficiencies	Conceptual	Wenatchee	Chiwawa River		$170,000.00									$170,000.00
16925	USFS Chiwawa River Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	Chiwawa River				$25,000.00							$25,000.00
18503	CCFEG Wenatchee Nutrient Assessment	Completed	Wenatchee	Chiwawa River	3 Food - Altered Primary Productivity		$256,828.00								$256,828.00
18702	CCFEG Chiwawa Nutrient Enhancement	Proposed	Wenatchee	Chiwawa River	3 Food - Altered Primary Productivity							$300,000.00			$300,000.00
29720	CCFEG Clear Creek Riparian Planting	Completed	Wenatchee	Chiwawa River	4 Riparian Condition - Riparian Vegitation	$400.00									$400.00
1701	CCD Chumstick Fish Passage Complex	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers										$240,600.00
1769	CCNRD Chumstick/Eagle Riparian Restoration 2007	Completed	Wenatchee	Chumstick Creek	4 Riparian Condition - Riparian Vegitation										$73,283.64
10712	CCD McDevitt Diversion Project	Completed	Wenatchee	Chumstick Creek	2 Injury and Mortality - Mechanical Injury										$2,000.00
10783	CCNRD Wenatchee Instream Flow Habitat Project	Completed	Wenatchee	Chumstick Creek											$187,469.01
10791	CCNRD Chumstick 2009 North Road Culvert Replacement	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers										$1,818,779.00
11921	CCNRD Chumstick Creek Culvert Replacement 2009 Projects	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers										$2,513,324.23
15866	CCD Freund Canyon Barrier Removal	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers	$148,000.00									$148,000.00
15957	CCNRD Chumstick Creek Culvert Replacement 2010 Project	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers										$60,000.00
15958	CCNRD Chumstick Creek Culvert Replacement 2011 Project	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers										$161,829.72
16142	TU-WWP Chumstick Creek Water Quantity Projects	Conceptual	Wenatchee	Chumstick Creek	9 Water Quantity - Decreased Water Quantity		$260,000.00								$260,000.00
16922	USFS Chumstick Creek Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	Chumstick Creek				$25,000.00							$25,000.00
16929	CCNRD Chumstick Creek Culvert Replacement 2012 Project	Completed	Wenatchee	Chumstick Creek	1 Habitat Quantity - Anthropogenic Barriers										$618,412.00
17508	CCD 2011 Chumstick Clean-up and Riparian Restoration	Completed	Wenatchee	Chumstick Creek	4 Riparian Condition - Riparian Vegitation										$16,000.00
17872	TU-WWP Lower Chumstick Flow Enhancement	Completed	Wenatchee	Chumstick Creek	9 Water Quantity - Decreased Water Quantity		$4,800.00								$4,800.00
19113	CCD Old Barn Farm Restoration	Completed	Wenatchee	Chumstick Creek	4 Riparian Condition - Riparian Vegitation	$3,500.00									$3,500.00
1636	USFWS LNH Icicle Creek Restoration Project	Active	Wenatchee	Icicle Creek	1 Habitat Quantity - Anthropogenic Barriers			$5,700,000.00							$5,700,000.00
1653	ICTU Icicle Creek Reach Level Analysis	Completed	Wenatchee	Icicle Creek											$47,500.00
1764	CCNRD Icicle Revegetation Fromm 7	Completed	Wenatchee	Icicle Creek	4 Riparian Condition - Riparian Vegitation										$21,114.00
10783	CCNRD Wenatchee Instream Flow Habitat Project	Completed	Wenatchee	Icicle Creek											$187,469.01
10796	CDLT Lower Icicle Creek Habitat Conservation	Completed	Wenatchee	Icicle Creek	5 Peripheral and Transitional Habitats - Floodplain Condition										$420,000.00
10797	CDLT Icicle Creek Conservation Opportunities Outreach	Completed	Wenatchee	Icicle Creek											$30,500.00
13396	CCNRD Lower Icicle Riparian Initiative	Completed	Wenatchee	Icicle Creek	4 Riparian Condition - Riparian Vegitation										$40,749.00
16143	TU-WWP Icicle Creek Alternatives Analysis	Conceptual	Wenatchee	Icicle Creek	9 Water Quantity - Decreased Water Quantity					$176,000.00					$176,000.00
16429	CDLT Icicle Creek Copper Notch Conservation Easement	Completed	Wenatchee	Icicle Creek	5 Peripheral and Transitional Habitats - Floodplain Condition										$0.00
16924	USFS Icicle Creek Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	Icicle Creek				$25,000.00							$25,000.00
18087	CCNRD Icicle Irrigation District Efficiencies	Proposed	Wenatchee	Icicle Creek											
18143	CDLT Lower Wenatchee Leavenworth Audubon Center Acquisition	Completed	Wenatchee	Icicle Creek	5 Peripheral and Transitional Habitats - Floodplain Condition										$0.00
18204	TU-WWP - Icicle Creek Boulder Field Assessment	Completed	Wenatchee	Icicle Creek	1 Habitat Quantity - Anthropogenic Barriers		$123,854.00								$123,854.00
18500	CCFEG Salmon Lifecycle Landscape	Completed	Wenatchee	Icicle Creek		$10,000.00									$10,000.00
18714	TU-WWP Icicle Boulder Field Passage Design	Proposed	Wenatchee	Icicle Creek				$185,000.00							$185,000.00
16565	CCNRD Lake Wenatchee Water Quality Monitoring	Completed	Wenatchee												$44,000.00
16926	JSFS Little Wenatchee River Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	Little Wenatchee Riv				$25,000.00							$25,000.00
18503	CCFEG Wenatchee Nutrient Assessment	Completed	Wenatchee	Little Wenatchee Riv	3 Food - Altered Primary Productivity		$256,828.00								$256,828.00
1630	CCD & CCPW Sleepy Hollow Bridge Restoration Project	Completed	Wenatchee	Lower Wenatchee	6 Channel Structure and Form - Instream Structural Complexity										$16,500.00
1649	CCNRD FLIR Assessment	Completed	Wenatchee	Lower Wenatchee											$65,317.00
1655	CCD Jones-Shotwell Screen & Diversion Enhancement	Completed	Wenatchee	Lower Wenatchee	2 Injury and Mortality - Mechanical Injury										$303,091.00
1665	CCNRD Wenatchee Revegetation Leavenworth Golf Course	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation										$24,427.88
1684	CCD Riparian Revegetation on Wenatchee River 02	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation										$2,000.00
1688	CCNRD Irwin Riparian Restoration RM 24.3	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation										$99,932.00
1696	CCNRD Lower Wenatchee Channel Migration Zone Study	Completed	Wenatchee	Lower Wenatchee											$233,142.00
1735	CCNRD CMZ 20	Completed	Wenatchee	Lower Wenatchee	6 Channel Structure and Form - Instream Structural Complexity										$169,932.00
1792	CCNRD CMZ 11	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$427,573.08
1794	CCNRD CMZ 12 & 13	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$225,649.16
1889	CCNRD CMZ 10 Gagnon	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$513,775.00
7102	CCNRD Cashmere Pond Off-Channel Habitat	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$433,992.11
7103	YN Goodfellow/Chotzen Floodplain Reconnection	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$360,000.00
10639	PRCC Blackbird Island Side Channel Habitat Complexity	Completed	Wenatchee	Lower Wenatchee	6 Channel Structure and Form - Instream Structural Complexity										$150,000.00
10701	CCD Cummings Restoration Project	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation										$42,400.00
10751	WSDOT CMZ 6 US 2/97 Monitor Flats Channel Enhancement	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										
10755	ICTU Blackbird Island Kids Fishing /Steelhead Acclimatization Pond	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$300,000.00
10758	ICTU & WDFW Blackbird Island Riparian Planting Project	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$250,000.00
10785	PUD Chelan Dryden Fish Enhancement CMZ Project	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$179,750.39
10788	ICTU Blackbird Island Channel Development	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$350,000.00
13373	CCNRD Wenatchee River Riparian Enhancement RM 11	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation										$60,088.27
13375	CCNRD Wenatchee River Riparian Enhancement RM 15.1	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation										$37,852.73
14464	CCNRD CMZ 6 Side Channel	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$120,451.67
14555	TU-WWP Lower Wenatchee River Instream Flow Enhancement Project	Completed	Wenatchee	Lower Wenatchee	9 Water Quantity - Decreased Water Quantity	$3,467,842.00									$3,467,842.00
15012	CCD CMZ 2 Lower Sleepy Hollow Island Riparian Restoration	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation										$52,000.00
15025	CCNRD Lower Wenatchee River Leavenworth Boat Launch Off-channel Reconnection	Completed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$149,500.00
16001	YN Sunnyslope ELJ	Completed	Wenatchee	Lower Wenatchee	6 Channel Structure and Form - Instream Structural Complexity										$400,000.00
16298	CCNRD Wenatchee River Riparian Enhancement RM 1.4	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation										$43,372.92
16300	CCNRD Wenatchee River Riparian Enhancement RM 13.6	Completed	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation										$39,474.05

16928	Wenatchee River mainstem Minimum Roads Analysis and Road System Improvement	Proposed	Wenatchee	Lower Wenatchee				$25,000.00							$25,000.00
16938	CCNRD Old Peshastin Mill Riparian Enhancement	Active	Wenatchee	Lower Wenatchee	4 Riparian Condition - Riparian Vegitation			$86,285.00							$86,285.00
17985	CDLT Wenatchee River Lower Sleepy Hollow Floodplain Conservation Easements	Proposed	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Floodplain Condition	$545,000.00									$545,000.00
18091	CCNRD Lower Wenatchee Levee Removal	Active	Wenatchee	Lower Wenatchee	5 Peripheral and Transitional Habitats - Floodplain Condition		$68,000.00								$68,000.00
19319	UCSRB Joy Creek Fish Passage Project	Active	Wenatchee	Lower Wenatchee	1 Habitat Quantity - Anthropogenic Barriers			$100,000.00							$100,000.00
1694	CCD Lower Mission Creek Planting Project	Completed	Wenatchee	Mission Creek	4 Riparian Condition - Riparian Vegitation										$110,000.00
1698	CCNRD Brender Creek Habitat Development	Completed	Wenatchee	Mission Creek	6 Channel Structure and Form - Bed and Channel Form										$46,931.00
1768	CCNRD Mission Creek Riparian Restoration 2007	Completed	Wenatchee	Mission Creek	4 Riparian Condition - Riparian Vegitation										$20,014.44
8523	CCD Mission Creek Diversion/Screens 2008	Completed	Wenatchee	Mission Creek	6 Channel Structure and Form - Instream Structural Complexity										$25,000.00
10315	CCD & CCPW Yaksum Creek-Horner Restoration Project	Completed	Wenatchee	Mission Creek	4 Riparian Condition - Riparian Vegitation										$36,900.00
10709	CCD Brender Creek Pond	Completed	Wenatchee	Mission Creek	4 Riparian Condition - Riparian Vegitation										$5,000.00
10711	CCD Mission Creek Habitat Restoration and Streambank Stabilization Project	Completed	Wenatchee	Mission Creek	6 Channel Structure and Form - Bed and Channel Form										$32,600.00
14458	CCD Yaksum Creek Riparian Enhancement	Completed	Wenatchee	Mission Creek	6 Channel Structure and Form - Instream Structural Complexity										$25,000.00
16132	TU-WWP Mission Creek Water Quantity Projects	Conceptual	Wenatchee	Mission Creek	9 Water Quantity - Decreased Water Quantity	$260,000.00									$260,000.00
16923	USFS Mission Creek Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	Mission Creek				$25,000.00							$25,000.00
1888	CCNRD Nason Creek 2007 Oxbow Reconnection	Completed	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Floodplain Condition										$800,000.00
7174	Nason Creek Kahler Design	Proposed	Wenatchee	Wenatchee - Nason	6 Channel Structure and Form - Instream Structural Complexity				$175,000.00						$175,000.00
10645	WSDOT Mill Creek Culvert Replacement	Completed	Wenatchee	Wenatchee - Nason	1 Habitat Quantity - Anthropogenic Barriers										$1,300,000.00
10747	BOR Nason Creek Assessments	Completed	Wenatchee	Wenatchee - Nason											$414,000.00
10752	PUD Grant - Nason Creek Godwin Parcel Purchase	Completed	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Floodplain Condition										
10783	CCNRD Wenatchee Instream Flow Habitat Project	Completed	Wenatchee	Wenatchee - Nason											$187,469.01
10792	CCNRD BNSF Railroad and Wenatchee Basin Coordination	Completed	Wenatchee	Wenatchee - Nason											$54,125.00
13410	CCNRD Nason N4 oxbow reconnection	Completed	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										$791,300.50
14462	CCNRD Nason Creek Lower White Pine Reconnection Project	Completed	Wenatchee	Wenatchee - Nason	1 Habitat Quantity - Anthropogenic Barriers	$99,166.00									$99,166.00
14463	CCNRD Nason Creek Upper White Pine Reach 2 Restoration	Active	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions			$225,000.00							$225,000.00
15026	CCNRD Nason N1-KDIZ3 Floodplain Reconnection	Active	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions			$107,300.00							$107,300.00
16127	USFS Nason Creek Minimum Roads Analysis	Completed	Wenatchee	Wenatchee - Nason											$25,000.00
16258	YN Nason Creek Inner Zone Project Identification	Completed	Wenatchee	Wenatchee - Nason											$15,000.00
16921	USFS Upper Peshastin Creek Roads Inventory	Active	Wenatchee	Wenatchee - Nason								$100,000.00			$100,000.00
16939	CCNRD Nason Creek Coulter Creek Barrier Replacement	Active	Wenatchee	Wenatchee - Nason	1 Habitat Quantity - Anthropogenic Barriers		$169,134.00								$169,134.00
16994	CDLT Nason Creek Lower White Pine Alcove Acquisition	Completed	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Floodplain Condition		$294,700.00								$294,700.00
18503	CCFEG Wenatchee Nutrient Assessment	Completed	Wenatchee	Wenatchee - Nason	3 Food - Altered Primary Productivity		$256,828.00								$256,828.00
18665	CDLT Nason Creek UWP Horseshoe Bend Acquisitions	Active	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Floodplain Condition			$379,700.00							$379,700.00
29743	1st Bend Nason LWP Habitat Restoration Project	Completed	Wenatchee	Wenatchee - Nason	4 Riparian Condition - Riparian Vegitation	$378,428.00									$378,428.00
29743	1st Bend Nason LWP Habitat Restoration Project	Completed	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Nearshore Conditions	$378,428.00									$378,428.00
29743	1st Bend Nason LWP Habitat Restoration Project	Completed	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$378,428.00									$378,428.00
29743	1st Bend Nason LWP Habitat Restoration Project	Completed	Wenatchee	Wenatchee - Nason	6 Channel Structure and Form - Bed and Channel Form	$378,428.00									$378,428.00
29743	1st Bend Nason LWP Habitat Restoration Project	Completed	Wenatchee	Wenatchee - Nason	6 Channel Structure and Form - Instream Structural Complexity	$378,428.00									$378,428.00
29746	Upper White Pine Sub-Reaches 3&4 Habitat Restoration Project	Proposed	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Nearshore Conditions										
29746	Upper White Pine Sub-Reaches 3&4 Habitat Restoration Project	Proposed	Wenatchee	Wenatchee - Nason	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										
1731	Longview Fibre Culvert Conversion (7)	Completed	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers										
1791	CCNRD Peshastin Irrigation Pipeline Schedule A	Completed	Wenatchee		9 Water Quantity - Decreased Water Quantity										$906,622.00
10317	CCD Mill Creek Ditch Fish Passage Improvement Project	Completed	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers										$35,000.00
10321	USFS Sand Creek and Little Camas Creek Culvert Replacement	Completed	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers										$150,000.00
10748	YN Peshastin Creek Reach Assessment	Completed	Wenatchee												$160,000.00
10757	ICTU & WDFW Brender Creek Riparian Planting Project	Completed	Wenatchee		4 Riparian Condition - Riparian Vegitation										$55,000.00
10780	CCNRD Peshastin Creek Fishway	Completed	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers										$237,950.31
10783	CCNRD Wenatchee Instream Flow Habitat Project	Completed	Wenatchee												$187,469.01
14449	CCNRD Peshastin Creek Reconnection Alternatives Analysis (RM 3.9)	Completed	Wenatchee		5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions	$98,102.00									$98,102.00
15027	CCNRD Peshastin Irrigation District Pump Exchange	Active	Wenatchee		9 Water Quantity - Decreased Water Quantity										
16093	CCNRD Peshastin Irrigation Pipeline Schedule B	Completed	Wenatchee		9 Water Quantity - Decreased Water Quantity										$304,960.86
16133	TU-WWP Peshastin Creek Water Quantity Projects	Conceptual	Wenatchee		9 Water Quantity - Decreased Water Quantity	$45,000.00									$45,000.00
16937	CCNRD Mill Creek Culvert Replacement Mountain Home Ranch Rd	Active	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers		$390,081.00								$390,081.00
17929	CCNRD Peshastin BRG Side Channel	Active	Wenatchee		5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions				$199,000.00						$199,000.00
17983	CCNRD Upper Peshastin Creek Reach Assessment	Conceptual	Wenatchee												$135,000.00
17984	CCNRD Ruby Creek barrier replacement	Conceptual	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers										$100,000.00
18711	CCNRD Camas Creek Fish Passage	Conceptual	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers										
18716	Restore Lower Peshastin Creek - Design	Proposed	Wenatchee		5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions			$140,000.00							$140,000.00
18737	YN Peshastin Creek RM 0.8	Completed	Wenatchee		5 Peripheral and Transitional Habitats - Floodplain Condition										$160,000.00
18738	YN Peshastin Fishway	Conceptual	Wenatchee		1 Habitat Quantity - Anthropogenic Barriers										$130,000.00
17255	Large Wood Coordination	Conceptual	Wenatchee												
17876	TU-WWP Beaver Reintroduction and Flow Augmentation Project	Proposed	Wenatchee		9 Water Quantity - Decreased Water Quantity						$250,000.00				$250,000.00
18188	Lamprey	Conceptual	Wenatchee												
18662	WDFW Wenatchee-Entiat Rivers Screen Inventory & Design	Proposed	Wenatchee					$100,000.00							$100,000.00
1706	CCNRD Beaver Creek #1, 2 & 3	Completed	Wenatchee	Upper Wenatchee (L	1 Habitat Quantity - Anthropogenic Barriers										$235,676.55
1763	CCNRD Upper Skinney Creek Culvert	Completed	Wenatchee	Upper Wenatchee (L	1 Habitat Quantity - Anthropogenic Barriers										$75,991.00
10646	WSDOT Skinney Creek Culvert Replacements (3)	Completed	Wenatchee	Upper Wenatchee (L	1 Habitat Quantity - Anthropogenic Barriers										$1,300,000.00
10783	CCNRD Wenatchee Instream Flow Habitat Project	Completed	Wenatchee	Upper Wenatchee (L											$187,469.01
15022	USFS Skinney Creek Restoration	Proposed	Wenatchee	Upper Wenatchee (L											$125,000.00
16028	CCNRD Ponderosa Community Riparian Assessment and Planting	Completed	Wenatchee	Upper Wenatchee (L											$25,077.00
16353	YN Upper Wenatchee Stream Corridor Assessment and Habitat Restoration Strategy	Completed	Wenatchee	Upper Wenatchee (L											$300,000.00
16928	Wenatchee River mainstem Minimum Roads Analysis and Road System Improvement	Proposed	Wenatchee	Upper Wenatchee (L				$25,000.00							$25,000.00
17879	TU-WWP Beaver Creek Diversion Conversion	Conceptual	Wenatchee	Upper Wenatchee (L	9 Water Quantity - Decreased Water Quantity										
29683	CCFEG - Thomson Creek Culvert Replacement	Completed	Wenatchee	Upper Wenatchee (L	1 Habitat Quantity - Anthropogenic Barriers										

1651	CDLT White River Martin Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$170,000.00
10328	USFS White River Log Jam	Completed	Wenatchee	White River	6 Channel Structure and Form - Instream Structural Complexity										$80,000.00
10330	USFS White River Oxbow Restoration Project	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Side Channel and Wetland Conditions										
14507	CDLT White River Nason View Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$684,000.00
14508	CDLT White River Tall Timber Ranch Conservation Easement	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$583,810.00
15032	CDLT White River Kasparek Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$35,955.39
15035	CDLT White River Bjorgen Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$96,333.01
15036	CDLT White River Kincaid Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$112,408.13
15038	CDLT White River Two Rivers Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$587,544.99
15044	CDLT White River RM 9 Conservation Easement	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$440,000.00
15045	CDLT White River RM 8.5 Conservation Easement	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$194,000.00
15048	CDLT White River Quintana-Leon Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$259,184.13
15051	CDLT White River Quintana-Leon II Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$315,000.00
15959	CDLT White River Tiegel Acquisition	Completed	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition										$199,500.00
16927	USFS White River Minimum Roads Analysis and Road System Improvements	Proposed	Wenatchee	White River				$25,000.00							$25,000.00
16940	CCFEG Large Wood Atonement White River	Active	Wenatchee	White River	6 Channel Structure and Form - Instream Structural Complexity		$352,392.00								$352,392.00
17926	CDLT White River Tall Timber Ranch Conservation Easement Phase 2	Active	Wenatchee	White River	5 Peripheral and Transitional Habitats - Floodplain Condition		$229,500.00								$229,500.00
18495	CCFEG Napeequa and White River Riparian Planting	Completed	Wenatchee	White River	4 Riparian Condition - Riparian Vegitation										$47,400.00
18503	CCFEG Wenatchee Nutrient Assessment	Completed	Wenatchee	White River	3 Food - Altered Primary Productivity		$256,828.00								$256,828.00

Upper Columbia Region

2013 Implementation Report

UPPER COLUMBIA SALMON RECOVERY BOARD

September 25, 2014

Prepared by: G. Maier, Upper Columbia Salmon Recovery Board

Prepared for: National Oceanic and Atmospheric Administration, National Marine Fisheries Service

Introduction

This annual Upper Columbia Salmon Recovery Board (UCSRB) report to NOAA Fisheries provides an overview of recovery projects completed in 2013 that benefit ESA listed Upper Columbia spring Chinook salmon, steelhead, and bull trout. The recovery of ESA-listed salmon, steelhead, and bull trout populations in the Upper Columbia Region is, in part, dependent upon the implementation of habitat restoration and protection actions identified in the *Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan* (UCSRB 2007[1]) and the Upper Columbia Regional Technical Team's (UCRTT) Biological Strategy (UCRTT 2013[2]). NOAA Fisheries formally adopted the Recovery Plan in October 2007. In 2008, the UCSRB approved a process to transmit annual Recovery Plan updates to NOAA Fisheries by systematically revising the implementation schedule (Appendix M). The process by which the Implementation Schedule is developed is presented in Appendix B of this report. The attached update and the following summary of habitat actions completed during the 2013 calendar year reflect a component of the UCSRB's approach to tracking implementation progress.

The Upper Columbia Region is located in north-central Washington, primarily within the Columbia Cascade Province of the Columbia River Basin. The region is comprised of the main stem Columbia River from Chief Joseph Dam downstream to the confluence of the Yakima River, and includes all the tributaries flowing into the Columbia River. The region includes six subbasins; however, the majority of salmon recovery habitat restoration occurs in the Wenatchee, Entiat, Methow, and Okanogan subbasins.

A comprehensive implementation framework, facilitated by the UCSRB, ensures strategic allocation of funds to priority recovery efforts throughout the subbasins of the region. Funding for implementation of the Recovery Plan comes from a variety of sources. Congress directly authorizes annual spending under the Pacific Coastal Salmon Recovery Fund (PCSRF). This funding allows for the capacity of regional organizations, although the majority of PCSRF investment is for on-the-ground actions consistent with the Recovery Plan, and is matched by the Washington State Legislature. Mitigation for the operation of the hydropower dams on the Columbia River also supports implementation. This mitigation funding comes from the mid-Columbia PUDs (Grant, Chelan, Douglas), and from two of the three Action Agencies to the Federal Columbia River Power System Biological Opinion (Bonneville Power Administration and Bureau of Reclamation).

The systematic tracking of habitat implementation in the Upper Columbia is part of a comprehensive effort to track recovery across all management and geographic boundaries. With this information, the UCSRB intends to convene decision-makers from each management sector to develop collaborative solutions that accelerate the push towards recovery. The Recovery Plan envisions an "All-H" approach for success, and information and collaborative solutions across all of the management sectors will be pertinent for recovery.

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[1] Upper Columbia Salmon Recovery Board (UCSRB). 2007. Upper Columbia spring Chinook salmon and steelhead recovery plan. Wenatchee, Washington, 300 pp. Available at: www.ucsrb.org.

[2] Upper Columbia Regional Technical Team (UCRTT). 2008. A Biological Strategy to Protect and Restore Salmonid Habitat in the Upper Columbia Region. A report to the Upper Columbia Salmon Recovery Board from the Upper Columbia Regional Technical Team. Available at: www.ucsrb.org.

Analysis of UC Projects Completed in 2013

In 2013, partners completed 41 projects across all four major subbasins, a 40% increase above the number of projects implemented in 2012. A total of While actions may have begun in different years, all were completed during the 2013 calendar year. The 41 projects breaks down as: 31 restoration (of various types), 2 protection, 4 combination acquisition and restoration (an emerging project type in the region), and 4 non-capital (e.g. design). The projects implemented in 2013 ranged from riparian habitat projects to educational projects. The top three project types were riparian habitat (30%), fish passage (25%), and instream habitat (20%). Protection (10%), assessment and design (8%), educational, and instream flow projects were also implemented. Figure 1 shows locations of projects completed in 2013.

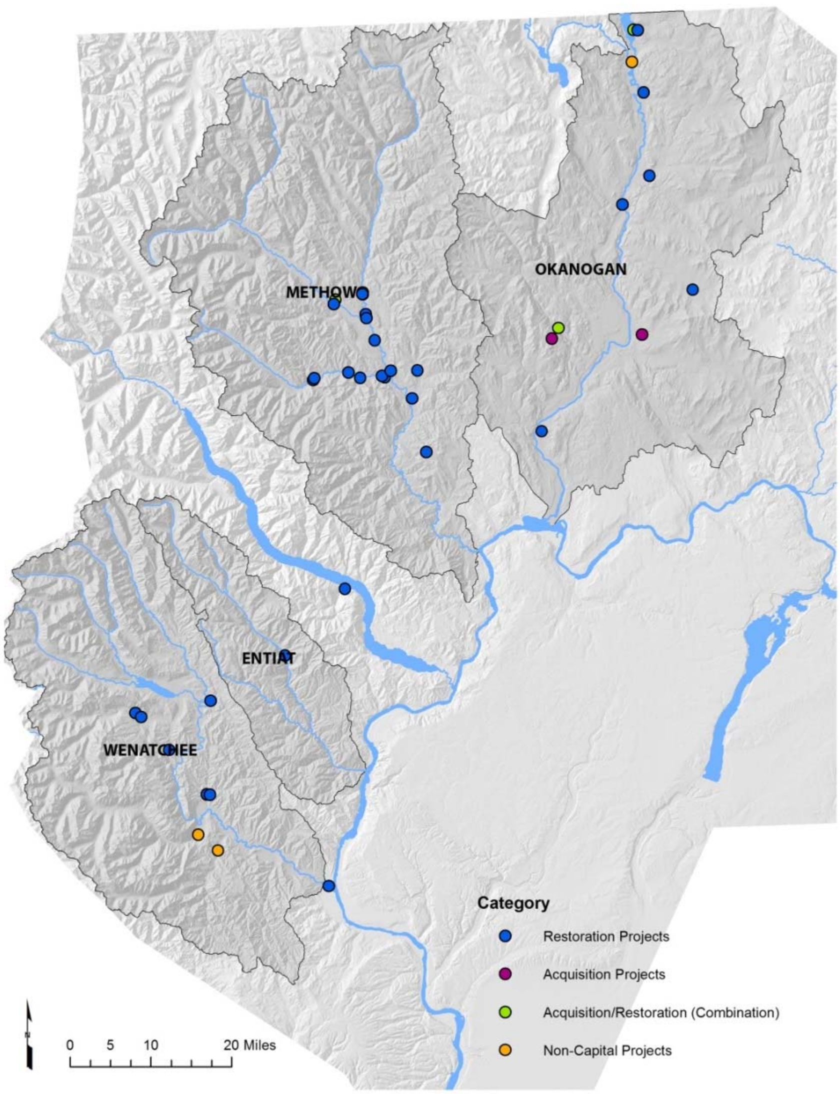


Figure 1. Map of 2013 completed projects by type.

The 2013 projects resulted in 6 additional miles of stream improved, 20 additional miles opened for fish passage, 176 additional acres of floodplain reconnected as well as 38 additional cubic feet per second of flow returned instream. Other outcomes are summarized in the box to the right.

<u>2013 Habitat Accomplishments</u>
41 projects completed

6 miles of stream improved
83 acres of riparian habitat improved
5.3 mile of off-channel habitat improved
176 acres of off-channel habitat reconnected
17 barriers removed
20 miles opened to fish
38 cfs returned instream
24 acres protected
1.2 miles of stream protected

As illustrated in Figures 2 and 3 below, the majority of restoration and protection projects were implemented in high and medium priority areas as identified by the Upper Columbia Regional Technical Team and documented in the Upper Columbia Biological Strategy (UCRTT 2013). Priorities were developed based on the current status of habitat, the threat of future degradation (protection), and the potential for restored benefit and function (restoration and protection).

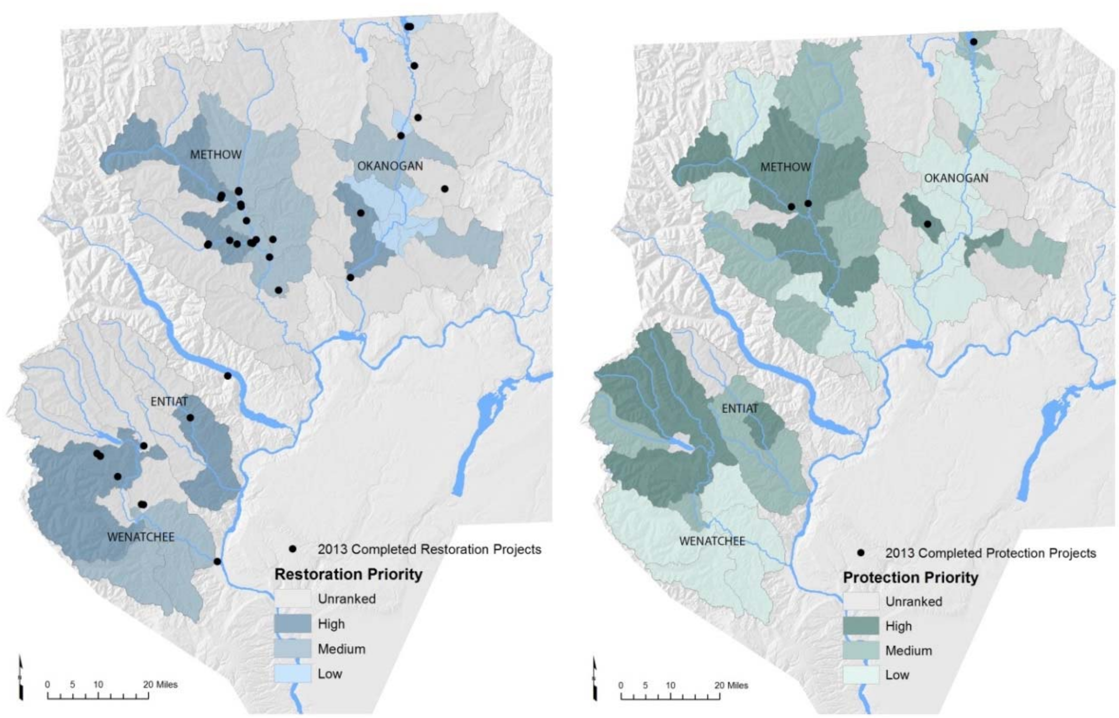
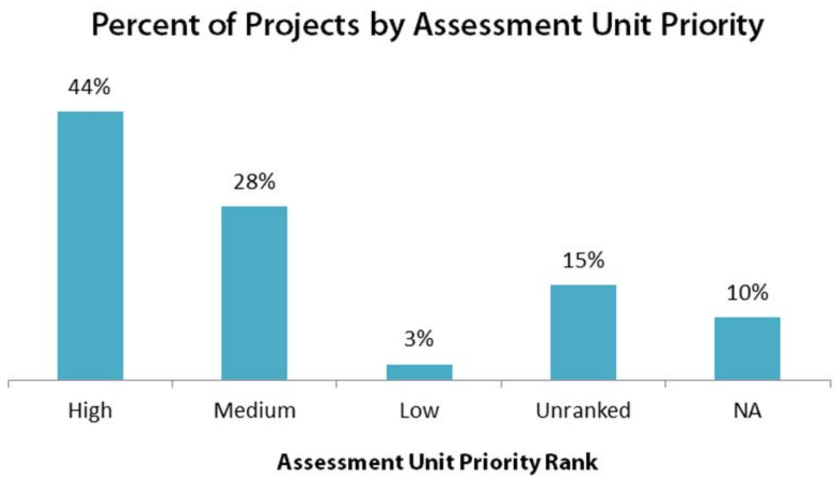


Figure 2. Maps showing locations of 2013 completed projects within priority assessment units in the UC.



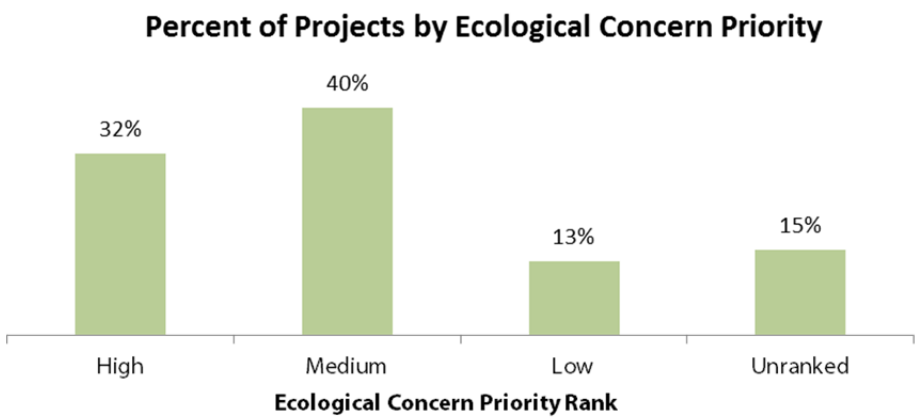


Figure 3. Number of projects in each priority ranking category. Priority is based on UCRTT Biological Strategy (UCRTT 2013).

Projects implemented in 2013 benefitted ESA-listed spring Chinook, steelhead, and bull trout. Nearly all projects benefitted steelhead with less benefitting spring Chinook and bull trout. Many projects benefitted more than one species.

The top three ecological concerns addressed by the 2013 projects include riparian condition (37%), side channel and wetland conditions (13%), and anthropogenic barriers (12%). Most projects addressed more than one ecological concern. See Figure 4 for all ecological concerns addressed. Compared with the top ecological concerns for the affected assessment units, projects generally addressed primary ecological concerns.

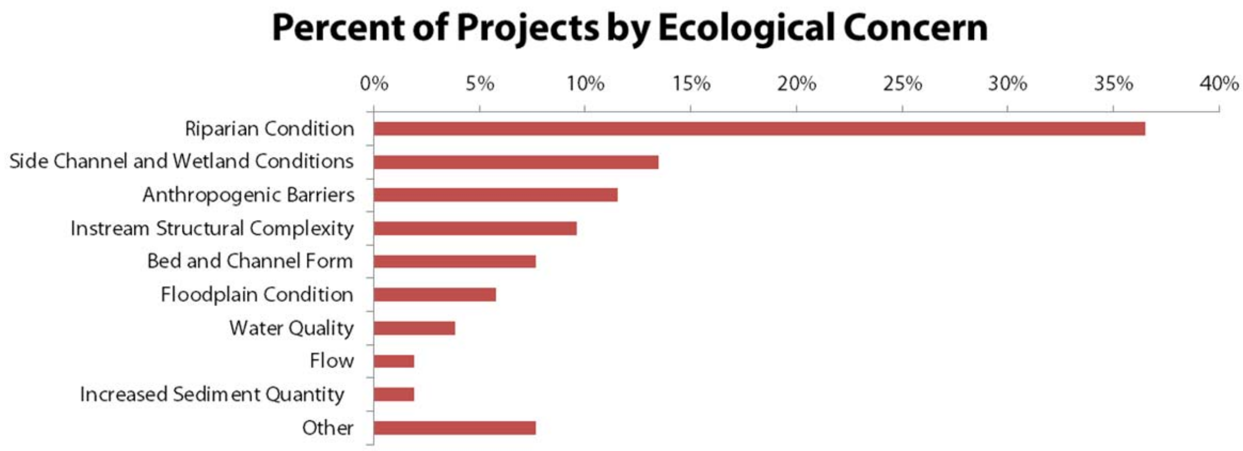


Figure 4. Ecological Concerns addressed by projects completed in 2013

Implementation in the Upper Columbia Subbasins

The four subbasins (Wenatchee, Entiat, Methow, and Okanogan) discussed in this report span an area of over eight million acres. Although there are some similarities in degraded habitat conditions throughout the tributaries, each watershed is diverse and has specific ecological concerns. The region uses a reach-based action approach to ensure priority habitat projects are implemented with a clear understanding of the existing physical processes. This reach-based approach to project development incorporates information from Tributary Assessments and Reach Assessments completed by project partners, which ensures restoration and protection actions are based on a sound scientific assessment of physical channel processes.

The following section briefly discusses the subbasins where projects occurred, and includes information about feature projects that address the identified ecological concerns in those subbasins. The following demonstrates the UCSRB's commitment to a large-scale, reach-based approach to implementing river restoration projects.

Okanogan Subbasin

Partners in the Okanogan subbasin implemented 11 projects. Five of these projects were restoration projects, two combination acquisition/restoration, two acquisitions, and one non-capital project, (See *Appendix A* for a complete list of project information for this subbasin.)

The Okanogan/Similkameen is the largest and most complex subbasin in the region. Barriers, poor water quality and low late-summer instream flows (mainstem and tributary) limit the survival, distribution, and productivity of both anadromous and inland salmonids. Trans-boundary planning and implementation are ongoing and critical activities since more than half of the subbasin is within British Columbia. Disruptions to the hydrologic system have resulted in elevated water temperatures in the mainstem, substantially reducing the suitable migratory period for adult Chinook and sockeye salmon to access productive habitat. For sockeye, this habitat is primarily north of the border. Furthermore, severe alterations to cold water tributaries have diminished the amount of cold water refugia in the mainstem, and spawning and rearing habitat for summer steelhead. Consequently, other stream-type anadromous fish species, such as spring Chinook salmon are now extirpated in the Okanogan River. In addition to inhospitable thermal conditions in the mainstem, and lack or loss of stream flow in the tributaries, excessive amounts of fine sediment and migration barriers are other factors limiting salmonid production within the Okanogan River subbasin. The most widespread ecological concerns in the subbasin are instream structural complexity (82%), riparian condition (82%), increased sediment quality (79%), and decreased water quantity (71%) (UCRTT 2013). In 2013 the Colville Confederate Tribes completed two large acquisition projects in Salmon Creek to help protect some of the most important intact steelhead habitat in the Okanogan. The project is featured below.

Featured Project: Salmon Creek Acquisition Projects

Salmon Creek, a tributary to the Okanogan River, is considered to be one of the most significant opportunities to restore summer steelhead in the Okanogan Basin. The Colville Confederated Tribes (CCT) has focused on restoring and enhancing anadromous fish populations and habitat in Salmon Creek through public and private partnerships since April 1997. Recent Ecosystem Diagnostic and Treatment (EDT) modeling of Okanogan steelhead habitat supports this work by indicating that Salmon Creek may be one of the most important tributaries for protection in the Okanogan subbasin. In 2013 the Colville Confederate Tribes completed two acquisition projects to secure almost 200 acres of high quality riparian and upland habitat, 42 acres of which were in the floodplain. The purchase of these properties was for the protection of spawning and rearing habitat and for future habitat enhancement projects. Summer steelhead production in Salmon Creek could be increased through continued habitat rehabilitation opportunities and the upstream property was purchased for the development of an off channel rearing area that is fed by ground water. The habitat at this off channel area was degraded and had been previously manipulated to protect the banks with gabion structures. The project was able to reestablish a connection from the off-channel habitat to the mainstem of salmon creek, stabilize the banks along salmon creek with bioengineering techniques, protect the uplands surrounding this section of salmon creek and enhance off-channel rearing through development of the ground water fed channel.

CCT is currently working to enhance flow conditions and fish passage at the mouth of Salmon Creek and these acquisition projects complement that work. In addition, the Tribes and the Okanogan Irrigation District (OID) have developed a Memorandum of Agreement (MOA) which annually leases a minimum of 700 acre feet of water dedicated to instream flow for 12 consecutive years. The reconnection of Salmon Creek will provide access to approximately 11 miles of quality habitat upstream of the OID diversion dam. The two acquisition projects completed in 2013 will allow CCT to continue to protect, monitor, and restore Salmon Creek.

Salmon Creek

Methow Subbasin

The majority of completed projects in 2013 were in the Methow subbasin with a total of 19 projects, including 16 habitat restoration projects, two combination restoration/protection projects, and one non-capitol project (a reach assessment). (See *Appendix A* for a complete list of project information for this subbasin.)

The Methow River has a high proportion of pristine habitat in the upper portions of major tributaries. The primary habitat conditions in the Methow subbasin that currently limit abundance, productivity, spatial structure, and diversity of salmon and steelhead (as well as bull trout and Pacific lamprey) are mostly found in the middle and lower mainstem, and lower portions of major tributaries that have been affected by state highways, county roads, and housing and agricultural development that have diminished the overall function of the stream channel and floodplain. This has impaired stream complexity, wood and gravel recruitment, floodwater retention, and water quality. Additionally, late summer and winter instream flow conditions often reduce migration, spawning, and rearing habitat for native salmonids. This problem is partly natural (a result of watershed-specific weather and geomorphic conditions), but is exacerbated by long-standing irrigation withdrawals. The most widespread ecological concerns in the subbasin (by occurrence in assessment units) are riparian condition (93%), bed and channel form (87%), decreased water quality (80%), and instream structural complexity (80%) (UCRTT 2013). The restoration project featured for the Methow subbasin is on the Twisp River, and is a good example of the type of restoration going on in the region.

Featured Project: Elbow Coulee River Restoration

The Elbow Coulee restoration project was implemented by the Methow Salmon Recovery Foundation (MSRF) on land they purchased on the right (south) bank of the lower Twisp River at river mile 1.9 to provide riparian protection. The Twisp River is an important spawning and rearing area for listed spring Chinook, steelhead, and bull trout. It is highly ranked restoration action in the Regional Technical Team Biological Strategy (UCRTT 2013). Overall, the project resulted in 0.5 miles of re-connected and improved side-channel, and one replaced diversion screen to improve fish passage. Post-project monitoring from the site indicates an almost three-fold increase from 2008 in fish abundance and a greater diversity of fish species present in the restored side channel.

For the past 3 years, MSRF has been working to provide year-round surface water flow into and through the isolated side channel and pond complex, and to restore functional habitat. The goals are to provide rearing areas, improve acclimation ponds, increase floodplain width for bank storage, over-wintering refugia, new winter-rearing habitat, fish resting areas, increase floodplain wetland and riparian habitat, and improve potential l for groundwater recharge 6 miles downstream from the Elbow Coulee Project area.

The Elbow Coulee primary side-channel was re-connected by removing a man-made dike and installing a sill flow control structure. In addition, a woody debris complex was installed in the upper end of the re-connected primary side channel. Riparian buffer establishment was achieved through plantings at this site.

Elbow Coulee

Entiat Subbasin

Partners working in the Entiat subbasin finished riparian restoration on one project in 2013 (The Tyee Ranch Project) and did not implement any new projects because it was an off-year for implementation in the Intensively Monitored Watershed (IMW) study. The Entiat IMW follows a hybrid of a stair step and hierarchical approaches to implementing habitat actions, where restoration actions are implemented in a spatially and temporally explicit way to provide contrast to non-treated areas in space and time. In 2013 sponsors primarily focused on planning and design for 2014 implementation in the Lower Entiat.

There are many factors that adversely affect salmonids in the Entiat River; the most pressing needs are to enhance the lack of instream complexity and riparian cover. Reduced stream channel complexity is the primary limiting factor for salmonid productivity in the lower 10 miles of the mainstem Entiat River. Flood control dikes, channelization, and lack of native riparian vegetation limit fish habitat in the lower Entiat River. Stream sinuosity (i.e. curvature) is low, with limited gravel accumulation. Instream habitat diversity is also low, with few pools, glides, pocket waters or large woody material (LWM) accumulations. Human development has also impacted water quality by removal of streamside vegetation and increased water withdrawals. The most widespread ecological concerns in the subbasin (by occurrence in assessment units) are altered primary productivity (100%), increased sediment conditions (75%), instream structural complexity (75%), bed and channel form (75%), and riparian condition (75%) (UCRTT 2013).

Lower Entiat River

Wenatchee Subbasin

Nine projects were completed in 2013 in the Wenatchee subbasin, seven of which were habitat restoration and two of which were non-capital.

The Wenatchee subbasin is unique among those in the region in that it supports the greatest population diversity and overall salmonid abundance, yet is facing the greatest risk of habitat loss and degradation. State highways, railroads, and housing developments have substantially diminished the overall function of the stream channel and floodplain. This has impaired stream complexity, wood and gravel recruitment, floodwater retention, late summer flows, and water quality. The most widespread ecological concerns in the subbasin (by occurrence in assessment units) are riparian condition (91%), instream structural complexity (73%), side channel and wetland conditions (63%), and anthropogenic barriers (55%) (UCRTT 2013[2]).

The highest priority within the Wenatchee subbasin is the protection of habitat that supports salmonid communities so that the populations are robust to environmental disturbances, can increase in abundance, and expand their range to adjacent watersheds. These high priority watersheds within the Wenatchee subbasin include the White River, Chiwawa River, and the upper and middle mainstem Wenatchee River (including Lake Wenatchee).

Featured Project – Nason Creek Lower White Pine Project

Nason Creek has some of the highest production value for spring Chinook and steelhead in the region. It is a major spawning area for spring Chinook and steelhead and is ranked as the highest priority for restoration in the Wenatchee. The primary ecological concern for Nason Creek is the lack of side channel and wetland habitat and the lack of channel structure and form.

In 2013, the Chelan County Natural Resource Department (CCNRD) worked with multiple stakeholders to reconnect the two highest priority disconnected floodplains in Nason Creek. Nason Creek is one of the core areas for production of spring Chinook and steelhead in the region and the highest priority for restoration in the Wenatchee (RTT 2013). Construction of the railroad (currently Burlington Northern Santa Fe Railway- BNSF) in the mid-1890s cut off approximately 2 miles of Nason Creek where the stream meandered through wetlands just west of the SR 2 rest area. The project replaced a small, undersized culvert under the railroad prism with a wide-span concrete bridge to allow fish access to 152 acres of floodplain wetland (accounting for 39% of the total acres of disconnected floodplain with all of Nason Creek) and almost two miles of tributary habitat. It reconnected 15% of the Upper Nason Creek watershed within the previously isolated Coulter, Roaring, Gill and Knutson creek drainages. The CCNRD worked with BNSF Railway for several years to plan and design a bridge to provide access to the disconnected floodplain, side-channel, and tributary habitat behind the railroad prism.

The Lower White Pine floodplain reconnection project has been ranked as one of three projects in Nason Creek that is anticipated to provide the highest biological benefit to ESA listed salmon. This was the largest single project for floodplain reconnection within the Upper Columbia region. The Upper Columbia Biological Strategy (RTT 2013) identified the lack of off-channel/floodplain habitat as a primary ecological concern for listed salmonids in Nason Creek. Thus, the project goals were to reconnect flows and fish to off-channel refuge and foraging habitat directly addresses the primary habitat-limiting factor affecting anadromous fish populations in Nason Creek. The project is currently being monitoring by the Yakama Nation and the CCNRD to evaluate both fish and habitat response. This includes the installation of a PIT tag detector at the new bridge site to monitor fish use. Results are expected over the next several years.

Appendix A

Table of information for projects completed in 2013

Project Name	Subbasin	Goals and Objectives	Project Budget
1st Bend Nason LWP Habitat Restoration Project	Wenatchee	Instream Habitat	$378,428
BOR Winthrop to Wolf Creek Reach Assessment	Methow	Assessment (Non-Capital)	$30,000
CCD Entiat River Tyee Ranch Restoration	Entiat	Instream Habitat	$1,800,000
CCD Freund Canyon Barrier Removal	Wenatchee	Fish Passage	$148,000
CCFEG - Thomson Creek Culvert Replacement	Wenatchee	Fish Passage	Not Available
CCFEG 25 Mile Creek Passage Improvement Project	Wenatchee	Fish Passage	$19,649
CCFEG Clear Creek Riparian Planting	Chelan	Riparian Habitat	$400
CCFEG Driscoll Island Cold Water Refuge Design	Wenatchee	Design (Non-Capital)	$42,500
CCFEG East Fork Tunk Creek Culvert Replacement	Okanogan	Fish Passage	$150,000
CCFEG Salmon Lifecycle Landscape	Okanogan	Educational (Non-Capital)	$10,000
CCNRD Nason Creek Lower White Pine Reconnection Project	Wenatchee	Instream Habitat	$99,166
CCNRD Peshastin Creek Reconnection Alternatives Analysis (RM 3.9)	Wenatchee	Assessment (Non-Capital)	$98,102
CCT Aeneas Creek Spawning Development	Wenatchee	Fish Passage	$100,000
CCT Antoine Creek Corral Relocation	Okanogan	Riparian Habitat	$80,000
CCT Ninemile Acquisition	Okanogan	Acquisition	$150,000
CCT Salmon Creek Acquisition	Okanogan	Acquisition	$850,000
CCT Salmon Creek Acquisition 2	Okanogan	Acquisition	$330,000
CCT Wanacut Creek Acquisition	Okanogan	Acquisition	$60,000
CCT Wild Horse Spring Creek Culvert Replacement	Okanogan	Fish Passage	$60,000
MSRF 3R Riparian	Okanogan	Riparian Habitat	$68,287
MSRF Bulldog	Methow	Riparian Habitat	$34,927
MSRF Daudon Riparian	Methow	Riparian Habitat	$35,871
MSRF Elbow Coulee River Restoration	Methow	Instream Habitat	$54,061
MSRF Fine Riparian	Methow	Riparian Habitat	$33,301
MSRF Heath Phase II Install 2 Bridges	Methow	Fish Passage	$80,182
MSRF Macpherson Side Channel	Methow	Instream Habitat	$43,629
MSRF Operskalski	Methow	Instream Habitat	$31,589
MSRF Pete Creek	Methow	Instream Habitat	$60,138
MSRF Poorman Creek Barrier Removal	Methow	Fish Passage	$106,806
MSRF Satiqua Riparian	Methow	Riparian Habitat	$21,944
MSRF TRPLLC Riparian	Methow	Riparian Habitat	$95,630
MSRF Twisp Left Bank Complexity & Riparian	Methow	Instream and Riparian Habitat	$138,070
MSRF Twisp Right Bank	Methow	Riparian Habitat	$77,140
MSRF Winthrop Confluence Project Riparian	Methow	Riparian Habitat	$64,795
MSRF Witte Riparian	Methow	Riparian Habitat	$62,403
MSRF Wolfridge Riparian	Methow	Riparian Habitat	$115,835
OCD Lower Okanogan Irrigation Screens/Diversions Project	Methow	Fish Passage	Not Available
TU-WWP Lower Wenatchee River Instream Flow Enhancement Project	Wenatchee	Instream Flow	$3,467,842

TU-WWP Ninemile Creek, Riparian Restoration and Passage Improvement	Okanogan	Fish Passage	$165,783
YN Old Schoolhouse Fish Enhancement Project	Methow	Instream Habitat	$250,000

Source: Habitat Work Schedule database (September 2013).

Appendix B

Annual Implementation Schedule Development Process

Annual Implementation Schedule Development Process

The annual implementation schedule was generated directly from the Habitat Work Schedule online database. Summarized below are the steps the Upper Columbia region takes to build science, best available information, and public input into the implementation schedule updates. The process is based on guidance from NOAA Fisheries (*Interim Endangered and Threatened Species Recovery Planning Guidance*, July 2006) that outlines the following three types of Recovery Plan revisions, and required public process:

"Updates" – do not require formal public process. A memo to NMFS outlining the updates will complete the record.

"Revisions" – require a formal *Federal Register Notice*. These have an associated comment period.

"Addendum" – are communicated by attaching information updates as an addendum in a memo to NOAA Fisheries. This process may require formal public input.

Upper Columbia Process for Implementation Schedule Updates

Using NOAA Fisheries guidance, the UCSRB approved the following process for annual updates to the *Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan*.

***Step* 1** – In the fall (October/November) the Implementation Team Leader will assemble all updates in reporting terminology. The sources for reporting codes are derived from PNAMP, PCSRF and the HWS.[3] The IT Leader will engage the Regional Technical Team in a review of those terms.

***Step* 2** – The table of terms will be presented at the winter Implementation Team meeting for discussion and revision. The Implementation Team will also confirm the process for engaging the Watershed Action Teams in updating the Implementation Schedule.

***Step* 3** – The Implementation Team Leader will work with the 5 Watershed Action Teams to update the Implementation Schedule with (a) any revised reporting codes; and (b) all relevant information regarding actions implemented and actions planned for the future. The Watershed Action Teams will work with their constituents and respective stakeholders to engage them in the update process, which may include additional public meetings.

***Step* 4** – The Implementation Team Leader will consolidate all updates into the Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan Implementation Schedule. The IT Leader will also use this information to update the 3-5 year work plan for implementation.

***Step* 5** – The updated Implementation Schedule will be presented to the Board for discussion. Following the presentation of the updated Implementation Schedule, the Board will hold a formal public comment period during one of its regularly scheduled meetings. Upon approval by the Board, the updated Implementation Schedule will be sent as an attachment to a memo to NOAA Fisheries advising the agency of the updates.

Public Outreach Efforts by Okanogan County September 2003 - June 2005

Fishlines Newsletter (a link to the Newsletter was provided in each email update)			**OCSR Email Distribution List** (actual release date)	**OCSR USPS Mailing List** (actual release date)
September 2004	Volume I	Issue I	September 17, 2004 *	September 17, 2004
October 2004	Volume I	Issue 2	included in email update on 10/4/04	October 8, 2004
November 2004	Volume I	Issue 3	included in email update on 11/5/04	November 8, 2004
December 2004	Volume I	Issue 4	December 8, 2004	December 8, 2004
January 2005	Volume I	Issue 5	included in email update on 1/7/05	January 7, 2005
February 2005	Volume I	Issue 6	included in email update on 2/11/05	February 16, 2005
March 2005	Volume I	Issue 7	included in email update on 3/18/05	March 11, 2005
April 2005	Volume I	Issue 8	included in email update on 4/22/05	April 21, 2005
May 2005	Volume I	Issue 9		May 26, 2005

Email Updates			**Date Distributed**	
September 17, 2004	~	1	September 17, 2004 *	
October 4, 2004	~	2	October 4, 2004	
October 22, 2004	~	3	October 22, 2004	
November 5, 2004	~	4	November 5, 2004	
November 15, 2004	~	5	November 15, 2004	
December 3, 2004	~	6	December 3, 2004	
December 17, 2004	~	7	December 17, 2004	
January 7, 2005	~	8	January 7, 2005	
February 8, 2005	~	9	February 11, 2005	
February 18, 2005	~	10	February 18, 2005	
March 4, 2005	~	11	March 4, 2005	
March 18, 2005	~	12	March 18, 2005	
written but not sent	~	13	n/a	
April 15, 2005	~	14	April 15, 2005	
April 22, 2005	~	15	April 22, 2005	

OCSR Advisory Committee Meeting Schedule				
September 22, 2004	~	1		
October 21, 2004	~	2		
November 18, 2004	~	3		
December 16, 2004	~	4		
January 13, 2005	~	5		
February 17, 2005	~	6		
March 17, 2005	~	7		
April 13, 2005	~	8		
April 21, 2005	~	9		
April 27, 2005	~	10		
May 11, 2005	~	11		
June 16, 2005	~	12		

Additional Special-Interest Group Meeting				
May 12, 2005		1	Met with Bob Bugert of the Governor's Salmon Recovery Office	

Public Outreach Efforts by Okanogan County September 2003 - June 2005

OCSR Public Meetings (for document and Plan Draft reviews)				
September 15, 2004	Okanogan	1		
September 16, 2004	Twisp	2		
October 6, 2004	Okanogan	3		
October 7, 2004	Twisp	4		
January 11, 2005	Twisp	5		
January 12, 2005	Okanogan	6		
April 6, 2005	Okanogan	7		
April 7, 2005	Twisp	8		
Media Coverage (ads, announcements, radio spots etc)				
September 15 & 16, 2004 (Public Kick-Off Meetings)	News Release	1	Copy on file	
October 6 & 7, 2004 (Public Review Meetings)	News Release	2	Copy on file	
April 6 & 7, 2004 (Public Review Meetings)	News Release	3	Copy on file	Methow Valley News The Chronicle
September 15 & 16, 2004 (Public Kick-Off Meetings)	Radio	1	No Transcription Available	
October 6 & 7, 2004 (Public Review Meetings)	Radio	2	No Transcription Available	
September 15 & 16, 2004 (Public Kick-Off Meetings)	Ad	1	Published Copy on file	Methow Valley News
October 6 & 7, 2004 (Public Review Meetings)	Ad	2	Published Copy on file	Quad City Herald
January 11 &12, 2005 (Public Review Meetings)	Ad	3	Published Copy on file	Methow Valley News
April 6 & 7, 2004 (Public Review Meetings)	Ad	4	Published Copy on file	Methow Valley News The Chronicle
Open Line - Julie - Q&A on KOMW's Open Line Program	Radio Spot	8:30 AM	No Transcription Available	
"Draft salmon recovery plan ready for comment"	Article	Ann McCreary	Published Copy on file	Methow Valley News
"Only three people are worried about salmon recovery?"	Article	Ann McCreary	Published Copy on file	Methow Valley News
"Salmon recovery up for public review"	Article	author unknown	Published Copy on file	Methow Valley News
"Salmon plan presented"	Article	author unknown	Published Copy on file	Methow Valley News
"Upper Columbia Salmon Recovery Board reconsiders policy statement"	Article	author unknown	Published Copy on file	Quad City Herald
"Upper Columbia Salmon Recovery Plan discussed	Article	Chris Thew	Published Copy on file	The Chronicle
September 15 & 16, 2004 (Public Kick-Off Meetings)	Other	"In Brief"	Published Copy on file	Methow Valley News
"First drafts of salmon plan offered"	Other		Published Copy on file	Methow Valley News
Advisory Committee Meeting	Other	Calendar Events	Published Copy on file	Methow Valley News The Chronicle
Advisory Committee Meeting	Other	Calendar Events	Email request on file	Methow Valley News The Chronicle
Advisory Committee Meeting	Other	Calendar Events	Email request on file	Methow Valley News The Chronicle

Public Outreach Efforts by Okanogan County September 2003 - June 2005

Board of County Commissioner Agenda Updates

From October 2003 through June 2005, Okanogan County Commissioners received weekly briefings on watershed planning and salmon recovery planning. That information was provided by County Water Resources Coordinator Julie Pyper, during her regularly scheduled time in the Commissioners' public meetings.

Stakeholders and Agencies interviewed by Highland Associates for input on Habitat Matrices & Inventories

Bob Anderson, OCD; & Will Keller, NRCS
Chris Johnson, MSRF; Greg Knott, BOR; and Jennifer Molesworth, USFS (with Julie)
Greg Knott, BOR
Karla (MBPU) and Chris Christianson, ranchers
Steve Devin, rancher
Nim Titcomb, Wolf Creek Reclamation District
George Wooten, Northwest Ecosystem Alliance
Rocklynn Culp, Town of Winthrop
Craig Boesel, rancher & Chewuch Ditch Co.
Methow Conservancy Board & Staff
Dale Swedburg, WDFW
Alex Uber, WDFW
Mark Cookson, WDFW
Connie Iten, WDFW
Nancy Wells, USFS
Brian Derting, WDNR
Joe Kelly, BLM

Fishlines Newsletter

Okanogan County Office of Planning and Development
Water Resources Division
123 North 5th Avenue Room 110
Okanogan, WA 98840

SEPTEMBER MEETING SCHEDULE

2004	
September 15	Kick Off meeting: Okanogan County Commissioners' Hearing Room; 123 North 5th Avenue, Okanogan; 6:30 PM
September 16	Kick Off meeting: Methow Valley Senior Center, 215 Highway 20, Twisp; 6:30 PM
September 22	Advisory Committee meeting: Okanogan County PUD Auditorium; 1331 2nd Avenue, Okanogan; 6:30 PM
For a complete schedule go to www.okanogancounty.org/Water	

PROJECT MILESTONES

2004	
Beginning of October	Public Meeting: Present work products developed to date
October 01—31	Comment Period: Work products developed to date
2005	
Beginning of January	Public Meeting: Present work products developed to date
January 01-31	Comment period: 1st draft of regional salmon recovery plan
April—mid May	Comment period: final draft of regional salmon recovery plan
June 30	Plan submitted to the State of Washington
Monthly Okanogan County Regional Salmon Recovery Planning Advisory Committee meetings until June 30, 2005.	

Fish Lines

A newsletter providing information about regional salmon recovery planning in Okanogan County.
Volume I Issue 1 September 2004

Okanogan County Office of Planning and Development

Water Resources Division

Working to balance the needs of economy, salmon and the community in the Upper Columbia regional salmon recovery planning process.

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For information about regional salmon recovery planning in Chelan and Douglas counties contact:

Chelan County: Mike Kaputa
(509)667.6584

Douglas County: Chuck Jones
(509)884.7173

IN THIS ISSUE . . . .

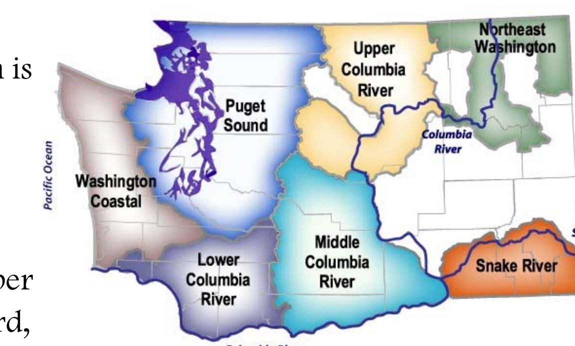
→*What is regional salmon recovery planning?*
→*Why is a regional salmon recovery plan needed?*
→*How can local stakeholders participate?*
→*Why is Okanogan County involved?*
→*Okanogan County's Regional Salmon Recovery Planning Advisory Committee*
→*Who is involved?*

WHY THE NEWSLETTER?

Regional salmon recovery planning was authorized by the Washington State legislature in 2001 as a means of involving local citizens and policy makers in the recovery of at-risk salmonid species. Regional salmon recovery planning is a means for local stakeholders to work with state and federal agencies to plan for delisting of threatened and endangered salmonid species. This newsletter has been developed to keep local citizens and other stakeholders informed about regional salmon recovery planning process and opportunities to become involved. It is part of a grant funded outreach project that will continue through June 30, 2005.

WHAT IS REGIONAL SALMON RECOVERY PLANNING?

In 2001, the Washington State legislature authorized regional salmon recovery planning as a means of involving local citizens and policy makers in the recovery of at-risk ESA listed salmonid species. This is an opportunity for local stakeholders to work with state and federal agencies to plan for delisting of threatened and endangered salmonid species.



A regional salmon recovery plan is a comprehensive document that defines the actions necessary to recover one or more salmonid populations within a particular area or region. Through the Upper Columbia Salmon Recovery Board, Okanogan County is working with Chelan and Douglas counties, the Colville Confederated Tribes, and the Yakama Nation to develop a recovery plan for populations of three species: Spring Chinook, Steelhead, and Bull Trout. The completed Upper Columbia plan will apply to the Moses Coulee, Wenatchee, Entiat, Methow, Okanogan, and Foster Creek subbasins.

WHY IS A REGIONAL SALMON RECOVERY PLAN NEEDED?

Regional salmon recovery planning was initiated in response to listing of fish species under the federal Endangered Species Act. Although we are seeing increased numbers of salmon and steelhead returning to rivers and streams in the Upper Columbia region including Okanogan County, the numbers still are not as high as they need to be for the species to be delisted. Regional salmon recovery planning is a response to a federal mandate. Local participation allows Okanogan County and local stakeholders to have a voice in how recovery is approached in our county.

HOW CAN LOCAL STAKEHOLDERS PARTICIPATE?

Local stakeholder participation is vital in the development of the Upper Columbia regional salmon recovery plan. There are several ways to get involved in regional salmon recovery planning in Okanogan County:

- Join the Okanogan County Regional Salmon Recovery Planning Advisory Committee
- Attend meetings and participate by sharing your ideas and opinions
- Read drafts of the Upper Columbia regional salmon recovery plan and comment
- Sign up to receive bi-weekly updates, monthly newsletters or both.
- Visit the Okanogan County Water Resources web site: www.okanogancounty.org/Water

WHAT IS IN A REGIONAL SALMON RECOVERY PLAN?

A regional salmon recovery plan includes:

•**Scientific assessments** of the status of each species and its habitat

•**Factors for decline**, threats to viability, and/or factors limiting recovery of the species, and **factors supporting** current populations

•**Measurable goals** that describe what recovery of the listed species looks like and against which the success of actions will be measured

•**Actions and commitments** for Habitat, Harvest, Hatcheries, and Hydropower that are necessary to reduce or eliminate the limiting factors and recover fish populations

•**Implementation components** such as time lines, funding, identification of responsible parties and authorities, research needs, monitoring plans, and a method for evaluating actions and adapting the plan.

The Upper Columbia Regional Salmon Recovery Plan will use the scientific assessments, information about factors for decline and goals that were developed as part of the Northwest Power and Conservation Council's subbasin planning process completed in May of this year. Actions, commitments, and implementation components for the habitat in the region will be developed by local agency staff and technical specialists in collaboration with local stakeholders (including watershed planning units). The Washington Department of Fish and Wildlife (WDFW) NOAA Fisheries, the U.S. Fish and Wildlife Service (USFWS) and the tribes will work together to identify harvest, hatchery and hydropower impacts and actions. The plan will integrate the work of the different groups to address all four "H"s.

Much of the information in this article was drawn from "An Outline for Salmon Recovery Plans", developed by WDFW and endorsed by NOAA Fisheries. More information can be viewed or downloaded from: http://wdfw.wa.gov/recovery/salmon_recovery_plan_model_dec03.pdf

WHY IS OKANOGAN COUNTY INVOLVED?

The Okanogan County Board of County Commissioners (BOCC) has chosen to participate in regional salmon recovery planning for a variety of reasons. Two of those reasons are:

1.) To ensure that **local interests** are represented in federal recovery plans aimed at delisting species, and

2.) To provide for better use of **local resources** by integrating regional salmon recovery planning with local planning efforts, including updating Okanogan County's Comprehensive Plan, Shoreline Master Program, and Flood Hazard Management Plan.

Regional salmon recovery planning in the Upper Columbia region is intended to develop a document that will be recognized by the federal agencies — NOAA Fisheries and USFWS — and used in making delisting decisions. The parties to the Upper Columbia regional salmon recovery plan are working closely with staffs of these agencies to ensure that the region's plan will facilitate delisting. One factor in the federal agencies acceptance of the plan will be the certainty that it can be implemented. The BOCC recognize that public support will be essential to the success of the plan. They have supported the County's involvement in order to ensure that local stakeholders have a chance to be heard in the plan's development, and that the plan will be realistic for our County and our region.

Okanogan County Regional Salmon Recovery Planning Advisory Committee

Okanogan County's Board of County Commissioners (BOCC) is committed to involving stakeholders in developing the Upper Columbia regional salmon recovery plan. Toward that end, the BOCC will appoint an Advisory Committee to:

- ***Comment** on work products developed*
- ***Provide guidance on** development of sections of the plan, and participate in the development of plan sections where appropriate*
- ***Inform** community members about Salmon Recovery Planning*
- ***Provide feedback** on the County's public outreach efforts*

Contact us if you are interested in being appointed.

The BOCC also wants the County to participate in developing the Upper Columbia Regional Salmon Recovery Plan so that the plan will be consistent with other locally developed plans including watershed plans. County involvement will help eliminate duplication, overlap and waste of local resources. The BOCC believes that working with federal agencies is the most responsible use of local resources, and will result in the most positive outcome for local taxpayers.

In the next issue of "Fish Lines" additional reasons will be discussed.

WHO IS INVOLVED?

Local Stakeholders. Please become involved, your involvement is crucial and needed!

Upper Columbia Salmon Recovery Board. The UCSRB oversees regional salmon recovery planning in Chelan, Douglas and Okanogan counties and on the Colville Confederated Tribes Reservation. The Board is comprised of one Commissioner or policy representative from each of the three counties and tribal governments with interests in the region—the Colville Confederated Tribes (CCT) and the Yakama Nation (YN).

Local, state, and federal agencies. Staff members representing Chelan, Douglas, and Okanogan counties, the CCT, the YN, WDFW, NOAA Fisheries, and USFWS meet regularly to coordinate and discuss issues related to regional salmon recovery planning.

Technical Writer. A technical writer will use technical information and input from participating agencies to develop the plan. Stakeholder input will shape the information that Okanogan County contributes.

Outreach staff. Because effective public involvement is critical to the success of regional salmon recovery planning, Okanogan County has hired Highlands Associates to coordinate public meetings and public communication. Okanogan County will also coordinate with the other counties and the tribes to ensure that the interests of stakeholders throughout the region are represented.

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Your October 2004 edition of

Fish Lines

OCTOBER MEETING SCHEDULE

2004	
October 06	Quarterly work-product review meeting; Okanogan County Commissioners' Hearing Room; Okanogan; 6:30 PM
October 07	Quarterly work-product review meeting; U.S.F.S Conference Room; Twisp; 6:30 PM
October 21	Regional Salmon Recovery Planning Advisory Committee Meeting #2; U.S.F.S. Conference Room; Twisp; 6:30 PM
For a complete schedule go to www.okanogancounty.org/Water	

PROJECT MILESTONES

2004	
October 6 & 7	Public Meeting: Present work-products developed to date
October 01—31	Comment Period: Work-products developed to date
2005	
Beginning of January	Public Meeting: Present first draft of regional salmon recovery plan
January 01-31	Comment period: first draft of regional salmon recovery plan
Beginning of April	Public Meeting: Present final draft of regional salmon recovery plan
April—mid May	Comment period: final draft of regional salmon recovery plan
June 30	Plan submitted to the State of Washington
Monthly Okanogan County Regional Salmon Recovery Planning Advisory Committee meetings until June 30, 2005.	

OTHER DATES OF INTEREST

October 28, 2004	WDFW/UCSRB Harvest/Hatchery Workshop; Chelan Fire House; Chelan; 6:30 PM
October 19, 2004	Salmon Creek EIS Comment Period Ends (www.efw.bpa.gov/cgi-bin/PSA/NEPA/SUMMARIES/SalmonCreek)

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Volume I Issue 2 October 2004

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IN THIS ISSUE . . . .

→ *Notes from the Advisory Committee's first meeting*
→ *Continuation of "Why is Okanogan County involved?"*
→ *Current Status of Select PNW ESA Listed Salmon Stocks*
→ *October 2004 meeting dates*

ESA LISTED SPECIES IN OKANOGAN COUNTY

Congress enacted the Endangered Species Act (ESA) in 1973 to provide for conservation of native species and the habitat on which they depend. Currently there are 19 populations of salmon, steelhead, and trout listed as endangered or threatened in the state of Washington. Three populations of salmon and steelhead native to Okanogan County were listed under the ESA in the late 1990s.

CHINOOK SALMON *Oncorhynchus tshawytscha* Listed as an endangered species on March 24, 1999, the ESU* includes all naturally spawned populations of chinook salmon in all river reaches accessible to chinook salmon in Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam in Washington, excluding the Okanogan River. Chinook salmon (and their progeny) from the following hatchery stocks are considered part of the listed ESU: Chiwawa River (spring run); Methow River (spring run); Twisp River (spring run); Chewuch River (spring run); White River (spring run); and Nason Creek (spring run).

STEELHEAD *Oncorhynchus mykiss* Listed as an endangered species on August 18, 1997, the ESU* includes all naturally spawned populations of steelhead (and their progeny) in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border. Wells Hatchery stock steelhead are also part of the listed ESU*.

BULL TROUT *Salvelinus confluentus* As of June 10, 1998, the Bull Trout is designated as Threatened in the U.S.A., conterminous, (lower 48 states). Within the area covered by this listing, this species is known to occur in: Idaho, Montana, Nevada, Oregon, Washington. The U.S. Fish & Wildlife Service is the administering agency for this species, with the agency's Pacific Region serving as the lead.

** An Evolutionarily Significant Unit or "ESU" is a distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout*

OKANOGAN COUNTY REGIONAL SALMON RECOVERY PLANNING ADVISORY COMMITTEE

Five stakeholders met with Okanogan County regional salmon recovery staff on September 22nd to learn more about regional salmon recovery planning and the Okanogan County Regional Salmon Recovery Planning Advisory Committee. The Okanogan County Board of Commissioners will appoint members to the Committee in November. Discussion centered on the relationship between regional salmon recovery planning and other natural resource planning efforts that are currently underway, and the role of the Committee.

Noting the low number of people who turned out for the meeting, the citizens in attendance expressed concerns that the Committee will be ineffective in fostering recovery actions that serve local interests. Acknowledging those concerns, Kurt Danison of Highlands Associates noted that there are some facets of regional salmon recovery that will be beyond local control—largely the harvest, hydropower and hatchery components. However, local citizens *can* have a voice in guiding the development of strategies for the habitat component of the regional salmon recovery plan that will be implemented in Okanogan County. In addition, stakeholders can help the authors of the plan understand what is working, so that local successes can be reflected in the document. In addition, Julie Dagnon-Pyper, Okanogan County Water Resource Coordinator, agreed to:

- Continue to work at the state level for incorporation of not just stakeholder comments but technical observations and comments into the Upper Columbia Regional Salmon Recovery Plan, and
- Research the idea of a performance-based, rather than prescriptive, plan, as suggested during the September 22nd meeting. A performance-based plan would specify outcomes to be obtained, and leave decisions about how to reach those outcomes to local interests. In contrast, a prescriptive plan would specify the means of reaching desired outcomes.

Committee Members Needed!

Your participation in the Okanogan County Regional Salmon Recovery Planning Advisory Committee is needed. Proposed membership of the Advisory Committee is as follows:

Interest Group Representation (two people per category, one to represent the Methow Valley and the other the Okanogan Valley)

- Business
- Municipalities/Cities
- Irrigated Agriculture/Irrigation
- Forestry
- Recreation
- Conservation
- Non-irrigated Agriculture
- Environment

Geographic Representation

- Upper Methow
- Lower Methow
- Upper Okanogan
- Lower Okanogan

Other Organizations

- Methow Basin Planning Unit
- Okanogan Basin Planning Unit
- Colville Confederated Tribes
- Okanogan County
- Okanogan Conservation District
- Economic Alliance
- Upper Columbia Regional Fisheries Enhancement Group

If you can represent one of the positions listed above on the Advisory Committee, please contact us.

The Committee's next meeting will be held at 6:30 on Thursday, October 21st, in the USFS conference room in Twisp. The agenda will include:

- Comments on first drafts of Sections 1 through 3 of the Upper Columbia Salmon Recovery Plan
- Review of Assessment Unit Summary Sheets developed during Subbasin Planning earlier this year. Management strategies outlined in the Okanogan and Methow Subbasin Plans will be the starting point for strategies and actions that will be included in the Upper Columbia Salmon Recovery Plan. The Committee will begin to refine those strategies based on limiting factors that have already been identified.
- Update on the review of local regulations, policies, and procedures being developed for the Upper Columbia counties.

WHY IS OKANOGAN COUNTY INVOLVED? A continuation from the September 2004 edition of *Fish Lines*

The Okanogan County Board of County Commissioners (BOCC) decided to participate in Regional Salmon Recovery Planning:

- To ensure that **local interests** are represented in federal recovery plans aimed at delisting at-risk salmonid species. The Upper Columbia Regional Salmon Recovery Plan is being written in cooperation with the federal agencies involved in salmon recovery—NOAA Fisheries and the U. S. Fish and Wildlife Service (USFWS). The BOCC want local stakeholders to have a voice in developing the plan. They know that plans that reflect local interests will be better for Okanogan County. **Public support** will be essential to the success of the plan. NOAA Fisheries and the USFWS are most likely to accept a plan that enjoys local support. *See the September issue of Fish Lines for further explanation of this point*
- To provide for **better use of local resources** by working to make the regional salmon recovery plan consistent with locally-developed plans, including watershed plans for the Methow and Okanogan basins. Consistency will make it easier to move forward with the plans. *See the September issue of Fish Lines for further explanation of this point*
- To ensure that **local stakeholders** have a chance to be heard in the plan's development, and that the plan will be realistic for **our county** and our region. The Upper Columbia Regional Salmon Recovery Plan will cover Chelan, Douglas, and Okanogan counties, and all of the Colville Reservation. It's important to recognize that the other areas involved will have a voice in final decisions about what the plan includes. Okanogan County will work with the other jurisdictions and with state and federal agencies to develop a plan that incorporates the opinions and preferences of the people who live and work in this county.

Current Status of Select Pacific Northwest ESA-Listed Salmon Stocks

Stock	% of Wild/Hatchery stocks	2000 returns	2001 returns	2002 returns	2003 returns	% Change 2000 to 2002/2003
Lower Columbia Chinook	50% wild; 50% hatchery	18,908	37,569	72,468	*	+283%
Lower Columbia Steelhead	70% wild; 30% hatchery	4,000	4,200	5,000	9,626	+141%
Upper Columbia Steelhead	20% wild; 80% hatchery	7,769	20,837	15,867	17,652	+126%
Mid-Columbia Steelhead	70% wild; 30% hatchery	23,448	28,138	33,765	*	+44%
Snake River Steelhead	15% wild; 85% hatchery	115,161	259,145	218,718	180,672	+57%
Snake River Fall Chinook	40% wild; 60% hatchery	3,696	8,915	12,351	11,732	+217%
Snake Spring/Summer Chinook	20% wild; 80% hatchery	51,835	192,632	101,226	98,763	+91%
Upper Willamette Chinook	20% wild; 80% hatchery	37,594	52,685	83,136	117,600	+213%
Upper Columbia Spring Chinook	50% wild; 50% hatchery	1,580	14,958	3,022	*	+91%
Upper Willamette Steelhead	75% wild; 25% hatchery	3,200	10,100	16,500	*	+416%

Source: NOAA Fisheries

* Data not available for 2003. Percent of change from 2000 is calculated from 2002. Snake River sockeye, not included in chart, is currently in the experimental stage, supported almost exclusively by safety-net hatchery group.

Many factors—including ocean conditions, fish harvest, hatchery practices, instream, riparian, and upland habitat condition, and the Columbia River hydropower system—affect the numbers of salmon that return to spawn each year. Increasing numbers may or may not indicate long-term trends toward recovery of at-risk stocks. Scientists representing NOAA Fisheries and the U. S. Fish and Wildlife Service believe it's still important to continue working to improve the health of threatened and endangered salmonid populations until those populations appear stable.

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NOVEMBER MEETING SCHEDULE

2004	
November 10	HCC; City of Leavenworth, Conference Room; Leavenworth; 1:00 PM
November 18	OC RSRP AC meeting; Okanogan County Commissioners Hearing Room; Okanogan 6:30 PM
November 30	HCC; location to be determined—please call us if you would like to attend; 10:00 AM
For a complete schedule go to www.okanogancounty.org/Water	

PROJECT MILESTONES

2005	
Beginning of January	Public Meeting: Present first draft of regional salmon recovery plan
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OTHER DATES OF INTEREST

November 9	Salmon Creek DEIS comment period ends (Comment period extended by BPA; original deadline was October 19)

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N THIS ISSUE . . .

↳ *Factors for decline: A brief history of salmon fishing in Okanogan County*
→ *Salmon Recovery matrices*

FACTORS FOR DECLINE: A BRIEF HISTORY OF SALMON FISHING IN OKANOGAN COUNTY

Scientists and policy makers use the term "Factors for Decline" to describe the activities and conditions that contribute to declines in salmonid populations. Most factors for decline can be related to one of four categories: habitat, harvest, hatcheries, or hydropower. Those four categories are referred to as the "Four Hs." Salmon Recovery work emphasizes improvements in all four categories to support recovery of salmon populations. This article focuses on how one of those "Hs", harvest, has contributed to the decline in salmonid populations that ultimately led to ESA listings in Okanogan County.

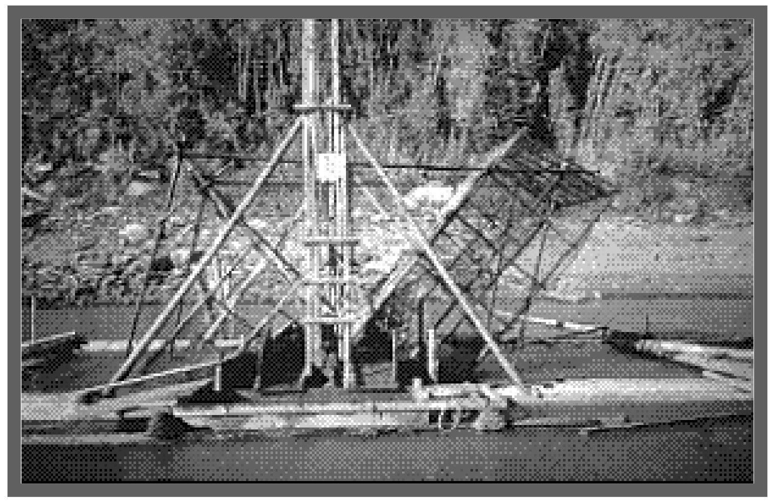
Following the last ice age, native Americans began to use the Columbia River Basin for a variety of activities, including hunting, fishing, and gathering native plants. As their culture evolved, the native people developed a heavy reliance on anadromous fish—the salmonids that are listed as threatened or endangered species today. Although the tribes of what is now Okanogan County both used and traded salmon, steelhead, and bull trout, it is unlikely that they had a significant effect on fish population size.

This article is continued on page 2 ....

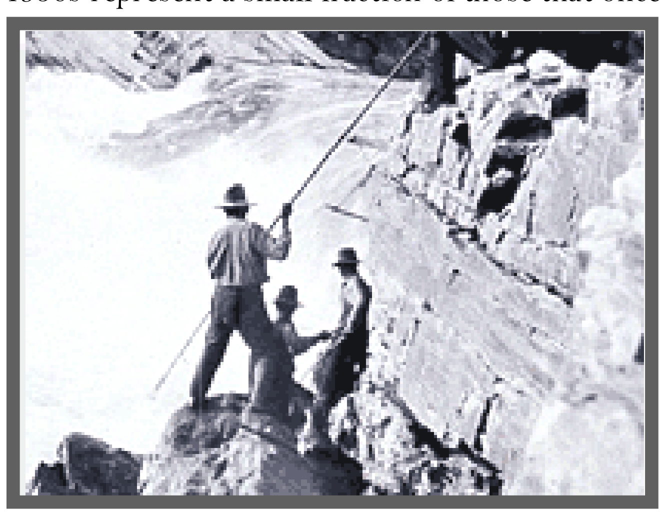
FACTORS FOR DECLINE: A BRIEF HISTORY OF SALMON FISHING IN OKANOGAN COUNTY

Nineteenth-century settlers of European ancestry found abundant fish in the rivers of the Columbia River Basin. In the DRAFT Upper Columbia Regional Salmon Recovery Plan, Tracy Hillman writes, "An intense industrial fishery in the lower Columbia River, employing traps, beach seines, gillnets, and fishwheels, developed in the latter half of the 1800s. In the early 1900s, troll fisheries developed to catch salmon even before they reached the Columbia River. The late-spring and early-summer Chinook salmon returns, which constituted the heart of the Columbia River runs, were decimated by the early 1900s. As these run components rapidly declined, fishing shifted earlier, later, and to other species, changes that, for a time, numerically masked the precipitous decline in the sought-after late-spring and early-summer fish."

Early in the 20th century, declines in fish populations became evident, and fishing began to be restricted. Dr. Hillman writes that "purse seines were outlawed in 1917, whip seines in 1923, fish wheels in 1927 (in Oregon), seines and traps east of Cascade Locks in Oregon in 1927, drag seines, traps, and set nets in 1935 (Washington), and seasons were gradually shortened."



By the early 1930s, fewer than 3,000 spring Chinook per year were returning to the Upper Columbia Basin (upstream from Rock Island Dam, then the only dam on the Columbia). Mean returns of steelhead to the Upper Columbia Basin were lower than 4,000 fish in the first part of the 1930s. We don't know how many of the fish reached their spawning grounds each year prior to European settlement; scientists estimate that about eight to fourteen million salmon and steelhead returned to the Columbia River each year. Biologists are confident that the few thousands of fish returning in the 1930s represent a small fraction of those that once spawned in the basin.



The 1930s saw dramatic social and economic changes in the Columbia Basin, as well. President Franklin Roosevelt initiated the New Deal in response to high unemployment and widespread poverty following the 1929 stock-market crash. Massive public works projects on the Columbia River and throughout the basin created jobs and stimulated investment—and forever changed the environment that had nurtured salmonids for centuries.

Hatcheries have operated in Washington since 1895; several were built in the Columbia Basin to mitigate the effects of the Columbia River hydropower system. With the advent of Columbia River dams, extensive irrigation, and hatcheries, it became more difficult to separate the effects of fishing on native salmonid populations from the effects of other factors.

Fishing continues to be regulated, with limits on numbers of fish caught and fishing seasons used to manage populations of salmon, steelhead, and bull trout. The effects of harvest on threatened and endangered fish populations will be addressed in the Upper Columbia Regional Salmon Recovery Plan. The plan will also include harvest-related actions that will contribute to recovery of listed salmonid species.

You can find the draft Table of Contents and drafts of the first three sections of the Upper Columbia Regional Salmon Recovery Plan at www.okanogancounty.org/water.

SALMON RECOVERY MATRICES

The draft Upper Columbia Regional Salmon Recovery Plan that is issued for review in January will include tables called *Salmon Recovery matrices* as a means of organizing information about the factors limiting salmonid production in the Methow and Okanogan subbasins and the strategies proposed to address those factors. Each matrix will look something like the sample below.

Population	Priority Assessment Unit	Primary Limiting Factor(s)	Management Actions / Scenario / Portfolio	Benefits to VSP
Okanogan Spring Chinook	Sample 1	Fish losses in unscreened irrigation canals	Prepare and implement screening plan. Complete survey where lacking information. Assess entrainment. Feasibility study for reconfiguration at mouth and lower reaches of creek	Abundance (M) and spatial diversity by maintaining a natural variety of available habitat types (H) and maintaining natural distribution of spawning aggregates (H)
Okanogan Spring Chinook	Sample 2	Predation	Investigate extent of losses. Prepare plan for control. Implement predator control program.	Abundance (L)

Population: the first column identifies the species being addressed (spring Chinook, steelhead, or bull trout) and the subbasin in which actions are proposed.

Priority Assessment Unit: the second column identifies the assessment unit in which a particular action or set of actions is proposed. *Assessment units* were identified during Subbasin Planning in 2003. An assessment unit is a drainage basin, a group of drainage basins, or a part of a drainage basin in which habitat characteristics are similar enough that the area could be evaluated as a unit. There are 10 assessment units in the U. S. portion of the Okanogan Subbasin, and 13 assessment units in the Methow Subbasin.

Primary Limiting Factors: limiting factors are defined by the state Salmon Recovery Act as conditions that limit the ability of habitat to fully sustain populations of salmon. The primary limiting factors are the ones considered to pose the greatest barriers to spring Chinook, steelhead, and bull trout recovery in each assessment unit, based on the conditions in that unit.

Management Actions/Scenario/Portfolio: the fourth column of each matrix will tell the reader what remedies the plan proposes to address the limiting factor shown in the third column. A *management action* is a specific activity intended to solve or diminish the effects of a problem. Examples include installing fish screens or developing a predator-control plan. A *scenario* is a set of actions that, together, will address a limiting factor. For instance, in order to increase habitat diversity, it may be necessary to add woody debris to a stream reach and reconnect the stream to adjacent floodplain areas. Those actions together constitute a scenario. A *portfolio* is a suite of scenarios that will be implemented in a particular subbasin.

Benefits to VSP: "VSP" stands for Viable Salmonid Population—a population that is able to maintain its vigor and potential for evolutionary change and adaptation in its ecosystem. The actions outlined in the recovery plan are intended to improve the viability of at-risk salmonid species in the Upper Columbia Basin. VSP is defined in terms of four parameters, or factors that may limit viability: abundance, production, spatial structure, or diversity. Column five identifies the parameter that will be affected by a particular action, and the degree to which it will be affected (high, medium, or low).

Okanogan County Office of Planning and Development
Water Resources Division
123 North 5th Avenue Room 110
Okanogan, WA 98840

Your December 2004 edition of *Fish Lines*

DECEMBER MEETING SCHEDULE

2004	
December 9	HCC; Douglas County Public Services Building; East Wenatchee; 8:00 AM
December 16	OC RSRP AC meeting; Okanogan County Commissioners Hearing Room; Okanogan 6:30 PM
For a complete schedule go to www.okanogancounty.org/Water	

PROJECT MILESTONES

2005	
Beginning of January	Public Meeting: Present first draft of regional salmon recovery plan
January 01-31	Comment period: first draft of regional salmon recovery plan
Beginning of April	Public Meeting: Present final draft of regional salmon recovery plan
April—mid May	Comment period: final draft of regional salmon recovery plan
June 30	Plan submitted to the State of Washington
Monthly Okanogan County Regional Salmon Recovery Planning Advisory Committee meetings until June 30, 2005.	

Fish Lines

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Volume I Issue 4 December 2004

Okanogan County Office of Planning and Development

Water Resources Division

Working to balance the needs of economy, salmon and the community in the Upper Columbia regional salmon recovery planning process.

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Douglas County: Chuck Jones
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N THIS ISSUE . . .

↳ *Factors for decline: A brief history of hydropower in Okanogan County*

FACTORS FOR DECLINE:

THE FEDERAL COLUMBIA RIVER HYDROPOWER SYSTEM

As noted in the last issue of *Fish Lines* in the article about salmon fishing in Okanogan County, scientists and policy makers use the term “Factors for Decline” to describe the activities and conditions that contribute to declines in salmonid populations. Most factors for decline can be related to one of four categories: habitat, harvest, hatcheries, or hydropower. Those four categories are referred to as the “Four Hs.” Salmon Recovery work emphasizes improvements in all four categories to support recovery of salmon populations.

This article focuses on hydropower and how the Columbia River Hydropower System has contributed to the decline in salmonid populations that ultimately led to ESA listings in Okanogan County.

Hydropower is energy derived from the flow of water. Fifty-five major projects on the Columbia River and its tributaries use hydropower to generate electricity. Thirty-one of those are federal projects; together, they constitute the Federal Columbia River Power System (FRCPS). Twenty-one of the federal dams are owned and operated by the Army Corps of Engineers (ACOE); the other ten are owned and operated by the Bureau of Reclamation (BOR). Federal dams in the Upper Columbia basin include Chief Joseph Dam, owned by the ACOE, and Grand Coulee Dam, owned by the BOR.

Continued on the next page

FACTORS FOR DECLINE: THE FEDERAL COLUMBIA RIVER HYDROPOWER SYSTEM

(Continued from the front page)

The other major dams are owned by public and private utilities. They include Rocky Reach and Rock Island dams, owned by Chelan County PUD, and Wells Dam, owned by the Douglas County PUD. Along with smaller dams, the 55 major dams in the Columbia Basin comprise the largest hydroelectric system in the world.

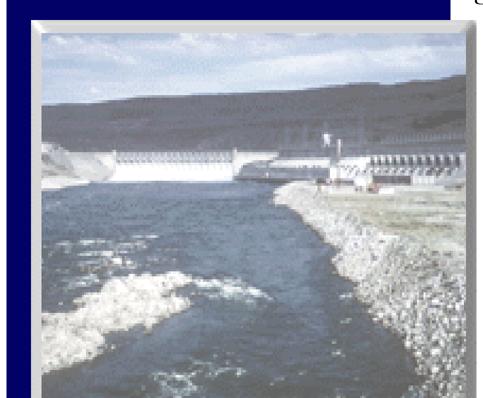
The idea of damming the Columbia River to irrigate the surrounding land was proposed late in the 19th century. Thirty-plus years of study, surveying, and argument over whether, where, and how to irrigate the Columbia Basin came to fruition in the 1930s with President Franklin D. Roosevelt's New Deal. Designed to stimulate the economy by putting people to work and creating public utilities, the New Deal provided the means and the impetus to build multi-purpose dams on the Columbia River.

Dams in the Upper Columbia basin were completed over a period of about 35 years, from the 1930s through the 1960s. The effects on the region's economy were dramatic. Many thousands of acres of land came under irrigation; inexpensive power was made available to millions of residences and businesses; and storage reservoirs created recreation opportunities that drew tourists to the area.

The dams had harmful consequences as well. Fishing areas were lost and many people lost their homes when reservoirs inundated land near the river. The power system also affected native fish.

Dams on the Columbia River have blocked the route by which migratory fish travel to and from the Pacific Ocean. In addition, the reservoirs created by the dams slow the flow of water in the river, which increases the time it takes for juvenile fish to migrate downstream. The river's slower velocity also increases water temperatures—which can affect both juvenile and adult fish—and makes it easier for predators to find fish.

The barrier effect of the dams has been addressed with adult and juvenile fish passage facilities. Fish ladders have been effective for adult fish. Each ladder consists of a series of steps and pools that allow fish traveling upstream to navigate the dams by leaping from one pool to the next.



Juvenile fish may migrate past dams by moving through the turbines, through juvenile fish bypass systems, or over dam spillways (where water may be spilled specifically as the young fish approach a dam, specifically to aid them in their migration). Some fish are transported past dams by barge and truck.

In spite of those measures, fish runs have suffered steep declines. The hydropower system is one factor in those declines; the other three "Hs" have also contributed, as have changes in ocean conditions.

The Upper Columbia Regional Salmon Recovery Plan will discuss the effects of the hydropower development on listed salmonid species, and the plan will include hydropower-related actions that will contribute to recovery of those species. *The draft Table of Contents and drafts of the first three sections of the Upper Columbia Regional Salmon Recovery Plan can be found at http://www.okanogancounty.org/water/salmon%20recovery;%20draft%review%20corner.htm*

FIRST DRAFT OF THE UPPER COLUMBIA SALMON RECOVERY PLAN DUE IN JANUARY

The Upper Columbia Salmon Recovery Board (UCSRB) will issue a draft of the Upper Columbia Salmon Recovery Plan for public review and comment in January, 2005. The draft plan is expected to be about 70% complete. Okanogan County will present the draft at public meetings in Okanogan and Twisp early in January.

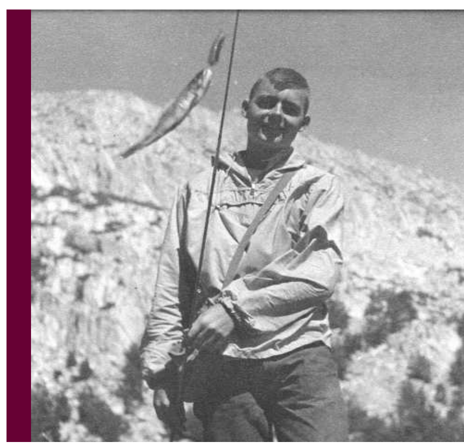
The draft presented in January will include revised versions of Sections 1-3 of the plan. Those sections will reflect comments from the Governor's Salmon Recovery Office (GSRO), the UCSRB, the Upper Columbia Regional Technical Team (RTT), the Habitat Coordinating Committee (HCC) that has been established to guide development of the technical material in the plan, and local stakeholders.

Okanogan County solicited comments on the initial draft of the first three sections in October, and in November began working with the Regional Salmon Recovery Planning Advisory Committee to prepare revisions to the text in response to those comments. Okanogan County will ask that the first three sections be amended to better reflect the interests of local stakeholders and communities.

The January draft will also include delisting criteria, a partially-complete strategy for recovery, material on social and economic considerations, and a section the relationship between salmon recovery and other efforts.

The HCC is now working on components of the strategy for recovery. Habitat matrices, discussed in the November issue of *Fish Lines*, are an important element of the strategy. (You can find the November issue of *Fish Lines* on our web site.) The HCC is also defining categories of actions to be considered for inclusion in the recovery strategy. The group is currently working with nine general categories of actions:

1. Add Large Woody Debris
2. Add Rock Structures (weirs etc.)
3. Water Conservation
4. Floodplain Reconnection
5. Riparian Restoration
6. Side Channel Reconnection
7. Remove Barriers
8. Improve Water Quality
9. Road Management



The HCC will analyze the effects of the actions on habitat in Upper Columbia stream reaches using a tool called Scenario Builder. Scenario Builder is a component of EDT, the Ecosystem Diagnosis and Treatment model that has been used to analyze habitat conditions in the Methow and Okanogan subbasins.

Biologists use Scenario Builder to estimate the effects of different actions or combinations of actions (known as scenarios) on various factors within the ecosystem. The results give them some sense of the relative benefits of different approaches, as well as estimating the amount of benefit that will be derived from each approach. For instance, Scenario Builder can be used to compare the effects of riparian restoration with and without the addition of large woody debris, and to estimate the number of fish that a stream reach will support after the restoration is complete.

The analysis of actions may not be complete in time for inclusion in the January draft of the Upper Columbia Salmon Recovery Plan. However, Okanogan County anticipates working with the Advisory Committee to review materials during the comment period, as the HCC develops them, and will submit comments reflecting local stakeholders' viewpoints for consideration when the draft is revised.

Okanogan County will accept comments on the first draft of the Upper Columbia Salmon Recovery Plan from January 3-31, 2005. Please contact us if you would like to be informed when the draft is available for review.

Okanogan County Office of Planning and Development
Water Resources Division
123 North 5th Avenue Room 110
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Your January 2005 edition of
Fish Lines

JANUARY & EARLY FEBRUARY MEETING SCHEDULE

2005	
January 11, 2005 *	First draft review—Methow Valley Senior Citizens Center, Twisp WA 6:30—8:30pm
January 12, 2005 *	First draft review—Okanogan County Board of Commissioners Hearing Rm, Okanogan WA 6:30—8:30pm
January 13, 2005	Advisory Committee Mtg—Okanogan County Board of Commissioners Hearing Rm, Okanogan WA 6:30—8:30pm
January 13, 2005	HCC Meeting—Douglas County Public Services Building, E. Wenatchee, WA 9:00am—3:00pm
January 20, 2005	HCC Meeting—Chelan County Planning Office, Wenatchee, WA 9:00am—2:00pm
January 26, 2005	UCSRB Board Meeting—E. Wenatchee, WA 10:00am—3:00pm
February 2, 2005	GSRO Quarterly Review of Salmon Recovery Plan—City of E. Wenatchee, Council Chambers, E. Wenatchee, WA 9:00am—1:00pm (meeting length is approximate)
February 2, 2005	RRS Staff Meeting—City of E. Wenatchee, Council Chambers, E Wenatchee, WA 1:00am—3:00pm (meeting length and start time are approximate)
For more detailed information please visit our website at www.okanogancounty.org/water or call 509.422.7113 Please note: Content in these two meetings will be the same *	

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IN THIS ISSUE . . .
↳ *Hydropower and Salmon Recovery*

Hydropower and Salmon Recovery

What are the Columbia River dam operators doing to help fish?

Scientists and policy makers have identified four categories of activities and conditions that contribute to declines in salmonid populations: habitat, harvest, hatcheries, and hydropower. Salmon Recovery emphasizes improvements in all four categories to support recovery of salmon populations. In the last issue of Fish Lines the Columbia River Hydropower System and the ways in which it has contributed to the decline in native fish populations was discussed. This article focuses on the actions that Columbia River Dam operators are taking to reduce the impacts of dams on salmon.

Under the Endangered Species Act (ESA), agencies that operate hydroelectric dams on the Columbia and Snake rivers and their tributaries are responsible for ensuring that their actions do not endanger spring Chinook and steelhead—species protected under the ESA.

Because salmonids migrate—the juvenile fish swimming downstream to the ocean and the adults swimming upstream to spawn in the streams where they were born—the dams in the Columbia Basin have had a substantial effect on them. Salmon and steelhead are able to negotiate natural obstacles—often quite large ones. The dams are a different story—they are too big for adult fish to leap over, and they present hazards to young fish on their way to the sea. The dam operators are doing a number of things to reduce the impacts of hydropower operations on fish. They include:

Passage facilities—to improve survival of juvenile fish migrating downstream and adults migrating upstream

Turbine replacement—to improve the chances that fish that pass through dam turbines will survive and be uninjured

Habitat protection and restoration

HYDROPOWER WORKSHOP

The Upper Columbia Salmon Recovery Board, the Governor's Salmon Recovery Office and the Washington Department of Fish and Wildlife will sponsor a Hydropower Workshop in Chelan on February 24th. The purpose of the workshop is to inform stakeholders throughout the region about the Columbia River Hydropower System and the role of dam owners and operators in salmon recovery. PUD, federal and state agency staff will answer questions as well as provide information. For more information about the workshop, please visit the Okanogan County Water Resources web site or call us at 509.422.7113.

next page please →

Hydropower and Salmon Recovery *continued from the front page*

Water management—to ensure that flows support salmonid survival and move migrating juvenile fish past the dams

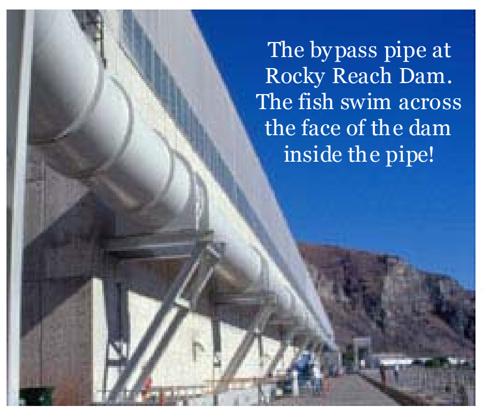
Juvenile fish transportation—to move fish around dams that act as barriers to safe migration

Reservoir survival actions—to reduce impacts on fish after they have passed the dams

Hatcheries—to supplement naturally producing native stocks of salmon and steelhead

The most common fish passage facilities are fish ladders. Fish ladders give adult fish who are migrating upstream a way to get past the dams on the Columbia River. Each "ladder" is a series of pools, each one foot higher than the one below. Adult fish are able to leap from one pool to the next, just as they leap over small waterfalls when migrating up streams without dams. Fish are attracted to the ladders with collection systems that simulate the turbulence found at the bases of natural waterfalls. Fish ladders were built into dams on the Columbia River beginning in the early 1930s.

Juvenile fish face challenges during migration as well. Dam turbines are one obstacle. While most fish pass through them unharmed a small percentage are killed or injured on their way through. Since the ESA calls for *no* loss of protected species, dam operators use bypass systems, water management, and barge and truck transportation to give juvenile fish a means of getting downstream without passing through the turbines.


The bypass pipe at Rocky Reach Dam. The fish swim across the face of the dam inside the pipe!

Bypass systems include collectors that move fish away from the turbines and channels to move them through the dam. Then the fish are either returned to the river or routed to a holding area where they will be collected for transportation by barges or trucks. To safeguard fish that do pass through dam turbines, dam operators have designed turbines with modified blades that are less hazardous.

Dam operators manage the water impounded behind the Columbia River dams for a number of purposes—power generation, irrigation, navigation, flood control, and salmon survival. Water management for salmon survival involves augmenting flows and spilling water over the dams instead of letting it run through the turbines when fish are migrating. Spill, combined with higher flows, draws fish away from the turbines and over the dams.

Finally, reservoir survival actions help migrating fish overcome hazards in the pools above and below the dams. The dams have modified the river so that it no longer provides the cover that fish once used to escape predators. Migrating fish are more vulnerable to attack by fish and birds—especially if they have been disoriented by turbulent water at the base of a dam. Dam operators may remove predatory fish and scare birds away from the dams to protect migrating salmon and steelhead.

In the Upper Columbia region, the Chelan and Douglas County PUDs use fish ladders, a bypass facility, water management, and reservoir actions to enhance fish survival at Rocky Reach, Rock Island, and Wells dams. The bypass facility, at Rocky Reach, uses large volumes of water to attract fish. A small amount of the water is used to transport the fish past the dam; most of it is expelled from the bypass system and sent through the turbines. By keeping most of the water available for power generation, the system minimizes loss in generating capacity as a result of fish transport.

Chelan County PUD has installed new turbines at Rocky Reach Dam, as well. The new turbines are also more efficient than the ones they replaced, so the cost of replacement is offset by increases in power generation.

The two PUDs have also developed Habitat Conservation Plans (HCPs) to ensure that the three dams they operate will have no net impact on Columbia River salmon and steelhead runs. The HCPs have been signed by the agencies overseeing the recovery of the protected species—NOAA Fisheries and the U. S. Fish and Wildlife Service (USFWS). The HCPs establish the PUDs' obligations with respect to anadromous fish. In return, NOAA Fisheries and the USFWS have issued permits that allow for the continued operation of the dams, even if there is some impact (referred to as incidental take) on the protected species, as long as the PUDs take the actions they have agreed to.

It pays to get involved!

The Bonneville Power Administration, Chelan and Douglas County PUDs, as well as the other hydroelectric dam operators invest in fish and wildlife recovery every year to mitigate the effects of the Columbia River hydropower system on fish, wildlife, and their habitats. Because the Okanogan PUD obtains the majority of its power through the Douglas County PUD or BPA, the cost of these mitigation efforts, about 10-15% of a ratepayer's power bill, is shared by Okanogan County residents. By getting involved in salmon recovery, you can help make sure those dollars are spent wisely—on work that will help fish and benefit the local economy.

HAPPY NEW YEAR HAPPY NEW YEAR

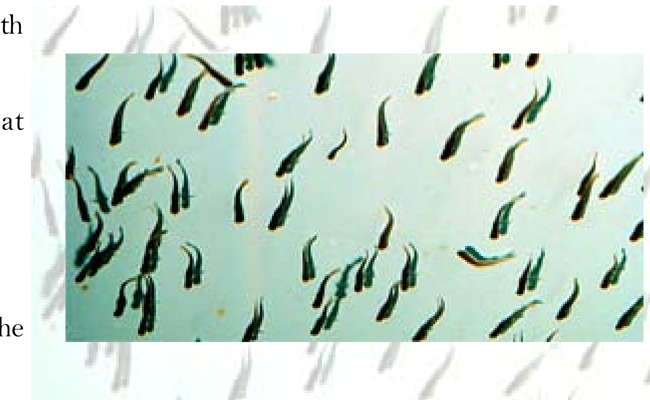
Next Steps: What happens after the first draft of the Regional Salmon Recovery Plan is released?

The first draft of the Upper Columbia Salmon Recovery Plan will be available for public review and comment throughout the month of January. (You can learn more about the first draft in the December issue of *Fish Lines*, available on our web site.)

The Upper Columbia Salmon Recovery Board (UCSRB) expects to submit a completed plan to the Governor's Salmon Recovery Office (GSRO) in June 2005. Here's what will happen between now and then:

February 2005

- The GSRO will review and comment on the first draft
- Regional Recovery Staff (RRS: employees of Chelan, Douglas, and Okanogan counties, the Colville Confederated Tribes, and the Yakama Nation who are working on salmon recovery) will review the comments and decide who will address each one.
- The Habitat Coordinating Committee and RRS will address both technical and socio-economic comments
- The RRS will discuss comments with the UCSRB and ensure that the responses reflect the UCSRB's chosen policy direction



March 2005

- The HCC and RRS will revise the plan in response to comments
- Additional material will be added to complete all sections of the plan
- The final draft of the plan will be released for comment by the GSRO, NOAA, fish and wildlife management agencies, and the public

April 2005

- Public final review and comment

May 2005

- Comments will be reviewed and responses developed, as with the first draft
- The UCSRB will review and endorse the final draft
- The final draft will be sent to the plan's technical writer for final editing and formatting

June 2005

- The final draft plan will be presented to the UCSRB and the public
- The technical writer will make final edits
- The plan will be delivered to the GSRO

PUBLIC COMMENT PERIOD

The Upper Columbia Salmon Recovery Board will accept comments on the first draft of the Upper Columbia Salmon Recovery Plan from January 03, 2005 through January 31, 2005. Please contact us if you would like to be informed when the draft is available for review. It will be posted on our web site. Okanogan County will host review meetings to introduce the first draft and answer questions on January 11th and 12th. Please see the meeting schedule in this newsletter, visit our web site, or call us at 509.422.7113 for more information about those meetings.

July 2005 and beyond

The recovery plan developed by the UCSRB will be used by NOAA Fisheries to develop a Recovery Plan for Chinook salmon and steelhead, and by the U.S. Fish and Wildlife Service to refine its draft bull trout recovery plan. That work will be done between June and December 2005. NOAA Fisheries expects its Recovery Plan to be complete by the end of 2005. Public comment will be accepted after June; NOAA Fisheries has not yet established the dates of the comment period.

Rocky Reach fish bypass system.
(CAD diagram showing pump station [left, in forebay] and fish return pipe [lower, right]).

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Your February 2005 edition of
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FEBRUARY / MARCH MEETING SCHEDULE

2005	
February 17, 2005	HCC Meeting—Douglas County Public Services Building, E. Wenatchee, WA 9:00am—2:00pm
February 17, 2005	Advisory Committee Mtg—Okanogan County Board of Commissioners Hearing Rm, Okanogan WA 6:30pm—8:30pm
February 24, 2005	UCSRB Board Meeting—Fire Station, 232 E Wapato, Chelan, WA 1:00pm—5:00pm
February 24, 2005	Hydropower Workshop—Fire Station, 232 E Wapato, Chelan, WA 6:30pm—9:00pm
March 2, 2005	RRS Staff Meeting—Douglas County Public Services Building, E. Wenatchee, WA 9:00am—3:00pm

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N THIS ISSUE . . .

- *What will recovery look like: Reclassification criteria and Delisting criteria*

COMMISSIONER HOVER NAMED TO UPPER COLUMBIA SALMON RECOVERY BOARD

Okanogan County Commissioner Don (Bud) Hover will represent Okanogan County on the Upper Columbia Salmon Recovery Board (UCSRB). Commissioner Hover, of Winthrop, was elected to the Board of County Commissioners in November and took office in January. On the UCSRB, he joins Chelan County Commissioner Ron Walter, Douglas County Commissioner Mary Hunt, Bill Towey of the Colville Confederated Tribes, and Paul Ward of the Yakama Nation. The UCSRB members are working together to ensure that the Upper Columbia Salmon Recovery Plan represents local interests as well as leading to the recovery of listed species.

UPPER COLUMBIA HYDROPOWER WORKSHOP

The Upper Columbia Salmon Recovery Board (UCSRB) will host a workshop highlighting hydropower issues related to salmon recovery within the Upper Columbia Region on February 24th. The workshop will give local stakeholders a chance to learn more about the hydropower system and how its effects on listed species are being addressed.

Date: Thursday, February 24, 2005
Time: 6:30 PM—9:00PM
Location: Chelan Fire Station — 232 E Wapato, Chelan WA 98816

The workshop follows a session on hatcheries held last November. Washington State's Salmon Recovery Strategy revolves around four factors that have affected salmon populations: habitat, harvest, hatcheries, and hydropower. Collectively, they are known as the "Four Hs." The Upper Columbia Salmon Recovery partners—Chelan, Douglas, and Okanogan counties, the Colville Confederated Tribes, and the Yakama Nation—are concentrating on habitat. That is the factor on which local decisions and actions have the most influence, and very important to fish production.

Other agencies are focusing more attention on the other three Hs.

To be placed on the mailing list for the hydropower workshop, or if you would like additional information on one of the four Hs, please contact our office. You can also take a look at the articles about hydropower in the December 2004 and January 2005 issues of *Fish Lines*!

What will recovery look like?

The first draft of the Upper Columbia Salmon Recovery Plan, released in January, includes some of the criteria that will be used to measure progress toward recovery of listed species in the Upper Columbia region. There are either two or three sets of criteria for each species.

Spring Chinook and Steelhead

Spring Chinook and steelhead will meet three sets of criteria before they are considered recovered:

1. **Reclassification**: once spring Chinook and steelhead meet the reclassification criteria, their status under the Endangered Species Act can be changed from "endangered" to "threatened"
2. **Delisting**: once fish meet the delisting criteria, they can be removed from the endangered species list

Recovery: recovery criteria represent viable and harvestable populations. Viable populations are considered strong enough and resilient enough that they face little risk of extinction. Harvest includes recreational, ceremonial, and subsistence harvest

Bull Trout

Bull trout are currently classified as threatened, not endangered, so they do not need to meet reclassification criteria, only criteria for delisting and recovery.

Each set of criteria refers to four factors known as **V**iable **S**almonid **P**opulation parameters—**VSP** parameters for short. The **VSP** parameters are:

- **Abundance**—a measure of population size, or numbers of fish
- **Productivity**—a measure of a fish population's ability to replace itself—how many juvenile fish mature for each parent fish
- **Spatial structure**—a measure of how fish are distributed in spawning areas throughout the region. When fish are distributed among a greater number of spawning areas, the species is more likely to survive events like floods and landslides that may damage portions of habitat
- **Diversity**—a measure of variability within a fish species. Variation within a species helps the species adapt to environmental changes because individuals can tolerate a wide range of conditions, such as water temperature and parents can pass on different combinations of traits that will help their offspring to survive

Reclassification criteria

The reclassification criteria for spring Chinook and steelhead are identical. There are two criteria:

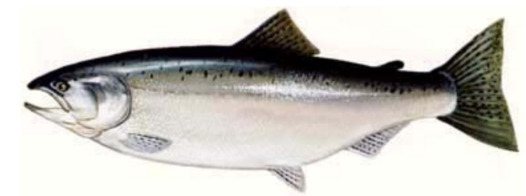
Abundance/productivity: abundance and productivity have been combined in the reclassification criteria. The criterion is based on a viability curve—a line that shows the levels of abundance and productivity at which there is a low risk of extinction. It calls for populations to remain above the 5% extinction-risk line for eight consecutive years.

Spatial structure/diversity: spatial structure and diversity have also been combined. The criterion calls for fish to be distributed within all currently-occupied major spawning areas and within 66% of all areas designated as "intrinsic potential" areas within each population.

Intrinsic Potential: *What was available historically before European settlement.*

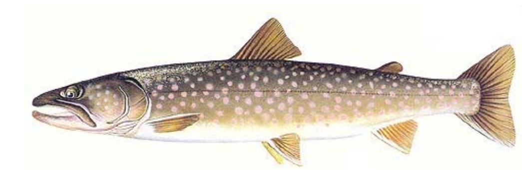
Delisting criteria

The delisting criteria are more specific. There are different criteria for each species. The abundance criteria are stated in terms of numbers of fish, as follows:



Spring Chinook: At least 4,500 spawners, with at least 2,000 in the Wenatchee, 500 in the Entiat, and 2,000 in the Methow population.

Steelhead: At least 3,000 spawners, with at least 1,000 in the Wenatchee, 500 in the Entiat, 1,000 in the Methow, and 500 in the U. S. Okanogan population.



Bull trout: At least 4,144 spawners, with at least 1,612 in the Wenatchee, 298 in the Entiat, and 2,234 in the Methow population.

Each species also needs to meet productivity standards that allow the populations to remain stable or increase over a period of twelve years; and to meet spatial structure and diversity standards by spawning in certain major and minor spawning areas over the same period. For instance, here is what the draft plan says about spatial structure and diversity for spring Chinook in the Methow and Okanogan subbasins:

"Methow: Spring Chinook spawning will occur within the Twisp, Chewuch, and Upper Methow major spawning areas, with each area containing at least 5% of the total spawning abundance. Within the Upper Methow spawning area, Chinook will consistently spawn in the Wolf Creek, Early Winters Creek, and the Lost Creek branches. Within the Chewuch major spawning area, Chinook will consistently spawn in the Eight-Mile Creek branch.

"Okanogan: Recovery of spring Chinook in the Okanogan Subbasin is not a requirement for delisting because the ICBTRT [Interior Columbia Basin Technical Recovery Team] determined that this population was extinct… However, this plan recognizes that if a major spawning area could be established in the Okanogan using an Upper Columbia spring Chinook stock, then the ESU would be at a lower risk of extinction."

The recovery criteria *as they are shown in the draft plan* are very similar to the delisting criteria; however, they are not yet complete. Okanogan County is continuing to work with the Upper Columbia Habitat Coordinating Committee to develop realistic numbers for delisting and recovery. Members of the Okanogan County Salmon Recovery Advisory Committee have asked county staff to find out how the abundance criteria were developed. County staff are working to understand the basis for the numbers so they have a way of determining whether they are realistic, and can be reached without interfering with county residents' livelihoods and the local economy.

Okanogan County Office of Planning and Development
Water Resources Division
123 North 5th Avenue Room 110
Okanogan, WA 98840

Your March 2005 edition of *Fish Lines*

MARCH MEETING SCHEDULE

2005	
March 2, 2005	RRS Staff Meeting—Douglas County Public Services Building, E. Wenatchee, WA 9:00am—3:00pm
March 10, 2005	HCC Meeting—Douglas County Public Services Building, E. Wenatchee, WA 9:00am—3:00pm
March 17, 2005	HCC Meeting—Douglas County Public Services Building, E. Wenatchee, WA 9:00am—2:00pm
March 17, 2005	Advisory Committee Mtg—Okanogan County Board of Commissioners Hearing Rm, Okanogan WA 6:30pm—8:30pm
March 23, 2005	UCSRB Board Meeting—Douglas County Public Services Building, E. Wenatchee, WA 1:00pm—5:00pm

PROJECT MILESTONES

2005	
Early April*	Public meetings: Present final draft of regional salmon recovery plan
March 31-April 29*	Comment period: Final draft of regional salmon recovery plan
June 30	Plan submitted to Washington State

* Dates subject to revision.
The schedule for completion of the final draft is under review to ensure it includes as much information as possible.
Monthly Okanogan County Regional Salmon Recovery Planning Advisory Committee meetings through June, 2005

Fish Lines

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Volume I Issue 7 March 2005

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Water Resources Division

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IN THIS ISSUE . . .

→ *Economic benefits of salmon recovery*
→ *Washington Legislature eyes salmon recovery*

ECONOMIC BENEFITS OF SALMON RECOVERY

Salmon recovery is widely perceived as beneficial to the environment. But what about the economy? Efforts to recover ESA-listed species—spring Chinook, steelhead, and bull trout—are costing a lot. A new report suggests recovery could pay off for rural communities.

Unlike many endangered species, salmon are a valuable commodity. A bill currently being considered by Washington's legislature states that "These [endangered species] listings threaten the sport, commercial, and tribal fishing industries as well as the economic well-being and vitality of vast areas of the state." Commercial fishing has long been an economic mainstay in many rural Washington communities—primarily in western Washington. Sport fishing may be of greater interest in the eastern part of the state. As salmonid populations recover, sport fisheries may be revived and expanded—and business people and communities may reap the benefits, in the form of increased local spending by anglers.

The Potential Economic Impact of Restored Salmon and Steelhead Fishing in Idaho, written by Idaho economist Don Reading, forecasts substantial economic gains for rural Idaho communities as a result of recovery. Dr. Reading's study analyzes the potential economic impact of a fully recovered salmon and steelhead fishery in Idaho. His report states that "the benefit of a restored salmon and steelhead fishery to Idaho's economy could reach $544 million annually."

Some analysts have questioned the accuracy of Dr. Reading's estimates; like most researchers, he used models and made assumptions in order to forecast future conditions. Most people do agree that recovering salmon and steelhead to harvestable levels will increase angler spending and create jobs. Anglers spend money on bait, tackle, equipment, guiding and outfitting, and food and lodging in places they visit. Many of those expenditures are made in river communities and directly benefit those communities.

Indirect benefits accrue, as well. Indirect benefits are economic impacts of angler spending in a community. For instance, a business owner may hire a new employee to meet growing demands for products or services; a newly-hired worked will have more money to spend, benefiting other local businesses. Indirect benefits are calculated by applying standard economic multipliers to direct expenditures.

(please continue this article on page 2)

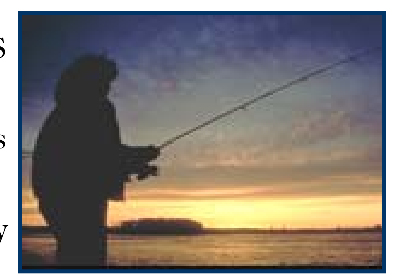
ECONOMIC BENEFITS OF SALMON RECOVERY (continued from page 1)

Save Our Wild Salmon (SOS), a nationwide coalition of conservation organizations, commercial and sport fishing associations, businesses, river groups, and taxpayer advocates, used the numbers in Dr. Reading's report to estimate economic benefits from salmon recovery in Oregon and Washington. SOS's estimate of benefits includes more than $1 billion and 9,400 jobs in Washington. Speaking to the *Columbia Basin Bulletin*, SOS spokeswoman Vicki Paris said "There's the potential for more economic benefit than all of the recovery efforts cost now."

SOS's estimates are just that. Research specific to eastern Washington would be necessary to understand just how recovery would benefit communities in Okanogan County. There seems little doubt, though, that sport fisheries on Chinook salmon and steelhead have the potential to be economically beneficial.

The *Columbia Basin Bulletin* quotes Trey Carskadon, Oregon businessman and president of the Northwest Sportfishing Industry Association: "Even the historically modest salmon and steelhead returns that we saw in 2001 meant more than $1.9 billion to our region…If annually harvestable runs were to be re-established, the boost throughout our economy would be tremendous, with major business and job growth in a cluster of industries, including boat building, outdoor gear, outfitting, restaurants and hotels."

In his report on potential economic impacts of recovery, Dr. Reading argues that about 60% of the economic gain would benefit river communities in Idaho. The rest would benefit other communities in the Upper Columbia region and statewide, through spending by residents of river communities and benefits to businesses outside the area that serve anglers, such as equipment dealers and manufacturers.



Fish recovery provides a means of strengthening and diversifying the economy. SOS reports that "The sportfishing industry is a $3.5 billion business in the Northwest supporting some 36,000 full time jobs." The U.S. Fish and Wildlife Service estimates that between 1991 and 1996, nearly 10,000 sportfishing industry jobs were lost. Fish recovery will probably mean the return of at least some of those jobs, and it may also lead to the creation of new ones.

From IAC's Assessment of Outdoor Recreation, October 2002, Page 107

Age group	0-9	10-19	20-34	35-49	50-65	65+	Totals
Bank fishing, fresh water	35,405	38,401	58,879	64,106	32,398	35,032	264,221
Private boat fishing, fresh water	26,822	29,971	53,359	64,106	30,435	32,029	236,722
Guide/charter fishing, fresh water	*	*	1,840	4,007	982	1,001	7,830

Numbers of people by age group estimated to take part in recreational fishing by the setting indicated
All numbers are estimates based on a statewide survey of randomly-selected individuals 1999-2000
Numbers are plus or minus 5% with a 95% confidence interval
* Insufficient samples were submitted

WASHINGTON LEGISLATURE EYES SALMON RECOVERY

The State Legislature is considering two bills to revise Washington's Salmon Recovery law. The bill is intended to improve the efficiency and effectiveness of salmon recovery work by providing for coordination among the various state agencies involved in recovery efforts.

In 1998 the legislature passed the Salmon Recovery Act (ESHB 2496), creating Washington's Salmon Recovery law—Chapter 77.85 in the Revised Code of Washington (RCW). The act was meant to keep responsibility for managing Washington's natural resources—including fish populations listed under the Endangered Species Act—in the hands of the state rather than allowing the federal government to take on the job.

It established a framework for salmon recovery in the state and authorized the designation of local Lead Entities to coordinate acceptance and review of applications for salmon habitat restoration and protection project funding. Proposed projects are prioritized by a local Citizens' Committee. Okanogan County Water Resources and the Colville Confederated Tribes have partnered to serve as the lead entity for the Methow and Okanogan subbasins.

In the years since passage of the Salmon Recovery Act, individuals and organizations throughout the state have developed and implemented dozens of salmon recovery projects. In spite of all the work that has been done, salmon and steelhead populations remain threatened or endangered. The aims of the bill now being considered are better coordination at the regional level, including coordination with watershed planning efforts; and better scientific oversight and monitoring.

The bill, Senate Bill (SB) 5610, provides for creation of salmon recovery regions and recognition by the Governor's Salmon Recovery Office (GSRO) of regional salmon recovery organizations "for the purpose of developing and implementing regional recovery plans." It also directs the GSRO and the Department of Ecology to make recommendations for improving coordination of salmon recovery, watershed, and related plans that have been prepared or are being prepared within a given watershed or group of watersheds (for instance, the six watersheds that compose the Upper Columbia Salmon Recovery Region).

The bill also provides for creation of a forum to oversee watershed health monitoring, with a focus on salmon recovery. Monitoring—evaluating the effectiveness of salmon recovery actions—is important so that all parties know what is working and what it not. Those actions that are not achieving the desired results can be discontinued, and projects that are effective can be replicated.

The second bill, HCR 4406, would establish a joint select legislative task force to review watershed health and salmon recovery plans. The task force would comprise representatives of the house of representatives economic development, agriculture, and trade committee, natural resources, ecology, and parks committee, and capital budget committee; and of the senate water, energy, and environment committee, natural resources, ocean, and recreation committee, and ways and means committee. The bill also calls for establishment of an advisory committee, coimprising representatives of the departments of ecology and fish and wildlife, the salmon recovery funding board, the governor's office, a watershed planning group, a lead entity, regional salmon recovery group, the federal fisheries service, and federally recognized Indian tribes. The job of the task force would be to evaluate and make recommendations to the legislature regarding the implementation of watershed health and salmon recovery plans.

Together, the two bills would provide the means for the legislature to evaluate watershed and salmon recovery in the state and revise the processes by which that work is done to better achieve the objectives of recovery, delisting, and watershed health.

For More information on these bills please visit these websites:

ESHB 2496: http://66.102.7.104/search?q=cache:PtP89dCFr-QJ:www.ecy.wa.gov/programs/eap/wrias/assessments/wria11/Chapter1.pdf+ESHB+

SB 5610: http://www.leg.wa.gov/wsladm/billinfo1/dspBillSummary.cfm?billnumber=

HCR 4406: http://www.leg.wa.gov/wsladm/billinfo1/dspBillSummary.cfm?billnumber=4406&year=2005

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Your April 2005 edition of
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APRIL / MAY MEETING SCHEDULE

2005	
April 21	Advisory Committee—Okanogan County Commissioners' Hearing Room—6:30 PM
April 28	Upper Columbia Salmon Recovery Board—Douglas County Public Services Building—10:00 AM
May 4	Upper Columbia Salmon Recovery Board—Staff Meeting—City of East Wenatchee Council Chambers—3:00 PM
May 4	GSRO—Quarterly Review—City of East Wenatchee Council Chambers—9:00 AM—3:00 PM

PROJECT MILESTONES

2005	
Beginning of January	Public Meeting: Present first draft of regional salmon recovery plan
January 01-31	Comment period: first draft of regional salmon recovery plan
Beginning of April	Public Meeting: Present final draft of regional salmon recovery plan
April—mid May	Comment period: final draft of regional salmon recovery plan
June 30	Plan submitted to the State of Washington
Monthly Okanogan County Regional Salmon Recovery Planning Advisory Committee meetings until June 30, 2005.	

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N THIS ISSUE . . .

↳ *Reaching Toward Recovery*

REACHING TOWARD RECOVERY

The Upper Columbia Salmon Recovery Board (UCSRB) will release the second draft of its regional Salmon Recovery Plan on March 31. Comments on the plan will be accepted throughout the month of April.

Can the Methow subbasin really support 2,000 spring Chinook spawners every year? That is the average number called for in an early draft of the Upper Columbia Salmon Recovery Plan. Later drafts will include targets for steelhead (in the Methow and Okanogan subbasins) and bull trout (in the Methow). Planners are grappling now with the question of how to meet those quotas…and whether they are even realistic.

As we've discussed before, the health of anadromous salmon populations is a function of many factors. Four of those factors are related to human activities. They are habitat, hatcheries, harvest, and hydropower system effects—often referred to as the 4 "Hs." Other factors, like climate and ocean conditions, bear less obvious links to us and our doings.

The UCSRB comprises representatives of Chelan, Douglas, and Okanogan counties, the Colville Confederated Tribes, and the Yakama Nation. Commissioner Bud Hover represents Okanogan County.

Within a given subbasin, landowners and land managers have the most effect on one factor: habitat. The Upper Columbia Habitat Coordinating Committee (HCC), the members of the Upper Columbia Salmon Recovery Board (UCSRB), and local stakeholders are scrutinizing the current condition of salmon habitat and discussing possibilities for improvement. Their work will inform a list of habitat action recommendations, which will be included in the Upper Columbia Salmon Recovery Plan.

Okanogan County's Office of Planning and Development (Water Resources Division) is working with all of the parties listed above to identify habitat actions that accurately reflect local interests and project feasibility. Project feasibility is a function of several factors, including cost and landowner willingness, as well as the anticipated effectiveness of the project in furthering salmon recovery.

REACHING TOWARD RECOVERY (*continued from the cover page*)

The Upper Columbia Salmon Recovery Plan will recommend several kinds of habitat actions, including restoration, protection, revisions to local regulations and policies, public involvement and education, and research, monitoring, and evaluation (RME).

In order to organize information related to habitat restoration decisions, the HCC has drafted a set of matrices—one for each subbasin in the Upper Columbia Region—and a habitat action library that lists possible actions in each of nine restoration action classes. (The library also includes protection and RME actions.) Non-restoration actions will be addressed using separate tables. This article explains the matrices and how they are being used to decide on recommended restoration actions.

Each matrix identifies ***limiting factors***, ***causal factors***, ***management objectives***, and ***classes of restoration actions***. It also includes information about ***specific actions*** (within the action classes) and ***benefits to salmon***. When it is complete, it will include information about ***restoration costs***. Unless you're involved with salmon recovery, most of those terms probably don't mean much to you. Here's a brief explanation:

- A ***limiting factor*** is anything that tends to make it more difficult for a species to live and grow or reproduce in its environment. Limiting factors for salmonids in our region include riparian habitat condition, in-stream obstructions such as culverts, and water quantity (low flow in the stream)

- ***Causal factors*** are the types of alterations to the ecosystem that have caused the limiting factors—such as riparian vegetation removal, development of roads that constrict a stream channel, or development of roads that act as conduits to concentrate water and direct it from the upper watershed to a stream more quickly than under pristine conditions. *The limiting factors and causal factors explain why a species is not able to make full use of habitat in a particular part of a subbasin*

- ***Management objectives*** identify the way in which habitat could be improved and how the change would affect salmon. For example, in a stream reach where riparian habitat quality is the primary limiting factor, an objective might be to "Increase juvenile survival by improving riparian habitat"

- ***Action classes*** state how a management objective could be accomplished—in the example above, "Riparian Restoration" would be an appropriate action class. The action classes are drawn from the habitat action library mentioned above. The library describes nine classes of restoration actions and lists possible ***actions*** within each class. For instance, "Plant and manage native trees and shrubs as site conditions dictate to provide shade and/or bank stability" is one of the actions listed in the "Riparian Restoration" class

- ***Restoration costs*** will be estimated using past costs for similar types of work

- ***Benefits to salmon*** are described in terms of four VSP parameters. "VSP" stands for Viable Salmonid Population—a population that is able to maintain its vigor and potential for evolutionary change and adaptation in its ecosystem. (To put is a little more simply—a viable population has what it needs to survive, reproduce, and adapt to change.) Viable Salmonid Populations are defined in terms of four parameters, or factors that may limit their viability: abundance, productivity, spatial structure, and diversity. The habitat matrices indicate whether a particular class of habitat actions has a high or low benefit to the VSP parameters.

VSP Parameters: Productivity ▷ Abundance ▷ Spatial ▷ Structure ▷ Diversity

Stakeholders and staff are also discussing the habitat action library to ensure that it does not rely too heavily on actions that are unrealistic. (Of course, since the Salmon Recovery Plan covers land outside as well as within Okanogan County, it may include some actions that are not relevant in either the Methow or Okanogan subbasin.)

All habitat restoration actions recommended in the Upper Columbia Salmon Recovery Plan will be voluntary. That makes it particularly important that the actions listed be acceptable to local landowners. They are one of the means (harvest, hatchery, and hydropower actions are the others) by which the plan's targets—like the 2,000 spawner figure that opened this article—will be reached.

The section of the Upper Columbia Salmon Recovery Plan that addresses habitat actions will not be complete when the second draft is released in April because the recommended action strategy is not finished yet.

A hardened access point gives livestock a way to reach a short segment of a stream where they can water without damaging the system as a whole. (Photo courtesy of Natural Resource Conservation Service)

This riparian restoration project stabilized the bank and added structure (logs and rootwads), which provides shelter for fish. (Photo courtesy of Chris Johnson)

Restoration Action Classes

- Riparian restoration
- Side-channel reconnection
- Obstruction restoration (removal of barriers to fish passage)
- Improve water *quality* in areas where it is impaired
- Water *quantity* restoration
- Add instream structures
- Road maintenance
- Floodplain reconnection/restoration
- Large woody debris restoration

You can comment on the matrices, or any other aspect of the plan, by: Email—ocsr@co.okanogan.wa.us; Postal mail—Okanogan County Office of Planning and Development, Water Resources Division, 123 N 5th Avenue, Room 110A, Okanogan, WA 98840; Telephone—509/422-7113

A comment form is available on our web site at: http://okanogancounty.org/water/salmon%20recovery;%20draft%20review%20corner.htm

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MAY / JUNE MEETING SCHEDULE

2005	
May 25 & 26, 2005	Upper Columbia Salmon Recovery Board — HCC Meeting — City of East Wenatchee Council Chambers—9:00 AM — 5:00 PM
June 1 & 2, 2005	Upper Columbia Salmon Recovery Board — Board Meeting - City of East Wenatchee Council Chambers—9:00 AM — 4:00 PM
June 8, 2005	Upper Columbia Salmon Recovery Board — Staff Meeting — City of East Wenatchee Council Chambers—9:00 AM — 3:00 PM
June 13—17, 2005	Upper Columbia Salmon Recovery Board — HCC Meetings—Location(s) to be determined — 9:00 AM—5:00 PM
June 16, 2005	Advisory Committee—Okanogan County Commissioners' Hearing Room — 6:30 PM
June 23, 2005	Upper Columbia Salmon Recovery Board — Board Meeting – Douglas County Public Services Building —10:00 AM — 3:00 PM
Monthly Okanogan County Regional Salmon Recovery Planning Advisory Committee meetings until June 30, 2005.	

REMAINING PROJECT MILESTONES

2005	
June 30, 2005	Plan submitted to the State of Washington
Month of July	Public and Agencies Review of Draft submitted to the State of Washington

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N THIS ISSUE . . .

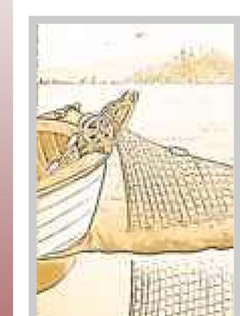
↳ Habitat project inventories—A look at what's already been done
→ April 6, 2005 spring chinook count at Bonneville Dam

Habitat project inventories—A look at what's already been done

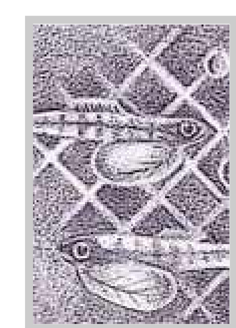
The Upper Columbia Salmon Recovery Plan will include measures to address four factors that have contributed to declines in salmon populations over time: Habitat, Harvest, Hatcheries, and Hydropower (often referred to as the "Four Hs"). Habitat actions—projects and programs to protect, restore, and reduce the risk of further damage to salmon habitat—will be an important part of salmon recovery in the Upper Columbia region. And…a lot of restoration work has already been done. The Upper Columbia Salmon Recovery Plan will include an inventory of completed and ongoing projects in each subbasin in the region (Entiat, Methow, Okanogan, and Wenatchee).

The habitat project inventories will document the efforts that have already been made to protect and restore salmon habitat—including projects aimed at learning more about salmon and their habitat needs so that future work will be as efficient as possible. Those efforts are already helping fish by improving instream and riparian habitat conditions. Some of them will help even more over time, as plants mature and provide shade, litter, and woody debris that make streams more hospitable for fish.

Salmon recovery is likely to take many years—probably decades. We've already made a good start in Okanogan County. The following examples showcase two projects—one in the Methow and one in the Okanogan subbasin—that will benefit listed fish species. In both cases, landowner participation was voluntary—as will be the case with habitat restoration projects undertaken under the Upper Columbia Salmon Recovery Plan.



Harvest



Hatchery

Habitat

Hydropower

Art: http://www.nwppc.org/library/2000/2000-19/4h.htm

The Chewuch River Restoration Project

In 1995, the Pacific Watershed Institute (PWI) partnered with the Methow Valley Ranger District (MVRD), the U. S. Fish and Wildlife Service, and the Washington Department of Fish and Wildlife (WDFW) to develop, implement, and monitor restoration projects on the lower 25 miles of the Chewuch River. All three of the listed salmonid species in the Upper Columbia region—spring Chinook, steelhead, and bull trout—use the Chewuch River and depend on the habitat it provides.

Several factors were identified as limiting the success of the three species: lack of instream large woody debris (log jams), loss of side channel habitat, and high levels of fine sediment deposition. The restoration projects were designed to address those factors and create high-quality habitat for the fish.

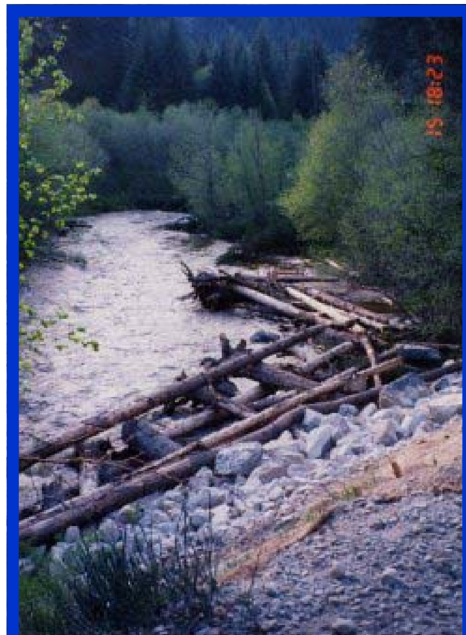
Project activities took place on U. S. Forest Service (USFS), WDFW, Washington Department of Natural Resources (DNR), and private land (with the cooperation of willing landowners). The work included adding instream structures, re-establishing two side channels, planting riverbanks and other disturbed areas with native plants, relocating roads and camping areas, and fencing.

The instream structures were built with logs. They provide places for fish to hide and to rest out of the current. They also reduce erosion of the river banks, which means less sediment enters the river. Rivers need some fine sediment; too much can smother fish eggs, bury spawning gravel, and fill in the pools and side channels that fish use as refuges from strong current and high flows. In many rivers—including the Chewuch—large logs are in short supply . The instream structures aim to replace some of the missing wood. Seventeen structures were added as part of the Chewuch River Restoration Project.

Bundling willows for bank stabilization

One large structure, called a chaotic crib, was installed in conjunction with re-establishing a side channel. Side channels are important as refuges for fish during high water. They are particularly valuable to juvenile fish, giving them calm places away fro the main channel in which to live until they are large enough to survive in faster-moving water. The chaotic crib was installed near a road, to protect the road slope from flows in the newly-reconnected side channel while providing cover for fish. The crib breaks up the direct flow of the water, causing it to lose energy, and erosive power, when its movement becomes "chaotic."

Relocating camping areas and replanting areas that had been degraded by camping was another part of the Chewuch River Restoration Project. Informal or "dispersed" campsites are sites outside of established campgrounds where people have set up camps, often using the same site for many years and causing extensive damage to riverbank vegetation. PWI staff moved campsites away from the riverbank, fenced the areas to prevent campers from driving so close to the river, created walkways that would allow people to walk to the river in places where they would do the least damage, and re-planted the river banks and upland areas with native plants collected within the subbasin. People can still camp *near* the river—just not right *on* the river. Three-quarter of a mile of sensitive riparian area was fenced, and between 20 and 30 acres of disturbed ground planted.



Log structure in the Chewuch

Monitoring—assessing the results of the restoration work—has been part of the project. Over time, monitoring data will improve our understanding of what works best under various circumstances.

Several sources funded the Chewuch River Restoration Project, including the U. S. Fish and Wildlife Service's *Jobs in the Woods* and *Jobs For the Environment* programs. The two programs were created to provide training and employment for displaced timber workers. The project and others undertaken by the Pacific Watershed Institute provided work for nine displaced timber workers and eight other residents of Okanogan County.

Similkameen River Conservation Reserve Enhancement

The Conservation Reserve Enhancement Program (CREP) is a joint program of the US Department of Agriculture and the State of Washington, implemented by county conservation districts. Authorized in 1996, the program provides incentives for removing land from production to create buffers along streams that are listed as critical habitat for salmon and steelhead. Landowners who enroll receive annual payments to compensate for the loss of productive use of their land, and cost-share for implementation of planted riparian buffers.

The Okanogan Conservation District (OCD) has worked with eight landowners in the county to establish CREP projects. Each project is tailored to the site and designed to meet the landowner's specific needs. Typically, a CREP project involves removing non-native vegetation (weeds) and planting native species that will stabilize the bank and improve habitat by shading the water and dropping leaves and other debris in the water. (Plant litter provides habitat for insects and the insects…you guessed it…provide food for fish. The nymphs and adults that fish eat start their lives underwater, as larvae.)

CREP contracts run for either 10 or 15 years. The project shown in the picture below was initiated in 1999, with a 15 year contract. It covers 18.2 acres, with a 150-foot wide buffer a little over a mile long planted with more than 9,000 seedlings. The project, located near the confluence of the Similkameen and Okanogan rivers, is larger than most in Okanogan County. The OCD's eight contracts cover just under 40 acres and protect 2.4 miles of stream bank.

Contractor planting vegetation at a CREP project site along the Similkameen River near Oroville

SPRING CHINOOK RUN EITHER REAL LATE, A LOT LESS THAN EXPECTED, OR BOTH

When only 69 spring chinook were officially counted at Bonneville Dam by April 6, fish managers began to wonder just how late the spring run was going to be. They're still wondering. However, just in case the run totally fizzles out, they have decided to keep all inriver commercial fisheries closed and planned to close all mainstem sports fishing from the estuary all the way to McNary Dam.

Spring chinook Update

Numbers have edged upward recently with the total now slightly above 2,000 fish, a record low for this time period. Over the past 10 years, the average to this date has been in the 55,000-fish range. On April 19, the managers' technical advisory committee reported they were not comfortable making a point estimate at this time, but all their current predictors are coming up with a spring run below 82,000 upriver spring chinook, a far cry from the pre-season estimate of more than 250,000 fish.

Information Source:

NW Fishletter produced by Energy NewsData
http://www.newsdata.com/enernet/fishletter/

Email Updates

REGIONAL SALMON RECOVERY PLANNING

EMAIL UPDATE # 1

September 17, 2004

Salmon Recovery Planning Kick-Off meetings

Okanogan County hosted meetings in Okanogan (September 15th) and Twisp (September 16th) to introduce Salmon Recovery Planning; explain how local stakeholders can get involved and stay informed; and answer questions about the process.

Okanogan County staff and consultants explained the Upper Columbia Regional Salmon Recovery process, the relationship between Salmon Recovery Planning and other local and regional planning efforts and the reasons for Okanogan County's involvement. They presented a draft Table of Contents and gave an overview of the elements that will compose the plan; discussed the composition and roles of the proposed Salmon Recovery Planning Advisory Committee; and explained the quarterly document-review process, which will provide opportunities for public comment by stakeholders who do not join the Advisory Committee.

The meeting agenda and presentation are posted on Okanogan County's Water Resources web site: www.okanogancounty.org/water

Advisory Committee meeting scheduled for September 22nd

The first meeting of the Salmon Recovery Planning Advisory Committee will be held next Wednesday. Please plan to attend if you are interested in joining the committee. Members will be appointed by the Okanogan County Board of Commissioners to represent different interests and geographic areas in the county.

Following the initial meeting next *Wednesday*, the Advisory Committee will meet on the third *Thursday* of each month. Members will be asked to:

- **Comment** on Salmon Recovery work products
- **Provide guidance** on development of sections of the plan, and participate in the development of plan sections where appropriate
- **Inform** community members about Salmon Recovery Planning
- **Provide feedback** on Okanogan County's public outreach efforts

First Advisory Committee meeting:

Wednesday, September 22nd
6:30 PM – 8:30 PM
Okanogan County PUD auditorium, Okanogan

Quarterly document-review meetings

The Upper Columbia Salmon Recovery Board has asked the parties developing the Regional Salmon Recovery Plan to submit draft documents for review once each quarter during the planning process. Initial drafts of the first three sections of the plan—the Introduction and chapters on Species Status and Factors for Decline—are due on September 30th.

Okanogan County will invite public comments on those sections of the plan at meetings in early October.

First Quarterly Document-Review meetings:

Wednesday, October 6th
6:30 PM – 8:30 PM
Okanogan County, Board of Commissioners Hearing Room,
Okanogan

Thursday, October 7th
6:30 PM – 8:30 PM
Twisp Forest Service Conference Room,
Twisp

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water
- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County will publish *Fish Lines* monthly from September 2004 through June 2005. The newsletter will cover Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us
- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 2

October 4, 2004

Quarterly Work-Product Review Meetings Scheduled for October 6th and 7th

Okanogan County will host public meetings in Okanogan (October 6th) and Twisp (October 7th) to present first drafts of the first three sections of the Upper Columbia Regional Salmon Recovery Plan and invite public comment.

The Upper Columbia Regional Salmon Recovery Plan will include scientific and policy components. Local officials—representatives of Chelan, Douglas, and Okanogan counties, the Colville Confederated Tribes, and the Yakama Nation—will ultimately decide what is included in the plan. The work of assembling the information and drafting text for local review, though, is being done by scientists and administrative staff. Those technical experts have been asked to submit the products of their work for review and comment once each quarter during the Regional Salmon Recovery Planning process.

The first work products were due at the end of September. They will be available for public review throughout the month of October. The work products include the Table of contents, Appendix A and first drafts of the first three sections of the Upper Columbia Regional Salmon Recovery Plan:

- Table of Contents
- 1.0 Introduction
- 2.0 Species Status
- 3.0 Factors for Decline
- Appendix A

When will future work products be available for review?

The first draft of the Upper Columbia Regional Salmon Recovery Plan will be available for review in January, 2005. The final draft will be available for review in April, 2005. Please note that the term "final draft" does not mean the document cannot be changed! The final draft will represent several months of work, including editing in response to comments on the first draft. We hope the final draft will not need *major* changes. Comments on the final draft will be considered in developing the plan that is submitted to the state in June, 2005.

Work-Product Review Meetings:

Wednesday, October 6th

6:30 PM – 8:30 PM

Okanogan County Commissioners' Hearing Room

123 Fifth Avenue North, Okanogan

Thursday, October 7th

6:30 PM – 8:30 PM

U. S. Forest Service Conference Room, Twisp

The material covered in the two meetings will be the same. One meeting has been scheduled in Okanogan and one in Twisp to make the meetings as convenient as possible for local stakeholders to attend.

First drafts of Sections 1-3 of the Upper Columbia Regional Salmon Recovery Plan have been posted on the Okanogan County Water Resources web site: http://okanogancounty.org/water/salmon%20recovery;%20draft%20review%20corner.htm

You may also request a copy by calling (509/422-7113) or emailing (ocsr@co.okanogan.wa.us) *our office.*

Anyone may comment on the work products, whether or not he or she attends the review meetings.

Advisory Committee Members Needed!

We are still recruiting stakeholders to serve on the Okanogan County Salmon Recovery Planning Advisory Committee. Local participation is needed to provide for adequate representation of local interests in the Upper Columbia Regional Salmon Recovery Plan. Proposed membership of the Advisory Committee is as follows:

Interest Group Representation (two representatives from each category—one each from the Methow and Okanogan basins)

- Business
- Municipalities/cities
- Irrigated agriculture/irrigation
- Forestry
- Recreation

- Conservation
- Non-irrigated agriculture
- Conservation/environment

Geographic Representation

- Upper Methow
- Lower Methow
- Upper Okanogan
- Lower Okanogan

Other Organizations

- Methow Basin Planning Unit
- Okanogan Basin Planning Unit
- Colville Confederated Tribes
- Okanogan County
- Okanogan Conservation District
- Economic Alliance
- Upper Columbia Regional Fisheries Enhancement Group

Responsibilities of Advisory Committee members will include:

- Commenting on work products developed by science and policy staff
- Providing guidance on development of sections of the plan, and participating in development of plan sections where appropriate
- Informing community members about Salmon Recovery Planning
- Providing feedback on the County's public outreach efforts

If you are interested in representing one of the areas listed above, please contact us.

October Advisory Committee meeting

Thursday, October 21st

6:30 PM – 8:30 PM

U. S. Forest Service Conference Room, Twisp

Fish Lines

The October issue of Okanogan County's Salmon Recovery newsletter, *Fish Lines*, is now available on our web site: http://okanogancounty.org/water/Salmon%20Recovery;%20community;%20outreach%20matierials;%20fish%20lines.htm

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water

- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County will publish *Fish Lines* monthly from September 2004 through June 2005. The newsletter will cover Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us

- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 3
October 22, 2004

Deadline approaching for comments on draft Salmon Recovery Plan text

Okanogan County Water Resources invites your comments on the first drafts of Sections 1-3 and Appendix A of the Upper Columbia Regional Salmon Recovery Plan. The draft text is posted on our web site—you may click on the link below to go directly to the draft review page. You may also call (509/422-7113) or email (ocsr@co.okanogan.wa.us) our office to request a paper or electronic copy of the text for review. ***Comments are due by the close of business on October 29th***.

The first draft of the entire Upper Columbia Regional Salmon Recovery Plan will be available for review in January, 2005. The final draft will be available for review in April, 2005. Comments on the final draft will be considered in developing the plan that is submitted to the state in June, 2005. We welcome your participation at any stage in the process.

Link to review documents:
http://okanogancounty.org/water/salmon%20recovery;%20draft%20review%20corner.htm.

Advisory Committee Members Needed!

We are still recruiting stakeholders to serve on the Okanogan County Salmon Recovery Planning Advisory Committee. Your knowledge, insights, and opinions are valuable, and will help ensure representation of local interests in the Upper Columbia Regional Salmon Recovery Plan. The Advisory Committee meets on the third Thursday of each month—the next meeting will be held on November 18th beginning at 6:30pm in the Board of Commissioners Hearing Room. If you are interested in participating, please contact us.

Upper Columbia Harvest and Hatchery workshop

The Upper Columbia Salmon Recovery Board, the Governor's Salmon Recovery Office and the Washington Department of Fish and Wildlife invite you to learn about harvest and hatchery issues related to salmon recovery within the Upper Columbia Region. This region includes Chelan, Douglas and Okanogan Counties. The program includes a panel discussion with representatives of the Washington Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, NOAA Fisheries (formerly NMFS), the Confederated Tribes of the Colville Reservation, and the Yakama Nation. Maps and brochures will be provided. The purpose of the workshop is to inform the public and listen to concerns and issues. The meeting will be held October 28th from 6:30 to 9 p.m. at the Chelan Fire House #7, 232 E. Wapato in Chelan.

<u>Upper Columbia Salmon Recovery Deliverables – Quarterly Review</u>

On October 20, 2004 the quarterly meeting to review the products and progress of the Upper Columbia Salmon Recovery Board in completing its salmonid recovery plan by June 2005 was held. It was reported by those attending that the GSRO was very pleased with the progress the UCSRB has been making on the recovery planning and the public involvement effort. More detail should be available in our next email update.

<u>Fish Lines</u>

Please tell us what you think…

Has *Fish Lines*–Okanogan County's Salmon Recovery newsletter–helped you understand Salmon Recovery Planning in Okanogan County? Are there topics you would like to see covered? Please let us know if you are finding the newsletter valuable or if you would like to see changes!

The September and October issues of *Fish Lines* are posted at http://okanogancounty.org/water/Salmon%20Recovery;%20community;%20outreach%20matierials;%20fish%20lines.htm

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water
- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County will publish *Fish Lines* monthly from September 2004 through June 2005. The newsletter will cover Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us
- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 4
November 5, 2004

Upper Columbia Salmon Recovery Deliverables – Quarterly Review

The Upper Columbia Salmon Recovery Board presented a progress report to the Governor's Salmon Recovery Office (GSRO) on October 20.

Excerpts from final notes for UCSRB Third Quarter review

The Habitat Coordinating Committee (HCC) has had a major positive impact on the delivery of products. Current document has gone through 3 iterations because of the HCC, with major contributions from WDFW, USFWS, and NOAA incorporated before the formal review that this group represents. Chapters will continue to be released to the HCC as they are developed. During the last HCC meeting, the group agreed that they would move to numbered lines to make review easier. New contractors will be on board in December. Other improvements will be in how the comments are formatted – using a standard format to make it easier for the consultant to incorporate them.

Bugert noted the state is very comfortable with the process that the Board has now adopted. We commend the approach and are pleased that it makes it easier for reviewers and for their comments to be incorporated. The HCC seems to be working very well in this process. We want to reinforce that the approval that we give today is provisional, however, based on the subsequent chapters. Nason noted that the Board understood and was comfortable; it is common for large documents to have a provisional adoption approach.

Public Outreach in Okanogan County……Elizabeth Gaar wanted to know if public was comfortable with only looking at habitat, or do they want to see all aspects. Also, calendar shows things end in June but fed's process continues through December. Julie said stakeholders are concerned that they could do everything possible in habitat, and recovery may not occur. Yes, there are lots of questions that habitat changes won't get them to the goal. Julie said there is limited stakeholder support for EDT at this point. There is a great deal of interest in the out of basin issues and other Hs. Outreach ends in June 05 because that is when the contract and money run out. If get more money to continue, they would consider extending outreach. Commissioners are more interested in habitat things right now because that is what they can do, but interested in facilitating dialogue in all Hs even though they know that they won't have a great deal of influence on their impacts or outcomes. Want to continue doing habitat projects, but know the reality of their situation is more complex. What happens after June 05 is still very much up in the air

Upper Columbia Harvest and Hatchery workshop

Washington State's Salmon Recovery Strategy revolves around four factors that have affected salmon populations: habitat, harvest, hatcheries, and hydropower. Collectively, they are known as the "Four Hs." The Upper Columbia Salmon Recovery partners—Chelan, Douglas, and

Okanogan counties, the Colville Confederated Tribes, and the Yakama Nation—are concentrating on habitat. That is the factor on which local decisions and actions have the most influence, and very important to fish production.

Other agencies are focusing more attention on the other three Hs.

On October 28th, the Upper Columbia Salmon Recovery Board (UCSRB) hosted a workshop highlighting harvest and hatchery issues related to salmon recovery within the Upper Columbia Region. The workshop gave local stakeholders a chance to learn more about those two Hs and how they are being addressed; and to meet and talk with federal, state, and tribal hatchery and fishery managers.

The UCSRB will host a hydropower workshop early in 2005. To be place on the invitation list for the hydropower workshop or if you would like additional information on one of the four Hs, please contact Sandy Cox by replying to this email or calling 509.422.7113.

November Habitat Coordinating Committee meetings

The Upper Columbia Regional Salmon Recovery Habitat Coordinating Committee (HCC) will meet in Leavenworth on November 10th. The HCC meeting agenda includes but is not limited to Actions List Review, review of Master Schedule for Public and Technical Review and Draft Completion Milestones for the January-June 2005 period and the review of Actions Library work done to date by HCC Actions subcommittee
The HCC will hold a second November meeting on the 30th of the month to review and discuss technical data that will inform salmon recovery strategies. A location has not been confirmed yet for this meeting – if you are interested in attending please contact Sandy Cox by replying to this email or calling 509.422.7113.

Advisory Committee Members Needed!

The Okanogan County Salmon Recovery Planning Advisory Committee is continuing to grow…and, we are still recruiting stakeholders to serve on the committee. Please consider joining! Your knowledge, insights, and opinions are valuable, and will help ensure representation of local interests in the Upper Columbia Regional Salmon Recovery Plan. The Advisory Committee meets on the third Thursday of each month. If you are interested in participating, please contact us.

The next meeting of the Okanogan County Salmon Recovery Planning Advisory Committee will be held on November 18th beginning at 6:30pm in the Board of Commissioners Hearing Room.

Our Website

Okanogan County Water Resources web site. www.okanogancounty.org/water

Fish Lines

The November as well as previous issues of *Fish Lines*–Okanogan County's Salmon Recovery newsletter–are now available online at:
http://okanogancounty.org/water/Documents%20on%20Site/3NewsletterFINAL110104.pdf

This month's issue features:

- A brief history of salmon fishing in Okanogan County
- An explanation of the Salmon Recovery matrices that will be used to organize and present recovery information in the Upper Columbia Regional Salmon Recovery Plan

Community Events

EVENT: Methow Valley Fly Fishers November Monthly Meeting.
DATE: Tuesday, November 16, 2004
LOCATION: Liberty Bell High School.
TIME: 7:00 PM

SPEAKERS/PRESENTERS:

- Bob Jateff, Methow Okanogan WDFW Biologist, will lead a presentation on local regulations, projected fishery changes, current fishery counts and winter fishery rules

- Cal Tresser, Methow Game Enforcement, will discuss this seasons enforcement issues

- Pat Herdt will also present a fly for current Methow River conditions

As members have been active this fall steelhead season, we look forward to interesting catch reports.

CONTACT: Duncan Bronson
Secty MVFF
509 996 3218
bronson@methow.com

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water
- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County published the first issue of *Fish Lines* in September 2004; the publication will continue monthly through June 2005. The newsletter covers Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us
- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 5
November 15, 2004

Habitat Coordinating Committee news

The Upper Columbia Regional Salmon Recovery Habitat Coordinating Committee (HCC) met in Leavenworth on November 10th. The HCC established a comment and review schedule for the next two drafts of the Upper Columbia Regional Salmon Recovery Plan. The first draft of the entire plan, expected to represent a 70%-complete plan, will be released for public comment in early January 2005. The final draft will be available for public comment during the month of April. Stakeholders will also have an opportunity to comment on the plan after it has been submitted to the state on June 30th, 2005.

A subcommittee of the HCC is identifying categories of restoration actions to be considered in the Upper Columbia basin. The group has begun to rate the effectiveness of the various restoration actions, using a set of matrices and EDT (Ecosystem Diagnosis and Treatment) modeling.

The HCC's November/December 2004 meeting schedule is as follows:

- Monday, November 15: Action subcommittee meets to discuss restoration actions and effects of various actions
- Tuesday, November 30: HCC meets to review and discuss technical data that will inform salmon recovery strategies, including smolt:redd ratios (which affect salmonid abundance and productivity), habitat matrices, and spatial diversity
- Thursday, December 9: regular HCC meeting
- Tuesday, December 14: HCC meets to complete habitat matrices for inclusion in first draft Upper Columbia Regional Salmon Recovery Plan

Stakeholders are welcome to attend HCC meetings. Please call Sandy Cox at (509) 422-7113 for information about meeting times and locations.

Okanogan County Salmon Recovery Planning Advisory Committee

The Okanogan County Salmon Recovery Planning Advisory Committee will meet:

Thursday, November 18th
6:30 PM
Okanogan County Commissioners' Hearing Room, Okanogan

The agenda will include

- Review of comments on the first draft of Sections 1-3 and Appendix A; discussion of the Upper Columbia comment process and handling of comments received by Okanogan County

- Review of habitat matrices
- Introduction to project prioritization framework

All interested stakeholders are welcome!

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water
- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County published the first issue of *Fish Lines* in September 2004; the publication will continue monthly through June 2005. The newsletter covers Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us. The September, October, and November issues may be viewed on the Water Resources web site: http://okanogancounty.org/water/Salmon%20Recovery;%20community;%20outreach%20matierials;%20fish%20lines.htm
- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 6
December 3, 2004

Habitat Coordinating Committee news

The Upper Columbia Regional Salmon Recovery Habitat Coordinating Committee's (HCC's) "Actions and Effects" subcommittee met on November 15th to refine the library of actions being considered for inclusion in the Salmon Recovery Plan. The HCC as a whole met on November 30th to finalize the action library and outline scenarios. Scenarios are groups of actions intended to mitigate specific limiting factors.

The HCC's December meeting schedule is as follows:

- Thursday, December 9: discuss scenarios and analyze their effects (this will be an abbreviated meeting that will be held from 8:00am to 11:30am)

- Tuesday, December 14: discuss material for inclusion in the first draft of the Upper Columbia Regional Salmon Recovery Plan, to be released in January, 2005

Stakeholders are welcome to attend HCC meetings. Please call Sandy Cox at 422-7113 for information about meeting times and locations.

Okanogan County Salmon Recovery Planning Advisory Committee

The Okanogan County Salmon Recovery Planning Advisory Committee will meet:

Thursday, December 16th
6:30 PM
Okanogan County Commissioners' Hearing Room, Okanogan

All interested stakeholders are welcome! We will discuss stakeholder comments and material to be included in the first draft of the Upper Columbia Salmon Recovery Plan

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water
- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County published the first issue of *Fish Lines* in September 2004; the publication will continue monthly through June 2005. The newsletter covers Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us. The September, October, and November issues may be viewed on the Water Resources web site: www.okanogancounty.org/water
- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 7
December 17, 2004

First draft Salmon Recovery Plan to be released in January

The Upper Columbia Salmon Recovery Board (UCSRB) will release the first draft of its Salmon Recovery Plan for public review on December 30th. The plan will be posted on the Okanogan County Water Resources web site as soon as it is available, and recipients of this update will be notified when the document has been posted.

The draft plan will be available for review and comment throughout the month of January. Okanogan County will host two public meetings—one in Twisp and one in Okanogan—to present the draft plan, discuss stakeholders' ideas and concerns, and answer questions about the plan. The meeting schedule is as follows:

Tuesday, January 11th, 2005
6:30 PM
(location to be determined), Twisp

and

Wednesday, January 12th, 2005
6:30 PM
Okanogan County Commissioners' Hearing Room, Okanogan

The two meetings will be identical in content so it is only necessary to attend one.

All interested stakeholders are welcome.

Comments on the draft plan should be submitted directly to the UCSRB. You will find a comment sheet on our web site, you can stop by and pick one up, or we are happy to mail or fax you one. You may submit your comments in any format you wish although we do encourage you to use the comment sheet which will make it easier to correlate comments to the document and review and respond to all comments received.

Please submit your comments using one of the following methods:

1) Mailing Address: Sandy Cox
Okanogan County Water Resources
123 – 5th Ave N
Room 110
Okanogan, WA 98840

2) Email Address: scox@co.okanogan.wa.us

3) Fax Number: 509.422.7349

All Comments are due no later than 4:00 PM on Monday, January 31, 2005.

UCSRB workshop

Regional recovery staff (representatives of Chelan, Douglas, and Okanogan counties, the Colville Confederated Tribes, and the Yakama Nation) conducted a workshop with the Upper Columbia Salmon Recovery Board on Thursday, December 9th. The purpose of the workshop was to ensure that the board members understand the plan components, planning process, public outreach efforts, and timeline, and to update them on the status of the plan relative to NOAA's criteria. Staff members' intent was to give the board members a solid foundation from which to make decisions when they review drafts in 2005. Board members will receive monthly briefings from staff next year through June, with the chance to ask questions as the draft plan is refined.

Okanogan County Salmon Recovery Planning Advisory Committee

The Okanogan County Salmon Recovery Planning Advisory Committee met on December 16th. The Committee's agenda included:

- An explanation of the handling of stakeholder comments on the initial draft text that were submitted to Okanogan County
- A review of the Master Planning Schedule for the Upper Columbia Salmon Recovery Plan, which outlines meeting dates, work product deadlines, review periods and other milestones in the planning process
- A briefing on the draft plan to be released in January, and the comment process for that draft
- An overview of the plan's purpose and components, with emphasis on the way in which the technical products are related to the goal of the plan
- A review of the Habitat Actions Library. The Library outlines actions that may be taken to address limiting factors identified for each stream reach in the planning area.

Advisory Committee members offered suggestions for strengthening the plan and ensuring that it supports local interests.

The Habitat Actions Library and other materials from the December Advisory Committee meeting have been posted to our web site.

The next Advisory Committee meeting will be held on January 20th, 2005 in the Board of County Commissioners' Hearing Room, Okanogan, WA from 6:30pm to 8:30pm. All interested stakeholders are welcome to attend.

New postings on Okanogan County's web site

Be sure to check our web site for meeting notes and other new documents! This link will take you to the Salmon Recovery pages: http://okanogancounty.org/water/Salmon%20Recovery.htm.

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water

- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County published the first issue of *Fish Lines* in September 2004; the publication will continue monthly through June 2005. The newsletter covers Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us. Past issues may be viewed on the Water Resources web site: www.okanogancounty.org/water
- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

REGIONAL SALMON RECOVERY PLANNING

EMAIL UPDATE # 8

January 7, 2005

First draft Salmon Recovery Plan has been released

The Upper Columbia Salmon Recovery Board (UCSRB) has released the first draft of its Salmon Recovery Plan for public review. The plan is posted on the Okanogan County Water Resources website at: http://okanogancounty.org/water/salmon%20recovery;%20draft%20review%20corner

The draft plan is available for review and comment throughout the month of January.

Comments on the draft plan should be submitted directly to the UCSRB. You will find a comment sheet on our web site, you can stop by and pick one up, or we are happy to mail or fax you one. You may submit your comments in any format you wish although we do encourage you to use the comment sheet which will make it easier to correlate comments to the document and review and respond to all comments received.

Please submit your comments using one of the following methods:

1) Mailing Address: Sandy Cox
Okanogan County Water Resources
123 – 5th Ave N
Room 110A
Okanogan, WA 98840
2) Email Address: scox@co.okanogan.wa.us
3) Fax Number: 509.422.7349

All Comments are due no later than 4:00 PM on Monday, January 31, 2005.

MEETING REMINDERS

Okanogan County is hosting two public meetings—one in Twisp and one in Okanogan—to present the draft plan, discuss stakeholders' ideas and concerns, and answer questions about the plan. The meeting schedule is as follows:

Tuesday, January 11th, 2005
6:30 PM
Methow Valley Senior Citizens Center, Twisp

and

Wednesday, January 12th, 2005
6:30 PM
Okanogan County Commissioners' Hearing Room, Okanogan

These two meetings will be identical in content so it is only necessary to attend one.

All interested stakeholders are welcome and encouraged to attend.

Okanogan County Salmon Recovery Planning Advisory Committee

The next Advisory Committee meeting will be held on January 13th, 2005 in the Board of County Commissioners' Hearing Room, Okanogan, WA from 6:30pm to 8:30pm. All interested stakeholders are welcome to attend.

Public comment period and hearing scheduled for the revised drafts of the Methow, Okanogan, Entiat, Wenatchee and Yakima Subbasin Plan program amendments.

The Northwest Power and Conservation Council (Council) is accepting public comments on the above Subbasin Plans. The comment period closes on January 31, 2005. If you would like to testify in person, the Council is holding a series of hearings in January. A hearing for the drafts of the Entiat, Methow, Okanogan, Yakima and Wenatchee Subbasin Plan program amendments has been scheduled for Wednesday, January 26 at 6:30 PM at the Wenatchee Convention Center, Gala 1 and 2, 201 N. Wenatchee Avenue, Wenatchee, WA.

In addition to the hearing, comments may be submitted by mail, fax, or email. Please address all comments to Mr. Mark Walker. Comments must be in by close of business day on January 31, 2005.

Mark Walker
Director of Public Affairs
Northwest Power & Conservation Council
851 SW 6th Avenue, Suite 1100
Portland, OR 97204-1348

Fax (503) 820-2370

Email comments@nwcouncil.org

If you would like background information about the plans and the process, please visit the following website:
http://www.nwcouncil.org/fw/subbasinplanning/admin/NoticeToComment2.htm

The January issue of *Fish Lines* has been posted to the website at:

http://okanogancounty.org/water/Documents%20on%20Site/5NewsletterFINAL010705.pdf

New postings on Okanogan County's web site

We are updating our website all the time! This link will take you to the Salmon Recovery pages: http://okanogancounty.org/water/Salmon%20Recovery.htm.

Announcement for the January Methow Valley Fly Fishers Monthly Meeting

7:00 PM Tuesday January 18 at Liberty Bell High School.

Chris Fisher who is charge of the Colville Tribal Lakes will present several topics about fishing on the Colville Reservation. Crawfish, Goose, Buffalo, McGinnis and Omak are all popular fishing lakes.

There are several lakes available to fish and Chris will tell us how to fish, what to use, describe access, explain regulations and provide map handouts.

In addition, member Pat Herdt will present an exciting fly to use on the Colville lakes.

For questions please contact: Duncan Bronson, secretary/MVFF at 509 996 3218

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water
- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County published the first issue of *Fish Lines* in September 2004; the publication will continue monthly through June 2005. The newsletter covers Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us. Past issues may be viewed on the Water Resources web site: www.okanogancounty.org/water
- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 9
February 11, 2005

Joint meeting scheduled for Advisory Committee and HCC

In response to a request by members of the Okanogan County Salmon Recovery Advisory Committee, Commissioner Bud Hover and Water Resources Coordinator Julie Pyper arranged for Advisory Committee members to meet with the Upper Columbia Salmon Recovery Habitat Coordinating Committee (HCC). The session gave the two groups a chance to discuss the HCC's work and how it relates to local interests. The meeting took place on Thursday, February 10th, in East Wenatchee.

Upper Columbia Salmon Recovery Deliverables – Quarterly Review

The Upper Columbia Salmon Recovery Board presented a progress report to the Governor's Salmon Recovery Office (GSRO) on February 2nd at the GSRO Quarterly review held in East Wenatchee.

Comments on the work done thus far were presented by representatives from NOAA-F, WDFW, and USFWS. Expectations for the next 5 months were reviewed and upcoming issues were discussed. Mike Kaputa from Chelan County, Chuck Jones from Douglas County, and Julie Pyper from Okanogan County each presented a brief overview of their past, present and future Public Outreach efforts.

The next Quarterly review will be held on Wednesday, May 4, 2005 from 9:00am to 3:00pm at the City of East Wenatchee Council Chambers.

First Draft of the Upper Columbia Salmon Recovery Plan: Status and Next Steps

Review of comments on the first draft of the Upper Columbia Salmon Recovery Plan begins this month. The Upper Columbia Salmon Recovery Board (UCSRB) received public comments during the month of January. The Board, Regional Recovery Staff, and the HCC will review, discuss and consider those comments, along with comments from the GSRO, during the first several weeks of February. Responses will be drafted late this month, and reflected in the final draft of the plan, which will be issued in April.

Upper Columbia Hydropower workshop

The UCSRB will host a workshop highlighting hydropower issues related to salmon recovery within the Upper Columbia Region on February 24th. The workshop will give local stakeholders a chance to learn more about the hydropower system and how its effects on listed species are being addressed.

Date: Thursday, February 24, 2005
Time: 6:30 PM—9:00PM
Location: Chelan Fire Station — 232 E Wapato, Chelan WA 98816

The workshop follows a session on hatcheries and harvest held last November. Washington State's Salmon Recovery Strategy revolves around four factors that have affected salmon populations: habitat, harvest, hatcheries, and hydropower. Collectively, they are known as the "Four Hs." The Upper Columbia Salmon Recovery partners—Chelan, Douglas, and Okanogan counties, the Colville Confederated Tribes, and the Yakama Nation—are concentrating on habitat. That is the factor on which local decisions and actions have the most influence, and is very important to fish production.

Other agencies are focusing more attention on the other three Hs.

To be placed on the mailing list for the hydropower workshop, or if you would like additional information on one of the four Hs, please contact our office. You can also take a look on our website at the articles about hydropower in the December 2004 and January 2005 issues of *Fish Lines*!

Meeting Updates

Okanogan County Salmon Recovery Planning Advisory Committee

The Salmon Recovery Advisory Committee will meet on Thursday, February 17th to discuss the Habitat Action Library drafted by the Habitat Coordinating Committee. (Other topics may also be added to the agenda) All interested stakeholders are welcome to attend. The meeting will be held in the Okanogan County Commissioners' Hearing Room beginning at 6:30 PM. Please call if you would like more information about the Advisory Committee.

Habitat Coordinating Committee

The Upper Columbia Habitat Coordinating Committee (HCC) met on February 10th and will meet again on February 17th. The February 10th meeting will include sessions with local advisory groups, including the Okanogan County Salmon Recovery Advisory Committee. The meeting on the 17th will focus primarily on the review of comments received on the recovery plan. Please call our office for information about meeting times and locations. All interested stakeholders are welcome to attend HCC meetings.

Other Group Meeting Notices

Two Methow Valley Fly Club Meetings:

(1) Tuesday, February 15, 2005 – 7:00 PM at Liberty Bell High School.

February and March are Whitefish time ! Come and learn about this late winter fishery. A panel of local fly fishers will present a complete 'how to do it.' Gear, hookups, flies, fishing sites and cooking suggestions all will be discussed.

Pat Herdt will present a selected Whitefish fly.

WDFW has several lake improvement projects on the agenda. A WDFW representative will also discuss MVFF volunteer opportunities at this meeting.

(2) Tuesday, March 15, 2005 (Details not confirmed yet)

Bob Sheedy will be hosted. Bob is a fly fishing author from Manitoba, Canada who specializes in rather unique Stillwater fly fishing strategies and has written two books and produced videos on the subject. While dealing primarily with trout the tactics are equally effective for bass, walleyes and other species.

Interested parties can get more info from the web at http://www.mwflyfishing.net by following the "Presentation" links as well as a host of other free information in the E-Zine.

His email is: flyfisher@escape.ca and his telephone number is (204) 564-2447.

His books include: Lake Fly Fishing Strategies & Bob Sheedy's Top Fifty Stillwater Fly Patterns

For more information on these two meetings or the Methow Valley Fly Club in general please contact Duncan Bronson at 509 996 3218 or bronson@methow.com

The September, 2004 through February, 2005 issues of *Fish Lines* are available on the Okanogan County Water Resources website at:
http://okanogancounty.org/water/Salmon%20Recovery;%20community;%20outreach%20matierials;%20fish%20lines.htm

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If you would like to review any of our prior Email updates they are available on the Okanogan County Water Resources website at:
http://okanogancounty.org/water/Salmon%20Recovery;%20community;%20outreach%20materials;%20email%20updates.htm

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New postings on Okanogan County's web site
We are updating our website all the time! This link will take you to the Salmon Recovery pages: http://okanogancounty.org/water/Salmon%20Recovery.htm.

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water
- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County published the first issue of *Fish Lines* in September 2004; the publication will continue monthly through

June 2005. The newsletter covers Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us. Past issues may be viewed on the Water Resources web site: www.okanogancounty.org/water

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REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 10
February 18, 2005

Meeting Updates

The Upper Columbia Habitat Salmon Recovery Board (UCSRB), Habitat Coordinating Committee (HCC), and Salmon Recovery Advisory Committee (AC) all met yesterday (Thursday, February 17th). Following are updates on the three meetings.

Upper Columbia Salon Recovery Board

UCSRB members discussed policy issues raised by Regional Recovery Staff (RRS) members from Douglas and Okanogan counties. Staff members asked for guidance from the Board so that they can accurately represent the Board's position in discussions and negotiations regarding the content of the Upper Columbia Salmon Recovery Plan's. Board members drafted a set of position statements. Those statements will be refined by RRS members and presented to the Board for final approval next week.

Habitat Coordinating Committee

HCC members discussed habitat matrices and habitat modeling. The group reviewed and fine-tuned habitat matrices developed for the Entiat and Wenatchee subbasins. The committee members responsible for developing matrices for the Methow and Okanogan subbasins will review those matrices, edit them using the same principles that were used for the Entiat and Wenatchee matrices, and distribute them for comment next week. HCC members asked for help from local stakeholders in determining what actions are likely to take place in each assessment unit (subsets of subbasins; examples include the Lower Methow River, and Omak Creek and its tributaries).

HCC members also heard a presentation by Casey Baldwin, WDFW, about the models that are being used to estimate recovery outcomes. The group discussed ways to ensure that the models reflect realistic assumptions about what actions will be taken in each subbasin.

Okanogan County Salmon Recovery Planning Advisory Committee

The Salmon Recovery Advisory Committee met yesterday (Thursday, February 17th) and discussed ways of bringing local interests into the Salmon Recovery planning process. AC members commented on the list of policy issues that the UCSRB had discussed earlier in the day. Additional comments may be submitted to Sandy Cox until Tuesday (February 22nd). Committee members also talked about some on-the-ground factors that will influence salmon recovery (including desirable actions and outcomes), data they would like to see considered in modeling treatments and outcomes, and ways of contributing to refinement of the habitat matrices. Okanogan County staff and consultants will work with the AC to edit the matrices for the Methow and Okanogan subbasins and forward the local input to the HCC.

Hydropower Workshop

Reminder: the UCSRB will host a workshop highlighting hydropower issues related to salmon recovery within the Upper Columbia Region on February 24th. If you have any questions or require more information please give us a call.

Date: Thursday, February 24, 2005
Time: 6:30 PM—9:00PM
Location: Chelan Fire Station — 232 E Wapato, Chelan WA 98816

The February issue of *Fish Lines* has been posted to the Okanogan County Water Resources website at:
http://okanogancounty.org/water/Documents%20on%20Site/6NewsletterFINAL021105.pdf

The September, 2004 through January, 2005 issues of *Fish Lines* are also available on the website at:
http://okanogancounty.org/water/Salmon%20Recovery;%20community;%20outreach%20matierials;%20fish%20lines.htm

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REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 11
March 4, 2005

Upper Columbia Salmon Recovery Board releases policy statement

A number of policy issues have arisen in the last several weeks, and the UCSRB and its committees have discussed and begun to address various facets of the Upper Columbia Salmon Recovery Plan. At the last UCSRB Board meeting held on February 17th Board members adopted the following position statement defining recovery. The statement reads as follows:

Upper Columbia Salmon Recovery Board
Position statement regarding the Upper Columbia Salmon Recovery Board's definition of recovery of fish populations in the region.

In 2000, the Upper Columbia Salmon Recovery Board (UCSRB) developed a goal statement that defined recovery of salmon and steelhead as having viable and harvestable populations. The Board has reaffirmed this position on several occasions over the last five years. The UCSRB definition of recovery is not synonymous with the Endangered Species Act (ESA) definition. The ESA defines recovery as a process that changes the status of a species to allow delisting. This UCSRB goal is intended to achieve an enriched quality of life in the region, represented in part by healthy fish populations, and providing for clearly needed economic growth and diversity. It is not the intent of the Board to put any regulatory or legal burden above and beyond what is called for in the ESA on the citizenry of the region. The recovery plan will achieve delisting of threatened and endangered salmonid species and include information and voluntary actions that will result in salmonid populations capable of sustaining some level of recreational and tribal harvest.

The Board believes that there are three stages in the recovery process: 1) a change from endangered to threatened status, 2) from threatened to delisting, and 3) delisting to harvestable. The first two stages are ESA defined and regulated by the federal services (NOAA Fish and USFWS), whereas the last stage is a plan objective that contains non-regulatory potential for enhancing or creating fisheries in the region. The first stage, a change in status, allows more legal and regulatory flexibility as negotiated through what are called 4(d) rules. The second stage completely relieves ESA requirements and the third stage will assist in meeting federal tribal trust responsibilities and provide for recreational fisheries and economic benefit within the region. An example of the last stage might be voluntary landowner actions related to improving habitat conditions. This definition is conceptually consistent with, and intended to support, many community goals related to the quality of life in the region.

At the next UCSRB Board meeting the Board will review additional policy/position statements on other regional salmon recovery planning issues.

July comment period added to Salmon Recovery timeline

The schedule for the Upper Columbia Salmon Recovery Plan has been revised to include an additional public comment period. A complete final draft will be available for review during the month of July, with comments due by July 31st. The schedule has been reworked because it will not be possible to release a complete final draft at the end of March, as originally scheduled, or to allow the planned 45-day period for review of that draft.

The revised timeline calls for release of an incomplete final draft plan on March 31st. A 30-day review period will follow, with comments due on April 29th. The Habitat Coordinating Committee (HCC) and Regional Recovery Staff (RRS) will continue to add material to the final draft during the review period, making it impossible for stakeholders to comment on a complete draft before the plan is sent to the technical writer in June. The July review period has been added so that stakeholders can comment on a complete draft, and the UCSRB can consider comments and work to incorporate the comments.

Public comments will also be solicited by NOAA Fisheries before it adopts a recovery plan. Adoption by NOAA Fisheries is scheduled for December of this year.

What actions will be taken to further salmon recovery?

The HCC has developed a library of habitat actions—specific steps that will be taken to modify habitat conditions for the benefit of salmon. The committee has begun to discuss which actions will be appropriate in various parts of the Methow and Okanogan subbasins. To be accurate and effective, the Upper Columbia Salmon Recovery Plan must include actions that are appropriate from an ecological perspective and also acceptable to stakeholders and likely to be implemented.
Okanogan County Water Resources has begun to work on the latter two points. In addition, Staff members will meet next week with representatives of the Natural Resources Conservation Service, Forest Service, Methow Salmon Recovery Foundation, Bureau of Reclamation, and others to discuss projects that are underway, planned, or anticipated in the next five years. An email has been sent out to numerous individuals and interest groups to continue to build our existing inventory. Advisory Committee members will discuss the same topic at their next meeting, on March 17th. All stakeholders are welcome to join the discussion at that meeting. We are interested in knowing what projects you would like to see happen, what projects would be acceptable, and what projects you would not approve of.

Project inventories—we could use your help!

In order to understand the potential for salmon recovery in the Methow and Okanogan subbasins, we need to know what has already been done to protect and restore habitat. Recently completed project inventories aim to answer that question. If you have completed a habitat project (or have one underway)…or if one has been done on your

property…we would like to know about it so that it can inform the Salmon Recovery Plan. (Knowing what has already been done helps we understand what work remains, and may be done in the future.)
Okanogan County's Water Resources office has asked organizations that do habitat work in the Methow and Okanogan subbasins to review the inventories and let us know about errors and omissions. If you would like to help, too, you can find the inventories on our web site, at http://okanogancounty.org/water/salmon%20recovery;%20draft%20review%20corner.htm and chose Methow Inventory with VSP Link. Please take a look, and let us know if we have missed something! We will be adding the Okanogan Inventory soon.

Mid-Columbia Forum

Chelan and Douglas County PUDs worked for several years to develop hydropower Habitat Conservation Plans (HCPs) for anadromous salmonids in the Upper Columbia basin. The plans commit the two PUDs to a 5-year program that will ensure that Rocky Reach, Rock Island, and Wells hydroelectric projects have no net impact on salmon and steelhead runs. The plans were signed by the PUDs, NOAA Fisheries, the U. S. Fish and Wildlife Service, the Washington Department of Fish and Wildlife, and the Colville Confederated Tribes in 2002 and approved by the Federal Energy Regulatory Commission (FERC) in June of last year.
The HCP Coordinating Committees will hold a forum to mark the implementation of the HCPs at the Wenatchee Convention Center from 9:00 AM to 3:00 PM on March 29th. The forum will provide an opportunity to learn and ask questions about the HCPs, progress toward implementing them, and plans for future activities.
For more information, you may contact Michael Schiewe or Ali Wick at 206/287-9130.

News and Meeting Information from Other Groups

Methow Valley Fly Fishers March Monthly Meeting

7:00 PM Tuesday March 15 at Liberty Bell High School.

Bob Sheedy, one of Canada's foremost lake fly fishers will present "Lake Fly Fishing Strategies." Bob will cover forage items peculiar to stillwaters, their habits and preferred locations. Bob's two popular books, "Lake Fly Fishing" and "Top 50 Fly Patterns" which he will review will be available for purchase by attendees. Visit his web page www.mwflyfishing.net to see summaries of his presentation.

If you want to learn the secrets and techniques of successful lake fly fishing you will want to attend this presentation.

Pat Herdt will also present a fly for use on lakes opening day!

For more information please contact Duncan Bronson, secty/MVFF by phone at 509 996-3218 or by email at bronson@methow.com

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The February issue of Fish Lines has been posted to the Okanogan County Water Resources website at:
http://okanogancounty.org/water/Documents%20on%20Site/6NewsletterFINAL021105.pdf

The September, 2004 through February, 2005 issues of Fish Lines are also available on the website at:
http://okanogancounty.org/water/Salmon%20Recovery;%20community;%20outreach%20matierials;%20fish%20lines.htm

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New postings on Okanogan County's web site
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For more information:

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- Read Okanogan County's Salmon Recovery newsletter, Fish Lines. Okanogan County published the first issue of Fish Lines in September 2004; the publication will continue monthly through June 2005. The newsletter covers Salmon Recovery Planning and related topics. To add your name to the mailing list for Fish Lines, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us. Past issues may be viewed on the Water Resources web site: www.okanogancounty.org/water
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REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 12
March 18, 2005

Upper Columbia Salmon Recovery Board reconsiders policy statement

The Upper Columbia Salmon Recovery Board (UCSRB) is reconsidering the policy statement that it adopted on February 24th. Board members have decided not to release the statement pending amendment in response to points raised by UCSRB members.

Gathering information and opinions

Okanogan County is gathering information about restoration and protection projects in the Okanogan and Methow Subbasins. Staff members are interested in projects with a benefit to salmonids that have been completed, are in progress, are planned, or are anticipated for completion in the next 10 years. In addition to working with the Salmon Recovery Advisory Committee, they are meeting with organizations like the Okanogan Conservation District and the Natural Resource Conservation Service to collect general information. Information about specific landowners and projects and conditions on their land will not be used in developing the Salmon Recovery Plan. General information about kinds of projects being undertaken in different parts of the County will help show that landowners are *already* improving habitat. The information will be used to complete inventories and habitat matrices that will inform the plan.

What are habitat matrices?

A matrix is a table used to organize information. The HCC has drafted a matrix for each subbasin in the Upper Columbia Region.

Each matrix identifies limiting factors, causal factors, management objectives, and classes of restoration actions. A limiting factor is anything that tends to make it more difficult for a species to live and grow or reproduce in its environment. Limiting factors for salmonids in our region include riparian habitat condition, in-stream obstructions such as culverts, and water quantity—low flow in the stream (there are others as well).

Causal factors are the types of alterations to the ecosystem that have caused the limiting factors—such as riparian vegetation removal, development of roads that constrict a stream channel, or development of roads that act as conduits to concentrate water and direct it from the upper watershed to a stream more quickly than under pristine conditions. The limiting factors and causal factors explain why a species is not able to make full use of habitat in a particular part of a subbasin.

Management objectives identify the way in which habitat could be improved and how the change would affect salmon. For example, in a stream reach where riparian habitat quality is the primary limiting factor, an objective might be to "Increase juvenile survival by improving riparian habitat." Action classes would state how that could be accomplished—in this case, "Riparian Restoration."

The action classes are drawn from the habitat action library. The library describes classes of restoration actions (for instance, "Riparian Restoration") and lists possible actions within each class (for instance, "Plant and manage native trees and shrubs as site conditions dictate to provide shade and/or bank stability").

Okanogan County is planning a series of workshops to discuss current drafts of the matrices, including possible actions, with stakeholders. Dates have not yet been set, so please contact us if you would like to participate!

Meeting Updates

Habitat Coordinating Committee

The Upper Columbia Habitat Coordinating Committee (HCC) met on March 10th and 17th to discuss technical issues that will inform the Upper Columbia Salmon Recovery Plan. The group is focusing on Section 5, the Strategy for Recovery. The strategy will address all four of the "Hs" that affect salmonid populations—habitat, harvest, hatcheries, and hydropower. Text on habitat actions—the part of the plan most directly relevant in the Methow and Okanogan subbasins—will not be included in the next draft of the plan, due for release at the end of this month. As noted above, Okanogan County is gathering information about local stakeholder preferences and landowner willingness, which will inform that part of the plan.

Advisory Committee

Okanogan County's Salmon Recovery Advisory Committee (AC) met on Thursday (March 17th) to identify salmon recovery actions that will be feasible in the Methow and Okanogan subbasins. Because restoration actions will be voluntary, it is important that the Salmon Recovery Plan focus on actions that local landowners will be willing to perform. AC members and landowners invited by the members reviewed and commented on habitat matrices (see "**Gathering information and opinions**" above) drafted for the two subbasins by the HCC. Those comments, along with those of other stakeholders and local project proponents, will be forwarded to the HCC for use in modeling the outcomes of salmon recovery actions and developing a recovery strategy.

The March issue of *Fish Lines* has been posted to the Okanogan County Water Resources website at:
http://okanogancounty.org/water/Documents%20on%20Site/7NewsletterFINAL030805.pdf

(The dateline reads "February"—the contents are new, though!)

The September, 2004 through February, 2005 issues of *Fish Lines* are also available on the website at:
http://okanogancounty.org/water/Salmon%20Recovery;%20community;%20outreach%20matierials;%20fish%20lines.htm

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- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County published the first issue of *Fish Lines* in September 2004; the publication will continue monthly through June 2005. The newsletter covers Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us. Past issues may be viewed on the Water Resources web site: www.okanogancounty.org/water
- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 14
April 15, 2005

REVISED deadline for comments on second draft of Salmon Recovery Plan

The deadline for comments on the second draft of the Upper Columbia Salmon Recovery Plan has been extended to **Wednesday, May 4th, at midnight**. The deadline has been extended because technical difficulties delayed distribution of the draft.

You will find a comment sheet on our web site, you can stop by and pick one up, or we will be happy to mail or fax you one. You may submit your comments in any format you wish, although we do encourage you to use the comment sheet, which will make it easier to correlate comments to the document and review and respond to all comments received.

Please submit your comments using one of the following methods:

1) Mailing Address: Sandy Cox
Okanogan County Water Resources
123 – 5th Ave N
Room 110
Okanogan, WA 98840

2) Email Address: scox@co.okanogan.wa.us

3) Fax Number: 509.422.7349

All Comments are due no later than 12:00 midnight on Wednesday, May 4th, 2005.

Meeting Updates

Okanogan County Salmon Recovery Planning Advisory Committee

The Salmon Recovery Advisory Committee (AC) convened for a special session on Wednesday, April 14th to discuss technical questions. Chuck Peven, consulting biologist for Okanogan County attended to present information in response to previous questions, answer new queries, and hear comments about the content of the Upper Columbia Salmon Recovery Plan.

The AC will meet again on Thursday, April 21st (the committee's regular meeting date) to discuss habitat action matrices, project inventories, and the second draft of the plan. All interested stakeholders are welcome to attend. The meeting will be held in the Okanogan County Commissioners' Hearing Room beginning at 6:30 PM. Please call if you would like more information about the Advisory Committee.

Reminder to AC members: please bring your comments on the project inventory to the April 21st meeting!

Habitat Coordinating Committee

The Upper Columbia Habitat Coordinating Committee (HCC) met on April 14th to discuss mapping, habitat restoration recommendations and criteria, modeling outcomes, recovery criteria, and plan completion tasks and assignments. The committee will meet again in May at the Douglas County PUD auditorium for (2) 2-day work sessions – May 12th & 13th and then again on May 18th & 19th. Please call our office for information about meeting times and locations. All interested stakeholders are welcome to attend HCC meetings.

The September, 2004 through March, 2005 issues of *Fish Lines* are also available on the website at:
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New postings on Okanogan County's web site
The second draft of the Upper Columbia Salmon Recovery Plan (including appendices A, B, and C) and the draft project inventory for the Methow Subbasin have been posted to Okanogan County's Water Resources web site. This link will take you to the Salmon Recovery pages: http://okanogancounty.org/water/Salmon%20Recovery.htm. Click on the "Draft Review Corner" link to reach the documents.

For more information:

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- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County published the first issue of *Fish Lines* in September 2004; the publication will continue monthly through June 2005. The newsletter covers Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us. Past issues may be viewed on the Water Resources web site: www.okanogancounty.org/water
- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

News and Meeting Information from Other Groups
7:00 PM Tuesday April 19 at Liberty Bell High School.

Gil Nyerges, creator of the famous "Nyerges Nymph" fly, will discuss the use of his famous flies on the Columbia Basin fishery. Discussion will focus on historical changes over the last decade.

Pat Herdt will also present a fly for use on lakes opening day.

For more information please contact Duncan Bronson, secty/MVFF by phone at 509 996-3218 or by email at bronson@methow.com

REGIONAL SALMON RECOVERY PLANNING
EMAIL UPDATE # 15
April 22, 2005

***Special meeting*: Okanogan County Salmon Recovery Planning Advisory Committee**

The Salmon Recovery Advisory Committee (AC) will convene for a special session on Wednesday, April 27th to:

- Continue working on draft language for the habitat section of the recovery plan (including habitat matrices)
- Discuss how the habitat action matrices and habitat actions library will be presented in the plan
- Discuss the second draft of the plan
- Review project inventories

The AC began working on draft language for the habitat section of the recovery plan at its regular meeting on April 21st (the committee's regular meeting date). Because there was not time to complete that work, or to address the other items on the evening's agenda, the group scheduled the special meeting for next week. Chuck Peven, consulting biologist for Okanogan County, will be at the meeting to work with stakeholders on draft language.

The meeting will be held in the Okanogan County Commissioners' Hearing Room beginning at 6:30 PM. All stakeholders are welcome. Please call if you would like more information about the Advisory Committee.

***Reminder*:** comments on the second draft of the Upper Columbia Salmon Recovery Plan are due by midnight on **Wednesday, May 4th**. Please call us at 422-7113 for information about commenting…or see the April 15th email update for details.

The April issue of Fish Lines has been posted to the Okanogan County Water Resources website at:
http://okanogancounty.org/water/Documents%20on%20Site/8NewsletterFINAL041205.pdf

The September, 2004 through March, 2005 issues of *Fish Lines* are also available on the website at:
http://okanogancounty.org/water/Salmon%20Recovery;%20community;%20outreach%20matierials;%20fish%20lines.htm

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New postings on Okanogan County's web site
The second draft of the Upper Columbia Salmon Recovery Plan (including appendices A, B, and C) and the draft project inventory for the Methow Subbasin have been posted to Okanogan County's Water Resources web site. This link will take you to the Salmon Recovery pages:

http://okanogancounty.org/water/Salmon%20Recovery.htm. Click on the "Draft Review Corner" link to reach the documents.

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water
- Read Okanogan County's Salmon Recovery newsletter, *Fish Lines*. Okanogan County published the first issue of *Fish Lines* in September 2004; the publication will continue monthly through June 2005. The newsletter covers Salmon Recovery Planning and related topics. To add your name to the mailing list for *Fish Lines*, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us. Past issues may be viewed on the Water Resources web site: www.okanogancounty.org/water
- If you would prefer not to be on our electronic mailing list, please reply to this email and request that your name be removed from the list.

OCSR Advisory Committee Meeting Schedule

Upper Columbia Regional Salmon Recovery
Okanogan County Regional Salmon Recovery Planning
Advisory Committee Meeting Schedule

(third Thursday of each month)

		Date		Location	Time
	2004				
1	September	09-22-04 (*)		Okanogan PUD Auditorium	6:30pm – 8:30pm
2	October	10-21-04		Twisp Forest Service Conference Rm	6:30pm – 8:30pm
3	November	11-18-04		Okanogan BOCC Hearing Room	6:30pm – 8:30pm
4	December	12-16-04		Twisp Forest Service Conference Rm	6:30pm – 8:30pm

(*) – This meeting has been deliberately scheduled on a Wednesday

	2005			
5	January	01-13-05	Okanogan BOCC Hearing Room	6:30pm – 8:30pm
6	February	02-17-05	Okanogan BOCC Hearing Room	6:30pm – 8:30pm
7	March	03-17-05	Okanogan BOCC Hearing Room	6:30pm – 8:30pm
8	April	04-13-05 (#)	Okanogan BOCC Hearing Room	6:30pm – 8:30pm
9		04-21-05	Okanogan BOCC Hearing Room	6:30pm – 8:30pm
10		04-27-05 (+)	Okanogan BOCC Hearing Room	6:30pm – 8:30pm
11	May	05-19-05	Okanogan BOCC Hearing Room	6:30pm – 8:30pm
12	June	06-16-05	Okanogan BOCC Hearing Room	6:30pm – 8:30pm

(#) – This meeting added so that the AC could meet with biologist, Chuck Peven
(+) – This meeting added to continue review of Section 5

Public Meetings for Quarterly Deliverable &/or Draft Reviews

Deliverables:

October	10-06-04	Okanogan BOCC Hearing Room	6:30pm – 8:30pm
October	10-07-04	Twisp Forest Service Conf Rm	6:30pm – 8:30pm

January - First Draft and Quarterly Deliverables:

January	01-12-05	Okanogan BOCC Hearing Room	6:30pm – 8:30pm
January	01-11-05	Methow Valley Sr Citizens Ctr., Twisp	6:30pm – 8:30pm

April - Second Draft:

April	04-06-05	Okanogan BOCC Hearing Room	6:30pm – 8:30pm
April	04-07-05	Methow Valley Sr Citizens Ctr., Twisp	6:30pm – 8:30pm

OCSR Advisory Committee Meeting Agendas

OKANOGAN COUNTY WATER RESOURCES

123 North 5th Avenue Room 110 Okanogan, WA 98840
Telephone (509) 422.7113 Facsimile (509) 422.7349
Email ocsr@co.okanogan.wa.us
Web site http://www.okanogancounty.org/water

REGIONAL SALMON RECOVERY PLANNING

ADVISORY COMMITTEE MEETING AGENDA

September 22, 2004

- Introductions
- Advisory Committee formation
    - Purpose
    - Composition (proposed)
    - Meeting schedule and logistics
    - Roles and responsibilities
- Public outreach plan
- October meeting
    - Agenda
    - What will happen between now and then
        - First quarter work products released: October 1st
        - Quarterly work-product review meetings: October 6th (Okanogan) and 7th (Twisp)
        - Habitat Coordinating Committee (HCC) and Public Involvement and Policy Coordinating Committee (PIPCC) meetings: October 14th (Wenatchee)
    - Meeting date and venue: 6:30 PM, October 21st, USFS Conference Room, Twisp

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REGIONAL SALMON RECOVERY PLANNING

ADVISORY COMMITTEE MEETING AGENDA

October 21, 2004

- Introductions
- Updates
    - Advisory Committee formation
    - Performance-based planning
    - Subbasin Planning response loop
- Comments on Sections 1-3
    - Effectiveness of comments
    - Comment process
    - Process for review of comments
    - AC member comments
- Habitat matrices
- November meeting
    - Agenda
    - Meeting date and venue: 6:30 PM, November 18th, Commissioners' Hearing Room, Okanogan

Handouts

- Upper Columbia Regional Salmon Recovery Plan: draft Table of Contents; first drafts of Sections 1-3; first draft of Appendix A
- Comment sheet
- October 4, 2004 email update #2
- September 17, 2004 email update #1
- Advisory Committee and public meeting schedule
- Fish Lines Newsletter, Volume 1, Issue 2
- DRAFT Okanogan Matrix for Steelhead and Spring Chinook
- Chuck Peven's Update given at October 14, 2004 HCC Meeting
- PowerPoint slides from 10/6 & 10/7
- BioAnalysts, Inc. fact sheet
- Tracy Hillman, BioAnalysts fact sheet

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REGIONAL SALMON RECOVERY PLANNING

ADVISORY COMMITTEE MEETING AGENDA

November 18, 2004

- Introductions
- Salmon Recovery Planning overview and update
- Comments on 30% draft (Sections 1-3)
    - Review comments received during Okanogan County's October comment period
    - Upper Columbia comment process; handling of comments received by Okanogan County
- Draft Habitat matrices
- Draft Action Library
- December meeting
    - Agenda
    - Meeting date and venue: 6:30 PM, December 16th, Twisp

Handouts

- Draft Sections 1.0, 2.0 and 3.0 of the regional salmon recovery plan
- Draft Actions Library and Effectiveness Rating Spreadsheets; HCC Summary Paper and Instructions
- Draft Habitat matrices
- Salmon Recovery in Washington State flyer
- Okanogan County Newsletter – Fish Lines
- Comments received (Farm Bureau, Thorn)

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REGIONAL SALMON RECOVERY PLANNING

ADVISORY COMMITTEE MEETING AGENDA

December 16, 2004

- Introductions
- Project timeline and process
    - Handling of comments on initial draft of Sections 1-3 and Appendix A
    - Master Planning Schedule
    - January release of First draft Upper Columbia Salmon Recovery Plan; comment process and schedule
    - Plan development overview—an explanation of the elements and processes being used to develop the Upper Columbia Salmon Recovery Plan
- Habitat Actions Library
- Update on Policy and Program Evaluation
- January meeting
    - Agenda
    - Meeting date and venue: 6:30 PM, January 20th, BCC Hearing Room, Okanogan

Handouts

- Master Planning Schedule
- Fact sheet: January draft
- UCSRB workshop agenda
- UCSRB mission statement
- Action library

Season's Greetings

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REGIONAL SALMON RECOVERY PLANNING

ADVISORY COMMITTEE MEETING AGENDA

January 13, 2005

- Introductions
- Overview of the January Draft Upper Columbia Regional Salmon Recovery Plan
- Habitat Actions Library
- February meeting
    - Agenda
    - Meeting date and venue: 6:30 PM, February 17, BOCC Hearing Room, Okanogan

Handouts

- January Draft Upper Columbia Regional Salmon Recovery Plan
- Habitat Actions Library
- *Wenatchee World* salmon recovery article

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REGIONAL SALMON RECOVERY PLANNING

ADVISORY COMMITTEE MEETING AGENDA

February 17, 2005

- Introductions
- Updates
    - Status of comments on the January Draft Upper Columbia Regional Salmon Recovery Plan
    - Habitat Action Library
    - HCC
    - April draft
- Policy issues
- March meeting
    - Agenda
    - Meeting date and venue: 6:30 PM, March 17, BOCC Hearing Room, Okanogan

Handouts

- Habitat Action Library
- Policy issues
- February Fish Lines Newsletter
- Email Update # 9

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REGIONAL SALMON RECOVERY PLANNING

ADVISORY COMMITTEE MEETING AGENDA

March 17, 2005

- Introductions
- Updates
  - Master Planning Schedule
  - UCSRB policy statement
  - Habitat Action Library
- Work session: Assessment Units prescriptions
- Homework: Project inventories
- April meeting
  - Agenda
  - Meeting date and venue: 6:30 PM, April 21, BOCC Hearing Room, Okanogan

Handouts

- Master Planning Schedule
- UCSRB policy statement
- Revised Habitat Action Library
- Habitat action matrices (Methow & Okanogan)
- Project inventories (Methow & Okanogan)
- March Fish Lines Newsletter

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REGIONAL SALMON RECOVERY PLANNING

ADVISORY COMMITTEE **SPECIAL*** MEETING AGENDA

April 13, 2005

** Special meeting to answer technical questions and provide an opportunity for discussion with Okanogan County's science consultant, Chuck Peven*

- Introductions
- Technical questions
  - Questions raised during the March 17th Advisory Committee meeting and April 6th and 7th quarterly review meetings
  - Other technical questions
- Questions about the second draft of the Upper Columbia Salmon Recovery Plan
- Questions about the habitat matrices—review of matrices and development of AU prescriptions
- Questions about the habitat actions library
- Regular April meeting
  - Agenda
    - Habitat matrices
    - Habitat actions library
    - Project inventories
    - Project timeline and next steps
  - Meeting date and venue: 6:30 PM, April 21, BOCC Hearing Room, Okanogan

Handouts

- Agenda
- Powerpoint presentation notes
- Chuck Peven's Resume
- 2nd Draft of UC Salmon Recovery Plan (for those who don't have copies already)

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REGIONAL SALMON RECOVERY PLANNING

ADVISORY COMMITTEE MEETING AGENDA

April 21, 2005

- Introductions
- Habitat action matrices and habitat actions library – review how these will be presented in the Plan (Chuck Peven)
- Draft language for the Habitat section of the plan (Chuck Peven)
- Discuss second draft of the Upper Columbia Salmon Recovery Plan
- Project inventories
- Project timeline and next steps
  - Post-June 30, 2005 process
- May meeting
  - Agenda
  - Meeting date and venue: 6:30 PM, May 19, BCC Hearing Room, Okanogan

Handouts

- Second draft of the Upper Columbia Salmon Recovery Plan
  (no changes from ones handed out in March)

- Project inventories—Methow and Okanogan
  (no changes from ones handed out in March)

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REGIONAL SALMON RECOVERY PLANNING
SPECIAL ADVISORY COMMITTEE MEETING AGENDA

April 27, 2005

- Introductions
- Continue to draft language for the Habitat section of the plan (Chuck Peven)
- As time permits:
  - Habitat action matrices and habitat actions library – review how these will be presented in the Plan (Chuck Peven)
  - Discuss second draft of the Upper Columbia Salmon Recovery Plan
  - Project inventories
  - Project timeline and next steps
    - Post-June 30, 2005 process
- May meeting
  - Agenda
  - Meeting date and venue: 6:30 PM, May 19, BCC Hearing Room, Okanogan

Handouts

- Second draft of the Upper Columbia Salmon Recovery Plan
  (no changes from ones handed out in March)
- Project inventories—Methow and Okanogan
  (no changes from ones handed out in March)

Sandy Cox - DATE CHANGE: For Additonal OCSR Advisory Committee Meeting

From: Sandy Cox
To: Cox, Sandy; Dagnon Pyper, Julie E; Danison, Kurt; Fisher, Chris; Gillespie, Jere; Goroch, John; Hajny, Darlene; Henneman, Chad; Johnson, Chris; Lawrence, Bonnie; Longanecker, Ralph; Nelson, Craig; Peven, Chuck; Strieby, Sandra; Towey, Bill
Date: 5/5/2005 2:02 PM
Subject: DATE CHANGE: For Additonal OCSR Advisory Committee Meeting

Good Afternoon Everyone!

To meet the needs of as many folks as possible (we inadvertently scheduled the original meeting on the night the Cattlemen's Association meets) we are changing the meeting date from Tuesday, May 10, 2005 to Wednesday, May 11, 2005 for this additional meeting.

Chuck Peven is available on Wednesday, May 11, 2005 so we have re-scheduled it for that day.

Location: Board of County Commissioners Hearing Room
Time: 6:30 - 8:30 PM

This meeting is a continuation of last week's discussion and review of the Draft Habitat Section 5.

Again, Thank you all for your time - your input into this review process is very valuable.

If you have any questions please do not hesitate to contact Julie or I.

Sandy Cox

Okanogan County
Office of Planning and Development
Water Resources Division

Physical and Mailing Address:
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Okanogan, WA 98840

Phone: (509) 422-7113
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Email: scox@co.okanogan.wa.us

Website: http://okanogancounty.org/water/

"Don't wait for the perfect opportunity.
Just take an opportunity and make it as perfect as you can."

OCSR - NOTICE: Salmon Recovery Advisory Committee Meeting 6/16/05 (A-C)

From: OCSR
To: OCSR - (A-C)
Date: 6/9/2005 4:46 PM
Subject: NOTICE: Salmon Recovery Advisory Committee Meeting 6/16/05 (A-C)

Good Afternoon,

This is a reminder that there will be a Salmon Recovery Advisory Committee Meeting held this month.

Date: Thursday, June 16, 2005
Time: 6:30 PM - 8:30 PM
Location: Board of County Commissioners' Hearing Room

Agenda:
Review documents in preparation for the July comment period
Discuss the final work product for the June 30, 2005 deadline

If you have any questions please let Julie or I know.

Thanks,

Special Interest Group Meeting Agendas

STATE OF WASHINGTON
GOVERNOR'S SALMON RECOVERY OFFICE
Natural Resources Building, PO Box 43135 ● Olympia, Washington 98504-3135 ● (360) 902-2216

Okanogan County Farm Bureau & GSRO Meeting

May 12, 2005
6:30 – 9:00 PM
Okanogan County PUD Auditorium, Okanogan

6:30 Welcome, Introductions, and Meeting Objectives

6:45 Opening Comments by Elected Officials

7:15 The Statewide Strategy for Salmon Recovery

7:45 The Upper Columbia Salmon Recovery Plan

- Timelines for review
- Implementation strategies
- How to better participate

8:30 Open Discussion

9:00 Adjourn

Handouts

- 04/05/05 Letter from Conrad C. Lautenbacher, Department of Commerce The Under Secretary of Commerce for Oceans and Atmosphere to Theodore R. Kulongoski, Governor of Oregon
- 05/10/05 Memo from Chris Drivdahl, Governor's Salmon Recovery Office to Regional Recovery Organizations regarding Draft Recovery Plans

OCSR Public Meeting Agendas

REGIONAL SALMON RECOVERY PLANNING in the UPPER COLUMBIA REGION

KICK-OFF MEETING AGENDA

September 15 (Okanogan) and 16 (Twisp), 2004

Your questions and comments are welcome any time during tonight's meeting. We have also scheduled time for questions and answers at the end of the agenda.

- INTRODUCTIONS
- INTRODUCTION TO REGIONAL SALMON RECOVERY PLANNING
    - What is regional salmon recovery planning?
    - Why is a regional salmon recovery plan needed?
    - Why is Okanogan County involved in regional salmon recovery planning?
    - Who is currently involved in regional salmon recovery planning?
    - Who is developing the plan and how is it being developed?
    - How does regional salmon recovery planning relate to other planning projects currently underway in Okanogan County?
        - Brief update on Subbasin Planning
        - Brief update on Watershed Planning
    - Timeline for the Upper Columbia Regional Salmon Recovery Plan
- WHAT WILL BE IN THE UPPER COLUMBIA REGIONAL SALMON RECOVERY PLAN
    - Main components of a regional salmon recovery plan
    - Overview of the DRAFT Table of Contents
    - How material from the Okanogan and Methow Subbasin Plans will be incorporated in the Upper Columbia Regional Salmon Recovery Plan
    - What other information sources will be used to develop the Upper Columbia Regional Salmon Recovery Plan
- PUBLIC PARTICIPATION
    - Overview of public involvement opportunities, communication plans, and information sources
    - Advisory Committee. First meeting: Wednesday, September 22nd
    - Quarterly document reviews. First meetings: Wednesday, October 6th (Okanogan) and Thursday October 7th (Twisp)
- QUESTIONS AND ANSWERS

For more information:

- Visit Okanogan County's Water Resources web site: www.okanogancounty.org/water
- Read Okanogan County's regional salmon recovery planning newsletter, *Fish Lines*. Okanogan County will publish *Fish Lines* monthly from September 2004 through June 2005. The newsletter will cover regional salmon recovery planning and related topics.
- Sign up to receive bi-weekly regional salmon recovery planning updates via email, starting this month and continuing through June

To add your name to the mailing list for *Fish Lines*, email updates, or both, please contact Okanogan County Water Resources: by phone at 509/422-7113; or by email at ocsr@co.okanogan.wa.us

OKANOGAN COUNTY WATER RESOURCES

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REGIONAL SALMON RECOVERY PLANNING

QUARTERLY WORK-PRODUCT REVIEW MEETING AGENDA

October 6 (Okanogan) and October 7 (Twisp), 2004

- Introductions
- Salmon Recovery Planning
  - Introduction to Salmon Recovery Planning
  - Salmon Recovery Planning process overview
  - Timeline for 2nd and 3rd quarterly reviews
    - A first draft of the Upper Columbia Regional Salmon Recovery Plan will be available for review in January, 2005. The 2nd quarterly work-product review meeting will be held in early January
    - A final draft of the Upper Columbia Regional Salmon Recovery Plan will be available for review in April, 2005. The 3rd quarterly work-product review meeting will be held in early April
- Introduction to Table of Contents
- Commenting on drafts of the Upper Columbia Regional Salmon Recovery Plan
- Getting information
  - Information about Salmon Recovery Planning can be found on the Okanogan County Water Resources web site, www.okanogancounty.org/water. Feel free to call if you have questions
  - First drafts of Sections 1-3 of the Upper Columbia Regional Salmon Recovery Plan are posted at http://okanogancounty.org/water/salmon%20recovery;%20draft%20review%20corner.htm. You may also call, email, or fax our office to request copies. All contact information is listed at the top of this page

Handouts

- Upper Columbia Regional Salmon Recovery Plan: draft Table of Contents; first drafts of Sections 1-3; first draft of Appendix A
- Comment sheet
- October 4, 2004 email update #2
- September 17, 2004 email update #1
- Advisory Committee and public meeting schedule
- Fish Lines Newsletter, Volume 1, Issue 2
- PowerPoint slides
- BioAnalysts, Inc. fact sheet
- Tracy Hillman, BioAnalysts fact sheet

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REGIONAL SALMON RECOVERY PLANNING

QUARTERLY WORK-PRODUCT REVIEW MEETING AGENDA

January 11 (Twisp) and January 12 (Okanogan), 2005

- Introductions
- Overview of the January Draft of the Upper Columbia Regional Salmon Recovery Plan
- Commenting on the January Draft of the Upper Columbia Regional Salmon Recovery Plan
    - How to comment
    - How comments will be addressed
- Next step
- Getting information
    - Information about Salmon Recovery Planning can be found on the Okanogan County Water Resources web site, www.okanogancounty.org/water. Feel free to call if you have questions
    - The January Draft of the Upper Columbia Regional Salmon Recovery Plan is posted at http://okanogancounty.org/water/salmon%20recovery;%20draft%20review%20corner.htm. You may also call, email, or fax our office to request copies. All contact information is listed at the top of this page

Handouts

- January Draft of the Upper Columbia Regional Salmon Recovery Plan
- Comment sheet

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REGIONAL SALMON RECOVERY PLANNING
QUARTERLY WORK-PRODUCT REVIEW MEETING AGENDA

April 6 (Okanogan) and April 7 (Twisp), 2005

- Introductions
- Overview of the Second Draft of the Upper Columbia Regional Salmon Recovery Plan
- Commenting on the Second Draft of the Upper Columbia Regional Salmon Recovery Plan
    - How to comment
    - How comments will be addressed
- Next steps
- Getting information
    - Information about Salmon Recovery Planning can be found on the Okanogan County Water Resources web site, www.okanogancounty.org/water. Feel free to call if you have questions
    - The January Draft of the Upper Columbia Regional Salmon Recovery Plan is posted at http://okanogancounty.org/water/salmon%20recovery;%20draft%20review%20corner.htm. You may also call, email, or fax our office to request copies. All contact information is listed at the top of this page

Handouts

- Second Draft of the Upper Columbia Regional Salmon Recovery Plan
- Comment sheet

Distribution Lists

Email

US Postal Service

Okanogan County Public Outreach Email List September 2003 through June 2005 (1 of 5)

	Organization	Title	First Name	Last Name	City	State
1	WA State DOE - Watershed/Salmon Recovery	Mr.	Neil	Aaland	Olympia	WA
2	Okanogan Conservation District	Mr	Bob	Anderson	Okanogan	WA
3	Canoe/Kayaking	Mr.	Jim	Anderson	Okanogan	WA
4	WDFW	Ms.	Carmen	Andonaegui	Chelan	WA
5	Washington State House of Representatives	Repre	Mike	Armstrong	Wenatchee	WA
6		Mr.	John	Arterburn	Omak	WA
7	UCRFEG	Mr.	Arnold	Asmussen		
8	WA State Dept. Fish &Wildlife - Fish Biologist	Mr.	Casey	Baldwin	Spokane	WA
9	NOAA	Mr.	Dale	Bambrick	Ellensburg	WA
10		Mr.	Mark	Bareither		
11	WA State Dept. Fish & Wildlife	Ms.	Heather	Bartlett	Olympia	WA
12		Ms.	Kathleen	Bartu		
13	Oregon State University	Dr.	Peter	Bayley		OR
14	Dregate	Mr.	Philip	Bedard	Omak	WA
15	WA State Dept. Fish &Wildlife	Mr	Dennis	Beich	Ephrata	WA
16	Laura Berg Consulting	Ms.	Laura	Berg	Portland	OR
17	Okanogan Wilderness League	Mr.	Lee	Bernheisel	Carlton	WA
18	Douglas County PUD		Shane	Bickford		
19	Methow Conservancy	Ms.	Katharine	Bill	Winthrop	WA
20	City of Entiat	Mr.	Wendell	Black		
21		Mr.	Bob	Blank	Okanogan	WA
22	Department of Ecology		Gale	Blomstrom	Olympia	WA
23	Benton County	Mr.	Leo	Bowman	Prosser	WA
24	Coalition of Wenatchee River Cities	Ms.	Linda	Boyd		WA
25		Mr.	George	Brady	Pateros	WA
26	City of Oroville	Mr.	Chris	Branch	Oroville	WA
27	City of Tonasket	Mr.	Chris	Branch		WA
28	Lower Columbia Fish Recovery board	Mr.	Jeff	Breckel		
29	Office of Senator Maria Cantwell	Mr.	Clark	Brunkow-Mather	Richland	WA
30		Mr.	Tom	Buckley		
31		Mr. &	Craig & Claire	Bunney	Winthrop	WA
32	Board of Directors	Ms.	Sammi	Buzzard	Okanogan	WA
33	Shady Pines Resort		Steve & Dena	Byl	Conconully	WA
34	Washington Department of Fish and Wildlife Commission Chair	Mr.	Russ	Cahill	Olympia	WA
35	U. S. Senate	Sen.	Maria	Cantwell	Washington	DC
36	NPCC (NW Power & Conserv Council, West)	Mr.	Larry	Cassidy, Jr.	Vancouver	WA
37	US Fish & Wildlife Service-Fishery Resource Office	Mr.	Brian	Cates	Leavenworth	WA
38			Patti	Charles		
39		Mr.	Chris	Charters	Twisp	WA
40	Okanogan County Parks & Recreation Board	Mr.	Carl	Christiansen	Okanogan	WA
41	Okanogan Natural Resource Conservation District	Mr.	Bob	Clark	Okanogan	WA
42	Okanogan Natural Resource Conservation District	Ms.	Laura	Clark	Okanogan	WA
43	Colville Confederated Tribes - Planning	Ms.	Mary Beth	Clark	Nespelem	WA
44	Public Utility District, Douglas County	Mr.	Bob	Clubb	East Wenatchee	WA
45	Upper Columbia Regional Fisheries Enhancement Group	Ms.	Daphne	Cockle	Oroville	WA
46		Ms	Carol	Coleman	Tonasket	WA
47	Washington State House of Representatives	Rep	Cary	Condotta	Olympia	WA
48	Chelan-Douglas Land Trust	Mr.	Gordon	Congdon	Wenatchee	WA
49	WDFW Omak Hatchery	Mr.	Mark	Cookson	Omak	WA
50	NMFS	Mr.	Tom	Cooney		OR
51		Ms.	Carol	Cowling		
52		Ms.	Lisa	Croft		
53		Ms.	Rocklynn	Culp	Twisp	WA
54	WA State Dept. Fish &Wildlife	Ms.	Judy	dela Vergne	Wenatchee	WA

Okanogan County Public Outreach Email List September 2003 through June 2005 (2 of 5)

	Organization	Title	First Name	Last Name	City	State
55		Mr.	Steve	Devin	Winthrop	WA
56		Mr.	Rocky	DeVon	Oroville	WA
57	Douglas County PUD	Mr.	Bill	Dobbins	East Wenatchee	WA
58	Governor's Salmon Recovery Office	Ms.	Chris	Drivdahl	Olympia	WA
59	US Fish & Wildlife Service	Mr.	Charles	Dunn	Portland	OR
60	Grant County PUD	Mr.	Dave	Duvall		
61		Mr.	David	Ebenger	Winthrop	WA
62	Inter-Agency Commission	Ms.	Laura	Eckert-Johnson	Olympia	WA
63		Ms.	Shari	Erickson		
64	Washington State Senate	Senat	Linda	Evans Parlette	Wenatchee	WA
65		Mr.	Bob	Fateley	Brewster	WA
66	Okanogan Communities Development Council	Mr.	Mike	Ferris	Carlton	WA
67		Mr.	Ollie	Flor	Twisp	WA
68	National Marine Fisheries Service, SFD	Mr.	Bob	Foster	Lacey	WA
69	Salmon Recovery Funding Board	Mr.	Jim	Fox	Olympia	WA
70		Mr.	Ron	Fox		WA
71		Ms.	Lorie	Fundingslund		
72	NOAA Fisheries	Ms.	Elizabeth	Gaar		OR
73	US Fish & Wildlife Service	Ms.	Amy	Gaskill	Portland	OR
74		Mr.	Rollie	Geppert		
75	Washington Cattlemen's Association		Dan & Jane	Gerth	Oroville	WA
76	Shuswap Nation Fisheries Commission	Mr.	Aaron	Gillespie	Kamloops	BC
77		Ms.	Jere	Gillespie	Okanogan	WA
78	BioAnalysts, Inc.	Mr.	Albert	Giorgi	Redmond	WA
79		Mr.	Dave	Goetz	Okanogan	WA
80		Mr,	John	Goroch	Okanogan	WA
81	NOAA Fisheries Upper Columbia Basin	Mr.	Mike	Grady	Seattle	WA
82		Mr.	Tony	Grover		OR
83		Mr.	Phil	Gum	Okanogan	WA
84	Okanogan Farm Bureau		Jim & Darlene	Hajny	Okanogan	WA
85		Mr.	Greg	Hamilton	Okanogan	WA
86		Mr.	Barry	Hansen	Omak	WA
87		Ms.	Richelle	Harding		OR
88		Ms.	Jimmie	Harter	Riverside	WA
89	U.S. Forest Service	Ms.	Margaret	Hartzell		
90	Washington Congressman	Congr	Doc	Hastings	Pasco	WA
91	NOAA	Mr.	Lynn	Hatcher		WA
92	Chelan County	Mr.	Buell	Hawkins	Wenatchee	WA
93	Douglas County PUD	Mr.	Lynn	Heminger	East Wenatchee	WA
94		Mr.	Chad	Henneman	Tonasket	WA
95		Ms.	Diane	Hodgson		WA
96		Mr.	Glen	Hoffman		WA
97			Stacy	Horton		WA
98		Mr.	Charlie	Hosken		WA
99		Ms.	Bonnie	House	Brewster	WA
100		Mr.	Bud	Hover	Winthrop	WA
101		Ms.	Gail	Howe	Pateros	WA
102	Okanogan County Historical Society, VP	Mr.	Don	Hruska	Omak	WA
103	City of Leavenworth	Mr.	Scott	Hugill	Leavenworth	WA
104	Bonneville Power Administration	Mr.	Jim	Irish		
105	WA State Dept. Fish &Wildlife	Ms.	Connie	Iten	Omak	WA
106	Columbia Basin Fish and Wildlife Authority	Mr.	Tom	Iverson	Portland	OR
107		Mr.	Paul	James		WA
108	Asotin County Conservation District	Mr.	Brad	Johnson	Clarkston	WA
109		Mr.	Chris	Johnson	Okanogan	WA
110	Desautel-Hege	Ms.	Sara	Johnston	Spokane	WA

	Organization	Title	First Name	Last Name	City	State
111	Port of Chelan County	Mr.	Ron	Rodriguez	Wenatchee	WA
112			Chris	Jordan		
113	NPCC (NW Power & Conserv Council, East)	Mr.	Tom	Karier	Spokane	WA
114		Mr.	Rick	Karro	Winthrop	WA
115		Mr.	Charles	Keeton		WA
116		Ms.	Jennice	Kelly		
117	Bureau of Land Management - Wenatchee Resource Area	Mr.	Joe	Kelly	Wenatchee	WA
118		Ms.	Patti	Kelly	Okanogan	WA
119		Mr.	Ralph	Kiona	Twisp	WA
120		Mr.	Dave	Kleigman	Tonasket	WA
121	U. S. Bureau of Reclamation	Mr.	Greg	Knott	Twisp	WA
122	Bureau of Reclamation	Mr.	Steve	Kolk	Wenatchee	WA
123		Mr.	Hank	Konrad	Twisp	WA
124	Partnership for a Sustainable Methow	Ms	Sue	Koptonak	Twisp	WA
125		Mr.	Jim	Kramer		
126	Okanogan County Farm Bureau	Mr.	Joel	Kretz	Wauconda	WA
127	City of Leavenworth	Ms.	Connie	Krueger	Leavenworth	WA
128	RTT	Mr.	Joe	Lange		
129	State of Washington Office of Trade and Economic Development	Mr.	Terry	Lawhead	Spokane	WA
130	OC3 (Okanogan Council Citizen's Coalition)	Ms.	Bonnie	Lawrence	Omak	WA
131	Okanogan Resource Council	Ms.	Bonnie	Lawrence	Omak	WA
132		Mr.	Ed	Lawrence	Tonasket	WA
133	Congressmen Nethercut's Office	Ms.	Cathy	Lebret	Colville	WA
134	Omak Chamber of Commerce	Ms.	Linda	Lewis	Omak	WA
135	WA State Dept. Fish &Wildlife	Ms	Tracy	Lloyd	Ephrata	WA
136	Okanogan Conservation District, Pest Board	Mr.	Ralph	Longanecker	Tonasket	WA
137		Ms.	Nancy	Lopez		
138	Okanogan Nation Fisheries Commission	Mr.	Byron	Louis	Westbank	BC
139		Mr.	Jay	Lucas	Winthrop	WA
140	Colville Confederated Tribes - Fish & Wildlife - Salmon Creek	Ms.	Hilary	Lyman	Winthrop	WA
141		Ms.	Kristi	Lynette		
142	DCWPA - Douglas County Watershed Planning Association - DCWPU	Ms.	Marilynn	Lynn		
143	Okanogan-Wenatchee National Forest	Mr.	Kenneth	MacDonald		WA
144	Okanagan Nation Fisheries Commission	Ms.	Deana	Machin	Westbank	BC
145	Colville Confederated Tribes - Fish & Wildlife	Mr.	Jerry	Marco	Nespelem	WA
146	Snake River Salmon Recovery Board	Mr.	Steve	Martin	Dayton	WA
147		Mr.	Michael "Buffalo"	Mazzetti	Tonasket	WA
148	Senator Patty Murray's Office	Ms.	Mary	McBride	Yakima	WA
149		Ms.	Cindy	McCartney		
150	IAC	Ms.	Barb	McIntosh	Olympia	WA
151	Washington State House of Representatives	Repre	Cathy	McMorris	Colville	WA
152	Northwest Power & Conservation Council	Ms.	Raven	McShane		
153				Methow Conservanc	Winthrop	WA
154	Foster Creek Conservation District	Mr.	Allen	Miller	Mansfield	WA
155	Oroville Chamber of Commerce	Mr.	Richard	Milligan	Oroville	WA
156	Forest Service: MVRD Fisheries Biologist	Ms.	Jennifer	Molesworth	Winthrop	WA
157	Washington Department of Ecology	Mr.	John	Monahan	Yakima	WA
158	Okanagan Nation Fisheries Commission	Mr.	Dave	Moore	Westbank	BC
159		Mr.	Jerry	Moore	Pateros	WA
160	Pacific Biodiversity Institute	Mr.	Peter	Morrison	Winthrop	WA
161	Washington State Senate	Sen.	Bob	Morton	Kettle Falls	WA
162		Mr.	Tom	Mumford		WA

	Organization	Title	First Name	Last Name	City	State
163	U. S. Senate	Sen.	Patty	Murray	Washington	DC
164				MVSTA	Winthrop	WA
165			Andrei	Mylroie		
166	LGL Limited Environmental Research	Mr.	Bryan	Nass	Ellensburg	WA
167	Okanogan Natural Resource Conservation District	Mr.	Craig	Nelson	Okanogan	WA
168		Mr.	Dennis	Nicholson		
169	Columbia River Inter-Tribal Fish Commission	Ms.	Lenora	Oftedahl	Portland	OR
170		Ms.	Lisi	Ott		
171	IAC / SRFB	Ms.	Tammy	Owings		
172	NWPCC	Ms.	Lynn	Palensky	Portland	OR
173		Ms.	Lisa	Parks		
174	Colville Confederated Tribes - Environmental	Mr.	Gary	Passmore	Nespelem	WA
175		Mr.	Randy	Pauli		
176		Ms.	Carolyn	Pearson	Pateros	WA
177	Washington Water Trust	Ms.	Lisa	Pelly	Seattle	WA
178	Colville Confederated Tribes - Fish & Wildlife Director	Mr.	Joe	Peone	Nespelem	WA
179		Mr.	Ron	Perrow	Winthrop	WA
180		Mr.	Pete	Peterson		
181	Chelan County Public Utility District	Mr.	Chuck	Peven		WA
182		Mr.	Brent	Phillips		BC
183		Ms.	Jennifer	Pratt		OR
184	Colville Confederated Tribes - Fish & Wildlife	Mr.	Jim	Priest	Nespelem	WA
185	The Nature Conservancy of Canada (Okanagan Program Manager)	Ms.	Barbara	Pryce	Penticton	BC
186		Ms.	Julie	Pyper	Okanogan	WA
187		Ms.	Marlene	Rawley	Omak	WA
188		Mr.	Michael	Rickel		
189		Mr.	Albert	Roberts	Omak	WA
190	The Performance Center	Mr.	Walt	Roberts	Portland	OR
191		Mr.	Bill	Ruckleshaus		
192	Fulton Ditch	Mr.	Dave	Sabold	Winthrop	WA
193	Chelan County PUD	Mr.	Rob	Salter		
194	Chelan County Natural Resource Program	Ms.	Mary Jo	Sanborn	Wenatchee	WA
195	Program	Mr.	Bruce	Schmidt	Gladstone	OR
196	WWPU WQS TMDL	Mr.	Dave	Schneider		
197	Okanogan County	Mr.	Dave	Schulz	Okanogan	WA
198	Upper Columbia Salmon Recovery Board	Ms.	Theresa	Scott	Olympia	WA
199	Chelan County PUD, Director of Fish & Wildlife		Shaun	Seaman	Wenatchee	WA
200		Mr.	Chad	Short	Omak	WA
201	Aid to Congressman Nethercut	Ms.	Shelly	Short	Colville	WA
202	Colville Confederated Tribes - Culture	Mr.	John	Sirois	Nespelem	WA
203	Omak Mayor	Mr.	Dale	Sparber	Omak	WA
204	Ziji Creative Resources Inc.	Ms.	Alison	Squier	Boise	ID
205	Grant County PUD	Ms.	Kristin	Stallard	Ephrata	WA
206	Washington Department of Fish & Wildlife	Mr.	Bob	Steele		WA
207		Ms.	Robin	Stice	Oroville	WA
208	Washington Department of Ecology	Mr.	John	Stormon	Twisp	WA
209	Inland Northwest Land Trust	Ms.	Stacey	Stovall	Leclede	ID
210		Mr.	William	Stroud		
211	Okanogan Irrigation District	Mr.	Tom	Sullivan	Okanogan	WA
212	Washington State House of Representatives	Repre	Bob	Sump	Republic	WA
213	Okanogan Valley Land Trust	Mr.	Dale	Swedberg	Oroville	WA
214		Ms.	Melody	Tereski		
215	U. S. Fish and Wildlife - Fisheries Resources	Ms.	Kate	Terrell	Leavenworth	WA
216		Mr.	Bob	Tollefson	Omak	WA

	Organization	Title	First Name	Last Name	City	State
217		Mr.	Bill	Towey		
218		Mr.	Phil	Trask		
219	Washington Department of Fish and Wildlife	Mr.	Bill	Tweit	Olympia	WA
220	Quad City Herald	Mr.	Ike	Vallance	Brewster	WA
221		Mr.	Patrick	Verhey		
222		Mr.	Richard	Visser		WA
223		Mr.	Gary	Wade		
224	Watershed Planning Unit	Ms.	Sarah	Walker	Wenatchee	WA
225	WA State DOE - Watershed/Salmon Recovery	Mr.	Dick	Wallace	Olympia	WA
226		Mr.	Mike	Ward		
227	Okanogan County PUD	Mr.	Harlan	Warner	Okanogan	WA
228	The Nature Conservancy	Ms.	Nancy	Warner	Wenatchee	WA
229		Ms.	Mary	Washkoske		
230		Ms.	Lorah	Waters		
231	Okanogan County Public Health District	Mr.	Paul	Waterstrat	Okanogan	WA
232	Pacific Northwest Trail Alliance	Mr.	Jim	Weed	Omak	WA
233	Friends of the Trees Society		Ed & Vicky	Welch	Twisp	WA
234	Forest Service: Tonasket Fisheries Biologist	Ms.	Nance	Wells	Tonasket	WA
235	Okanogan and Wenatchee National Forest	Ms.	Karin	Whitehall		WA
236	Okanogan County Planning Department	Mr.	Greg	Wilder	Okanogan	WA
237		Ms.	Debra	Wilhelmi		WA
238	Wenatchee Valley Transportation Council	Mr.	Jeff	Wilkens	Wenatchee	WA
239	Colville Confederated Tribes	Mr.	Keith	Wolf	Duvall	WA
240	Kettle Range Conservation Group	Mr.	George	Wooten	Twisp	WA
241	Chelan County PUD		Tracy	Yount		
242	Canaan Ranch				Tonasket	WA
243	KMBI Radio				Spokane	WA
244	North Cascades Broadcasting (KZBE,KOMW,KNCW Radio)				Omak	WA
245	KPBX Radio KPBX Spokane Public Radio				Spokane	WA
246	Wenatchee World				Wenatchee	WA
247	Okanogan Chamber of Commerce				Okanogan	WA
248	Omak Chronicle				Omak	WA
249	Omak Visitor Information Center				Omak	WA
250	Oroville Visitor Information Center				Oroville	WA

Okanogan County Public Outreach USPS Mailing List September 2003 through June 2005

	Organization	Title	First Name	Last Name	City	State
1	High School Rodeo, Secretary	Ms.	Debbie	Achord	Grand Coulee	WA
2	Grand Coulee Dam Area Chamber of Commerce	Mr.	Tim	Ailing	Grand Coulee	WA
3	Conconully Mayor	Mr.	Chuck	Alexander	Conconully	WA
4	Friends of the Stampede		Chuck & Barb	Alexander	Conconully	WA
5	Butte Busters Snowmobile Club	Mr.	Gary	Allard	Omak	WA
6	Friends of the Stampede	Mr.	Gene	Allen	Omak	WA
7	ORNAC		Lou	Anderson	Omak	WA
8	Washington State House of Representatives	Rep	Mike	Armstrong	Olympia	WA
9	Associate Board Member		Arron Wendy Jim	Hensarling	Okanogan	WA
10	Chelan Chamber of Commerce	Mr	Emmit	Aston	Chelan	WA
11	Board of Directors		Mike & Sandy	Baker	Omak	WA
12		Mr.	Rick	Baker	Tonasket	WA
13	Board of Directors	Mr.	Lee	Barker	Omak	WA
14	Whitestone Reclamation District	Mr	Jerry	Barnes	Loomis	WA
15	Associate Board Member		Jack & Karmen	Beeman	Loomis	WA
16	Associate Board Member	Ms.	Shauna	Beeman	Moses Lake	WA
17	Forest Service: Okanogan-Wenatchee SO	Mr.	Mel	Bennett	Okanogan	WA
18	Border Knights		Don & Pam	Bensing	Tonasket	WA
19	Associate Board Member		Dan & Cindy	Berg	Omak	WA
20	Okanogan County Snowmobile Advisory Committee	Mr.	Joe	Berney	Okanogan	WA
21	Okanogan County PUD	Mr.	Chuck	Berrie	Okanogan	WA
22	Friends of the Stampede		Tom & Shirley	Berschauer	Omak	WA
23	ORNAC - Board of Directors ORNAC	Ms.	Theresa	Best	Omak	WA
24	Friends of the Stampede		Kim	Bird	Okanogan	WA
25	Okanogan Mayor	Mr.	Micheal	Blake	Okanogan	WA
26	Agriculture	Mr.	Craig	Boesel	Winthrop	WA
27	Okanogan Valley Co-ed/Women's Leagues	Ms.	Shirley	Bowden	Okanogan	WA
28	Pateros Chamber of Commerce	Ms.	Brenda	Brady	Pateros	WA
29	Associate Board Member		Doug & Kitty	Bramer	Okanogan	WA
30	Okanogan County Artists Association	Ms.	Marylou	Bratner	Omak	WA
31	Conservation	Mr.	Duncan	Bronson	Twisp	WA
32	Okanogan Grange	Mr.	Howard	Burnett	Okanogan	WA
33	Okanogan County Artists Association	Ms.	Laverne	Bussler	Omak	WA
34	Eastern WA Pony Assoc.	Ms.	Pat	Byrd	Okanogan	WA
35	Tonasket Mayor	Mr.	David	Caddy, Sr.	Tonasket	WA
36	Okanogan Kiwanis Club	Ms.	Dee	Camp	Okanogan	WA
37	Okanogan County Artists Association	Ms.	Cecelia	Campbell	Twisp	WA
38	Okanogan County Artists Association	Ms.	Aileen	Carlton	Conconully	WA
39	Okanogan County Artists Association	Ms.	Emily	Carlton	Omak	WA
40	Classic Cruisers of Omak	Ms.	Nancy	Carlton	Omak	WA
41	Conconully Lake Resort			Carpenter	Conconully	WA
42	Honorary Board Member	Mr.	Homer	Carter	Omak	WA
43	Recreation	Mr.	Dick	Caryl	Omak	WA
44	Tonasket Chamber of Commerce	Ms.	Helen	Casey	Tonasket	WA
45	Okanogan County Artists Association	Ms.	Beverly	Chorey	Tonasket	WA
46	Recreation	Ms.	Paula	Christen	Winthrop	WA
47	Agriculture	Ms.	Karla	Christiansen	Twisp	WA
48	Local government	Mr.	Lee	Church	Conconully	WA
49	Omak City Council, Chairman	Mr.	Steve	Clark	Omak	WA
50	Washington Rural Electric Association	Mr	Dave	Clinton	Olympia	WA
51	Washington State House of Representatives	Repre	Cary	Condotta	Wenatchee	WA
52	Associate Board Member		George & Julie	Conkle	Omak	WA
53	Agriculture	Mr.	Andre'	Corso	Tonasket	WA

	Organization	Title	First Name	Last Name	City	State
54	Tonasket Youth Baseball (President)	Mr.	Tom	Cory	Tonasket	WA
55	Okanogan County Artists Association	Ms.	Carol	Cranfill	Omak	WA
56	Twisp Valley Grange	Ms.	Nancy	Dammann	Twisp	WA
57	Desert Drifters Motorcycle Club		J.D.	Davis	Omak	WA
58	Cariboo Trail Good Sams	Mr.	Keith	Davis	Okanogan	WA
59		Mr.	Nathan	Davis	Okanogan	WA
60	Davis Shows Northwest		Pat & Geraldine	Davis	Clackamas	OR
61	Friends of the Stampede		Sonny	Day	Malott	WA
62	Business	Mr. &	Pete & Patty	DeLange	Winthrop	WA
63	Friends of the Stampede	Mrs.	Daniel	Dengel	Omak	WA
64	Friends of the Stampede	Ms.	Jessica	Dengel	Omak	WA
65	Malott Grange	Mr.	Dwain	Denton	Malott	WA
66			Steve & Kristin	Devin	Winthrop	WA
67	Brewster Chamber of Commerce	Mr	Bob	Dewey	Brewster	WA
68	Friends of the Stampede	Mr.	Vic	Didra	Tonasket	WA
69	Okanogan County Artists Association	Ms.	Virginia	Dietz	Omak	WA
70	Board of Directors		Rita	Dow	Riverside	WA
71	Okanogan County Artists Association	Ms.	Becca	Downery	Okanogan	WA
72	Associate Board Member	Ms.	Carol	Downey	Omak	WA
73	Okanogan Senior Babe Ruth	Mr.	Rick	Duck	Omak	WA
74	Board of Directors	Mr.	George	Dunckel	Omak	WA
75	Board of Directors		Brian & Rebekka	Ellis	Omak	WA
76	Recreation	Ms.	Jan	Erickson	Winthrop	WA
77	Washington State Senate	Senat	Linda	Evans-Parlette	Olympia	WA
78	Friends of the Stampede	Mr.	Chuck	Everts	Riverside	WA
79	Local government	Mr.	John	Fabrizi	Bridgeport	WA
80	Associate Board Member	Mr.	Barry	Featherly	Malott	WA
81	Okanogan Valley Bass Club	Mr.	Otis	Femling	Omak	WA
82	Okanogan County Parks & Recreation Board	Mr.	Rich	Fewkes	Tonasket	WA
83	Okanogan County Artists Association	Ms.	Angela	Field	Oroville	WA
84	Okanogan County Artists Association	Ms.	Barbara	Forester	Oroville	WA
85	Omak City Council	Mr.	Michael	Foth	Omak	WA
86	Okanogan County Artists Association	Ms.	Jean	Fry	Omak	WA
87	Futsal/North Central Youth Soccer		Bill & Cindy	Gagne	Omak	WA
88	Associate Board Member		Phil & Millie	Gann	Omak	WA
89	Friends of the Stampede	Mr.	Rudy	Gates	Omak	WA
90	Agriculture	Mr.	Dan	Gebber	Brewster	WA
91	Agriculture	Mr.	Mac	Gebber	Brewster	WA
92	Friends of the Stampede	Mr.	John	Gelvin	Okanogan	WA
93	Conservation	Ms.	Jane	Gilbertsen		
94	Associate Board Member		Jim & Janie	Glover	Omak	WA
95	Agriculture	Mr.	Peter	Goldmark	Okanogan	WA
96	Brewster Kiwanis Club	Ms.	Doris	Goodell	Brewster	WA
97	Omak Swim Team	Ms.	Kim	Grattan	Okanogan	WA
98	Okanogan County Artists Association	Ms.	Lorraine	Green	Omak	WA
99	Okanogan County Artists Association	Ms.	Patricia	Green	Tonasket	WA
100	Winthrop Kiwanis	Mr	Bob	Grinstead	Winthrop	WA
101	Associate Board Member	Ms.	Sarah	Groomes	Okanogan	WA
102	Board of Directors		Scott & Quinta	Haeberle	Omak	WA
103	Brewster Grange	Ms.	Marge	Hagy	Brewster	WA
104	Farm Bureau		Jim & Darlene	Hajny	Okanogan	WA
105	Hamilton Farm Equipment Center, Inc.	Mr.	Greg	Hamilton	Okanogan	WA
106	Methow Valley News	Editor	John	Hanron	Twisp	WA
107	Friends of the Stampede	Ms.	Leda	Harlan	Okanogan	WA

	Organization	Title	First Name	Last Name	City	State
108	Washington Congressman	Congr	Doc	Hastings	Washington	DC
109	Rodeo Timer		Nell	Henderson	Tonasket	WA
110	Friends of the Stampede	Ms.	Mary	Henrie	Omak	WA
111	Associate Board Member	Ms.	Diana	Hersey	Omak	WA
112	Associate Board Member		Jim & Donna	Hersey	Omak	WA
113	Okanogan County Artists Association	Mr.	Mason	Hess	Tonasket	WA
114	Okanogan Valley Men's Softball League	Mr.	John	Hilts		WA
115	Okanogan County Artists Association	Ms.	Esther	Hinger	Brewster	WA
116	Okanogan County Artists Association	Ms.	Dorothy	Hix	Brewster	WA
117	Board of Directors	Ms.	Billie	Holden	Omak	WA
118	Tonasket Kiwanis Club	Ms	Becky	Holloway	Tonasket	WA
119	Brewster Mayor	Ms.	Bonnie	House	Brewster	WA
120		Mr	Bud	Hover	Winthrop	WA
121	Pateros Mayor	Ms.	Gail	Howe	Pateros	WA
122	Okanogan County Artists Association	Ms.	Doris	Hubbard	Okanogan	WA
123	Contractor	Mr.	Scott	Hughes	Riverside	WA
124	Okanogan Valley Cutter Association	Ms.	Verlene	Hughes	Twisp	WA
125	Unlimited Riding of Okanogan County	Ms.	Carey	Hunter	Omak	WA
126	Board of Directors	Ms.	Margie	Hutchinson	Okanogan	WA
127	Methow Valley Snowmobile Association	Ms.	Estelle	Imes	Winthrop	WA
128	Associate Board Member		Chick & Sindy	Jackson	Nespelem	WA
129	Bridgeport Mayor	Mr.	Steve	Jenkins	Bridgeport	WA
130	North Central Horsebreeders Association		Rita & Lacey	Jensen	Tonasket	WA
131	Jensen Sound	Mr.	Jerry	Jenson	Moses Lake	WA
132	Okanogan County Parks & Recreation Board	Mr.	John	Johnson	Okanogan	WA
133	Omak Park Board	Mr.	Loren	Johnston	Omak	WA
134	Okanogan County Artists Association	Ms.	Gloria	Jones	Tonasket	WA
135	Okanogan County Artists Association	Ms.	LaWanda	Jones	Okanogan	WA
136	Twisp Mayor	Ms.	Rose	Jones	Twisp	WA
137	Agriculture	Mr.	Maurice	Joy	Okanogan	WA
138	Associate Board Member	Mr.	Galen	Kaemingk	Omak	WA
139	Associate Board Member		Bob & Judy	Kawahara	Omak	WA
140	NRCS (National Resource Conservation Service)	Mr.	Randy	Kelley	Okanogan	WA
141	Agriculture	Mr.	Les	Kenney	Tonasket	WA
142	Okanogan County Artists Association	Ms.	Kitty	Kibbe	Omak	WA
143	Okanogan Wildlife Council	Mr.	Brian	Kirchner	Okanogan	WA
144	Okanogan County Artists Association	Ms.	Hedy	Kleemeier	Okanogan	WA
145	Economic Alliance	Mr.	Terry	Knapton	Omak	WA
146	Honorary Board Member	Ms.	Marj	Knowlton	Omak	WA
147	ORNAC - Board of Directors Project Museum		Cory	Lambson	Omak	WA
148	Friends of the Stampede	Mr.	Mark	Landa	Omak	WA
149	Winthrop Mayor	Ms.	Sue	Langdalen	Winthrop	WA
150	Okanogan County Artists Association	Ms.	Sandra	Leavell	Tonasket	WA
151	Omak City Council	Ms.	Leanne	Leifer	Omak	WA
152	Okanogan County Cattlemen's Association	Mr.	Gary	Lesamiz	Okanogan	WA
153	Nespelem Mayor	Ms.	Colleen	Leskinen	Nespelem	WA
154	Okanogan County Artists Association	Ms.	Pamela	Leslie	Oroville	WA
155	Honorary Board Member		Jim & Linda	Lewis	Omak	WA
156	Associate Board Member	Ms.	Mellissa	Louis	Omak	WA
157	Methow Valley Sport Trails Association	Mr.	Jay	Lucas	Winthrop	WA
158	Okanogan County Artists Association	Ms.	Doris	Mack	Winthrop	WA
159	Loup Loup Ski Education Foundation	Mr.	Ron	Mackie	Omak	WA
160	Board of Directors	Mr.	George	Marchand	Omak	WA
161	Conservation	Mr.	Brad	Martin	Winthrop	WA
162	Okanogan County Strutters	Mr.	George	Martin	Okanogan	WA

	Organization	Title	First Name	Last Name	City	State
163	Okanogan Highlands Alliance	Mr	Michael "Buffalo"	Mazzetti	Tonasket	WA
164	Soft Stock Rodeo Company	Mr.	Dave	McClure	Nespelem	WA
165	Okanogan County Parks & Recreation	Mr.	Murray	McCory	Okanogan	WA
166	Okanogan County Parks & Recreation Board	Mr.	James	McCuen	Okanogan	WA
167	Okanogan County Public Works Department	Mr.	Robert	McGaughey	Okanogan	WA
168	Okanogan County Artists Association	Ms.	Clovera	McLean	Conconully	WA
169	Aeneas Lake Irrigation District	Mr.	Brian	McMillan	Tonasket	WA
170	Washington State House of Representatives	Rep	Cathy	McMorris	Olympia	WA
171				Methow Basin Planning Unit	Winthrop	WA
172	Omak City Council	Mr.	Kirby	Michael	Omak	WA
173	Friends of the Stampede	Mr.	Cody	Miller	Omak	WA
174	Friends of the Stampede	Mr.	Geoff	Miller	Omak	WA
175	Associate Board Member	Ms.	Panda	Miller	Omak	WA
176	Chewuch Ditch	Ms.	Roxie	Miller	Winthrop	WA
177	Friends of the Stampede	Ms.	Sophie	Miller	Omak	WA
178	Friends of the Stampede	Ms.	Vickie	Mills	Omak	WA
179	North Cascades Althletic Club	Mr.	Mark	Milner	Omak	WA
180	Okanogan Valley Wings		Joe & Teri	Mitschelen	Malott	WA
181	Okanogan County Parks & Recreation Board	Mr.	Steve	Mitzner	Okanogan	WA
182	Winthrop Chamber of Commerce	Mr.	Doug	Mohre	Winthrop	WA
183	Associate Board Member		Edie	Moomaw-Stevens	Omak	WA
184	Okanogan County Artists Association	Ms.	Mary	Moran	Oroville	WA
185	Okanogan County Extension Office	Ms.	Debbie	Morris	Okanogan	WA
186	Forest Service: Tonasket District Ranger	Mr.	Mark	Morrison	Tonasket	WA
187	Washington State Senate	Senat	Bob	Morton	Olympia	WA
188	Okanogan County Fly Fishing Club	Mr.	Paul	Moses	Okanogan	WA
189	Honorary Board Member	Mr.	Bob	Moyer	Omak	WA
190	The Fitness Zone	Ms.	c/o Cheryl	Mullen	Omak	WA
191	The Corner Shelf	Mr.	Gary	Mundinger	Omak	WA
192	Agriculture	Mr.	Dean	Neff	Pateros	WA
193	Omak Chamber of Commerce	Mr.	Dick	Neimeyer	Omak	WA
194	Okanogan Valley Backcountry Horsemen	Mr.	Bill	Nelson	Tonasket	WA
195	Riverside Mayor	Mr.	Kyle	Nelson	Riverside	WA
196	U. S. House of Representatives	Rep	George	Nethercutt	Spokane	WA
197	U. S. House of Representatives	Repre	George	Nethercutt	Washington	DC
198	Forest Service: MVRD Ranger District	Mr.	John	Newcom	Winthrop	WA
199		Mr.	Dean	Nichols	Omak	WA
200	Friends of the Stampede	Ms.	Krystal	Nissen	Omak	WA
201	Okanogan Valley Chapter - Back Country Horseman	Mr.	Frank	Oborne	Tonasket	WA
202	Okanogan County Artists Association	Ms.	Carol	O'Dell	Omak	WA
203	Associate Board Member	Mr.	Brad	Olson	Okanogan	WA
204	North Central WA Audoubon Society (President)	Mr.	Mark	Oswood	Wenatchee	WA
205	Friends of the Stampede		Ed & Diana	Parker	Omak	WA
206	Omak Kiwanis Club	Mr.	Gary	Pederson	Omak	WA
207	Oroville Kiwanis Club	Mr.	Robert	Pellegrini	Oroville	WA
208	Okanogan County Water Landuse Subcommittee	Mr.	Mel	Peterson	Okanogan	WA
209	Friends of the Stampede	Mr.	Rod	Picking	Omak	WA
210	Conservation	Mr.	Mike	Price	Twisp	WA
211	ORNAC - Board of Directors Project Museum	Ms.	Esther	Rabchuk	Omak	WA
212	Caribou Trail Junior Rodeo	Ms.	c/o Denise	Ralston	Okanogan	WA
213	206 Snowriders Snow Club	Mr.	Dennis	Rawley	Tonasket	WA
214	Central Valley Sports Complex - Friends	Ms.	Monica	Rawson	Malott	WA
215	Okanogan County Artists Association	Ms.	Amber	Redman	Omak	WA
216	Okanogan County Artists Association	Ms.	Luella	Rehme	Okanogan	WA

	Organization	Title	First Name	Last Name	City	State
217	Friends of the Stampede	Mr.	Bill	Richter	Omak	WA
218	Associate Board Member	Ms.	Jackie	Richter	Omak	WA
219	Friends of the Stampede	Mr.	Marti	Robbins	Omak	WA
220	Okanogan Valley Ultimate Team Frisbee	Mr.	Dick	Roberts	Okanogan	WA
221	Conconully Chamber of Commerce	Ms.	Shelley	Robideau	Conconully	WA
222	Rivervalley Soccer		Jean	Rodgers	Okanogan	WA
223	Friends of the Stampede		Russ Bunnie Marguerite	Detro	Omak	WA
224	Yakama Indian Nation	Mr.	Jim	Russell	Toppenish	WA
225	Okanogan County Artists Association	Ms.	Roberta	Rust	Winthrop	WA
226	Friends of the Stampede	Mr.	John	Sackman	Omak	WA
227	Okanogan Valley Team Penning Assoc.	Mr.	Dennis	Saddin	Okanogan	WA
228	Board of Directors	Mr.	Dave	Sakaia	Omak	WA
229	Board of Directors		Irv & Marge	Sasse	Riverside	WA
230	Babe Ruth League/Omak Youth Baseball	Mr.	Mike	Saunders	Omak	WA
231	Friends of the Stampede	Ms.	Anne	Schneider	Omak	WA
232	Oroville Gun Club	Mr.	Paul	Schwilke	Oroville	WA
233	Oroville Tonasket Irrigation District	Mr.	Tom	Scott	Oroville	WA
234	Okanogan County Artists Association	Ms.	Glenda	Sewell	Oroville	WA
235	Okanogan Chamber of Commerce	Mr.	David	Sexton	Okanogan	WA
236	Honorary Board Member		Hoagy & Barb	Shattuck	Omak	WA
237	Friends of the Stampede		Fred & Sharon	Sheldon	Omak	WA
238	Board of Directors	Ms.	Donna	Short	Omak	WA
239	Business	Mr.	Tim	Shrout	Okanogan	WA
240	Bridgeport Chamber of Commerce	Mr.	Gene	Smit	Bridgeport	WA
241	Rodeo Timer	Ms.	Jan	Smith	Omak	WA
242	Board of Directors	Ms.	Lisa	Smith	Riverside	WA
243	Coulee Dam Mayor	Mr.	Quincy	Snow	Grand Coulee	WA
244	Okanogan County Artists Association	Ms.	Lisa	Spear	Loomis	WA
245	Oroville Mayor	Mr.	Chuck	Spieth, Sr.	Oroville	WA
246	Friends of the Stampede	Mr.	Roy	Spillman	Omak	WA
247	Okanogan County Artists Association	Ms.	Harriet	Stangland	Tonasket	WA
248	Oroville Grange	Ms.	Betty	Steg	Oroville	WA
249	Okanogan County Artists Association	Ms.	Rachel	Steiner	Okanogan	WA
250	Molson Grange	Mr.	Robin	Stice	Oroville	WA
251	Skyline Irrigation District	Mr	Jerry	Sullivan	Winthrop	WA
252	Pro West Rodeo	Ms.	Sandra	Sullivan	Moses Lake	WA
253	Washington State House of Representatives	Rep	Bob	Sump	Olympia	WA
254	Methow Valley Back Country Horseman	Ms	Sharon	Sutherland	Twisp	WA
255	Okanogan County Artists Association		Zoe	Sweger	Riverside	WA
256	Ghost Riders	Mr.	Harry	Taylor	Omak	WA
257	Twisp Chamber of Commerce	Mr	Jerome	Thiel	Twisp	WA
258	Board of Directors		Ed & Bev	Thiele	Omak	WA
259	Staff	Ms.	Sheri	Thiele	Omak	WA
260	Board of Directors		Jeff & Connie	Thomas	Omak	WA
261	Friends of the Stampede	Mr.	Joe	Thomas	Omak	WA
262	Honorary Board Member	Ms.	Sandy	Thomas	Omak	WA
263	Okanogan County Artists Association		Thom & Esther	Thompson	Omak	WA
264		Mr.	Todd	Thorn	Wauconda	WA
265	Elmer City Mayor	Mr.	Paul	Tillman	Elmer City	WA
266	Friends of the Stampede		Jim & Joanne	Tinsman	Omak	WA
267	Wolf Creek Irrigation District	Mr.	Nim	Titcomb	Winthrop	WA
268	ORNAC - Board of Directors Project Museum	Ms.	Lisa	True	Nespelem	WA
269	Staff		Missy & Lorraine	Utt	Riverside	WA

	Organization	Title	First Name	Last Name	City	State
270	Associate Board Member		Paul & Teena	Vickers	Tonasket	WA
271	Business	Mr.	Pat	Walters	Tonasket	WA
272	Okanogan County Artists Association	Ms.	Sandra	Walters	Omak	WA
273	Friends of the Stampede	Ms.	Ada	Ward	Okanogan	WA
274	Omak City Council	Mr.	Clinton	Watts	Omak	WA
275	Board of Directors	Mr.	Rick	Weber	Okanogan	WA
276	Okanogan County Artists Association		Lynnes	Welch	Riverside	WA
277	Friends of the Stampede	Mr.	Lou	Wenden	Omak	WA
278	Okanogan County Artists Association	Ms.	Wanda	Wertz	Okanogan	WA
279	Friends of the Stampede	Ms.	Sonia	Westvang	Okanogan	WA
280	Friends of the Stampede		Ben & Jeannie	Whitley	Okanogan	WA
281	Board of Directors	Mr.	Bob & Marti	Widdifield	Omak	WA
282	Honorary Board Member		Dick & Marion	Wilkie	Omak	WA
283	Board of Directors	Ms.	Flodell	Williams	Nespelem	WA
284	Mount Olive Grange	Mr.	Albert	Wilson	Riverside	WA
285	Grand Coulee Dam Volkssport Assn.	Ms.	Constance	Wilson	Coulee Dam	WA
286	Okanagan Nations Alliance	Chief	Stewart	Phillip	Westbank	BC
287	Methow Valley Soccer	Ms.	Dottie	Wilson	Winthrop	WA
288	Ellisforde Grange	Mr.	Henry	Wilson	Tonasket	WA
289	Okanogan County Pomona Grange	Mr.	Ron	Wilson	Tonasket	WA
290	Methow Valley Community Center	Ms.	Vickie	Wilson	Twisp	WA
291	Okanogan County Artists Association	Ms.	Patsy	Wisener	Oroville	WA
292	American Legion/Senior Babe Ruth League		Tory & Erica	Wolf	Brewster	WA
293	Friends of the Stampede	Mr.	Josh	Yaksic	Omak	WA
294	Okanogan County Horticulture Association	Mr.	Tracy	Zahn	Bridgeport	WA
295	Okanogan County Artists Association	Ms.	Ann	Zimmer	Oroville	WA
296	Okanogan County Junior Rodeo/Boots & Saddles	Ms.	Karen	Zittle	Omak	WA
297	Columbia Cove Youth Soccer League		Center		Brewster	WA
298	Methow Salmon Recovery Foundation				Winthrop	WA
299	Jack's RV Park & Motel				Conconully	WA
300	Tribal Tribune				Nespelem	WA
301	Okanogan County Board of County Commissioners				Okanogan	WA
302	Okanogan County Planning Department				Okanogan	WA
303	Okanogan Inn & Suites				Okanogan	WA
304	Okanogan Wildlife Council				Okanogan	WA
305	Ponderosa Motor Lodge				Okanogan	WA
306	U&I Motel				Okanogan	WA
307	Harrison Jewelers				Omak	WA
308	Motel Nicholas				Omak	WA
309	Okanogan Valley Golf Club				Omak	WA
310	Omak Inn				Omak	WA
311	The Omak Cinema				Omak	WA
312	Lake Pateros Motor Inn				Pateros	WA
313	Forest Service: Tonasket District Ranger				Tonasket	WA
314	Okanogan Highlands Alliance				Tonasket	WA
315	Red Apple Inn				Tonasket	WA
316	KLVR Radio				Twisp	WA
317	Methow Basin Planning Unit		Ron	Perrow	Winthrop	WA
318	Twisp Kiwanis				Twisp	WA
319	Bureau of Land Management - Wenatchee Resource Area				Wenatchee	WA
320	The Pacific Watershed Institute				Winthrop	WA

Media Coverage

OKANOGAN COUNTY WATER RESOURCES

123 North 5th Avenue Room 110 Okanogan, WA 98840
Telephone (509) 422.7113 Facsimile (509) 422.7349
Email ocsr@co.okanogan.wa.us
Web site http://66.133.20.113/home/

News Release

Contact: Julie Dagnon, Okanogan County Water Resources Coordinator
509/422-7370
jdagnon@co.okanogan.wa.us

For release September 2, 2004

Regional Salmon Recovery Planning was initiated as a means of involving local citizens and policy makers in the recovery of at-risk salmonid species. In Okanogan County, the process will get underway this month.

Okanogan County's Water Resources Division will host a pair of public meetings mid-month to introduce the project, explain how it relates to other planning endeavors in the county, and answer questions. In addition, the Board of County Commissioners will appoint an Advisory Committee to review technical work products and provide guidance in the development of strategies and actions to be employed in the Methow and Okanogan subbasins.

Regional Salmon Recovery Planning was authorized by the Washington State legislature in 2001 as a way for local stakeholders to work with federal agencies on plans for the delisting of threatened and endangered salmonid species. Through the Upper Columbia Salmon Recovery Board (UCSRB), Okanogan County is working with Chelan and Douglas counties, the Colville Confederated Tribes, and the Yakama Nation to develop a recovery plan for populations of three species: Spring Chinook, Steelhead, and Bull Trout. The completed Upper Columbia plan will apply to the Moses Coulee, Wenatchee, Entiat, Methow, Okanogan, and Foster Creek subbasins.

Regional Salmon Recovery Planning for the Upper Columbia Region will build on the Subbasin Plans developed in the last year and presently undergoing review and comment. The assessments, limiting factors, and goals in the Methow and Okanogan Subbasin Plans will be incorporated into the Regional Salmon Recovery Plan. Also included in the Regional Salmon Recovery Plan will be actions and commitments that are necessary to reduce or eliminate limiting factors and recover fish populations; and implementation components such as time lines, funding strategies, identification of responsible parties and authorities, research needs, monitoring plans, and a method for evaluating actions and adapting the plan.

As Regional Salmon Recovery Planning gets underway, Okanogan County will also be working to refine the Methow and Okanogan Subbasin Plans in response to comments from stakeholders and technical reviewers.

Regional Salmon Recovery Planning kick-off meetings are scheduled as follows:

- Wednesday, September 15th in the County Commissioners' Hearing Room, 123 N. 5th Avenue, Okanogan
- Thursday, September 16th at the Methow Valley Senior Citizens Center in Twisp
- Both meetings will start at 6:30 PM and run for about two hours.

The first meeting of the Regional Salmon Recovery Planning Advisory Committee will be held on Wednesday, September 22nd in the Okanogan PUD Auditorium (across from the Museum) This meeting will start at 6:30 PM and run for about two hours.

For more information about Regional Salmon Recovery Planning, or if you are interested in serving on the Advisory Committee, you may call the Okanogan County Water Resources Division at:

- 509/422-7113
- inquire via email sent to ocsr@co.okanogan.wa.us
- visit the Water Resources web site at http://66.133.20.113/home/.

The web site also includes information about Subbasin Planning and links to current drafts of the Methow and Okanogan Subbasin Plans.

Bi-weekly email updates and monthly newsletters will be available; you may use the contact information above to request that your name be added to either or both mailing lists.

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OKANOGAN COUNTY WATER RESOURCES

123 North 5th Avenue Room 110 Okanogan, WA 98840
Telephone (509) 422.7113 Facsimile (509) 422.7349
Email ocsr@co.okanogan.wa.us
Web site http://www.okanogancounty.org/water

News Release

Contact: Julie Dagnon, Okanogan County Water Resource Coordinator
509/422-7370
jdagnon@co.okanogan.wa.us

For release September 27, 2004

Okanogan County has partnered with Chelan and Douglas counties, the Colville Confederated Tribes, and the Yakama Nation to develop a Salmon Recovery Plan for the Upper Columbia Basin. The plan will present strategies and actions aimed at recovering at-risk stocks of spring Chinook, steelhead, and bull trout in the Okanogan, Methow, Foster Creek, Moses Coulee, Wenatchee, and Entiat subbasins. The partners are working together under the auspices of the Upper Columbia Salmon Recovery Board (UCSRB).

Okanogan County and representatives of the Upper Columbia Habitat Coordinating Committee (HCC) will present the first drafts of Sections 1-3 of the Upper Columbia Salmon Recovery Plan for public review and comment on October 6th for the Okanogan area stakeholders and October 7th for the Methow Valley area stakeholders. (Both of these meetings will cover the same information)

The HCC is a group composed of biologists who are working on the technical foundation of the Salmon Recovery Plan, and representatives of the partner agencies—the three counties and two tribes—that make up the UCSRB. The group includes but is not limited to representatives of state and federal fish and wildlife agencies—the Washington Department of Fish and Wildlife, the U. S. Fish and Wildlife Service, and NOAA Fisheries.

Okanogan County has organized the October 6th and 7th review meetings to invite comment from citizens of Okanogan County on the work that the HCC has done so far. Initial drafts of three sections of the plan will be available for review: the Introduction, Species Status, and Factors for Decline. The upcoming meetings will offer an opportunity to discuss the draft text and make comments. Additional comments will be accepted until October 29th.

As the Salmon Recovery Plan is developed, further public involvement and comment will be invited. Meetings to review revisions and additional text will be scheduled in January and April, 2005. Public comment will be supplemented by guidance from an Advisory Committee, to be appointed by the Okanogan County Board of Commissioners.

Meetings for review of draft Salmon Recovery Plan text are scheduled as follows:

- Wednesday, October 6th in the County Commissioners' Hearing Room, 123 N. 5th Avenue, Okanogan
- Thursday, October 7th in the Forest Service Conference Room in Twisp

Both meetings will start at 6:30 PM and run for about two hours. For more information about the meetings, the Salmon Recovery Advisory Committee, or Salmon Recovery Planning, you may call the Okanogan County Water Resources Division at 509/422-7113, inquire via email sent to ocsr@co.okanogan.wa.us, or visit the Water Resources web site at http://www.okanogancounty.org/water.

The Okanogan County Water Resources web site also includes information about Watershed Planning and Subbasin Planning, and links to the Methow Basin Watershed Plan and current drafts of the Methow and Okanogan Subbasin Plans. Bi-weekly email updates and monthly newsletters will be available; you may call 509/422-7113 or email ocsr@co.okanogan.wa.us to request that your name be added to either or both mailing lists.

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OKANOGAN COUNTY OFFICE OF PLANNING AND DEVELOPMENT - Water Resources

123 North 5th Avenue Room 110 Okanogan, WA 98840
Telephone (509) 422.7113 Facsimile (509) 422.7349
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Web site http://www.okanogancounty.org/water

News Release

Contact: Julie Dagnon, Okanogan County Water Resource Coordinator
509/422-7370
jdagnon@co.okanogan.wa.us

For release March 21, 2005

Okanogan County has partnered with Chelan and Douglas counties, the Colville Confederated Tribes, and the Yakama Nation to develop the Salmon Recovery Plan for the Upper Columbia Region. The plan will present strategies and actions aimed at recovering at-risk populations of spring Chinook, steelhead, and bull trout in the Okanogan, Methow, Foster Creek, Moses Coulee, Wenatchee, and Entiat subbasins. It will be submitted to the Governor's Salmon Recovery Office this summer for inclusion in the Northwest Salmon Recovery Plan being developed by the National Marine Fisheries Service (formerly NOAA Fisheries) as a step toward the delisting of fish stocks protected under the Endangered Species Act.

Okanogan County's Water Resources Division is working with local stakeholders to develop habitat action recommendations to be included in the Plan. Staff members are seeking to identify habitat restoration actions that accurately reflect local interests and project feasibility. Project feasibility is a function of several factors, including cost and landowner willingness, as well as the anticipated effectiveness of the project in furthering salmon recovery.

Recommended actions to improve instream and riparian habitat for the benefit of listed salmonid species will appear in the final draft of the plan, scheduled for release at the end of June. Comments on the final draft will be accepted throughout the month of July.

The starting points for identifying appropriate habitat actions are a set of matrices and a habitat action library drafted by the Upper Columbia Habitat Coordinating Committee (HCC). The HCC is a group composed of numerous biologists who are working on the technical foundation of the Salmon Recovery Plan, and representatives of the partner agencies—the three counties and two tribes—that make up the UCSRB. The committee includes representatives of state, tribal and federal fish and wildlife agencies—the Washington Department of Fish and Wildlife, the U. S. Fish and Wildlife Service, and NMFS (National Marine Fisheries Service).

Each matrix (one for the Methow and one for the Okanogan subbasin) identifies limiting factors, causal factors, management objectives, and classes of restoration actions. A limiting factor is anything that tends to make it more difficult for a species to live and grow or reproduce in its environment. Limiting factors for salmonids in our region generally include riparian habitat condition, in-stream obstructions such as culverts, and water quantity (low flow in the stream).

Causal factors are the types of alterations to the ecosystem that have caused the limiting factors—such as riparian vegetation removal, development of roads that constrict a stream channel, or development of roads that act as conduits to concentrate water and direct it from the upper watershed to a stream more quickly than under pristine conditions. The limiting factors and causal factors explain why a species is not able to make full use of habitat in a particular part of a subbasin.

Management objectives identify the way in which habitat could be improved and how the change would affect salmon. For example, in a stream reach where riparian habitat quality is the primary limiting factor, an objective might be to "Increase juvenile survival by improving riparian habitat." Action classes would state how that could be accomplished—in this case, "Riparian Restoration."

The action classes are drawn from the habitat action library. The library describes classes of restoration actions (for instance, "Riparian Restoration") and lists possible specific actions within each class (for instance, "Plant and manage native trees and shrubs as site conditions dictate to provide shade and/or bank stability").

All actions recommended in the Upper Columbia Salmon Recovery Plan will be voluntary. The plan is also expected to include recommendations for landowner education and changes in local regulations to better protect existing habitat. Okanogan County is planning a series of workshops to discuss current drafts of the matrices, including possible actions, with stakeholders. For more information about those workshops, please contact the Okanogan County Water Resources Division at 509/422-7113, inquire via email sent to ocsr@co.okanogan.wa.us, or visit the Water Resources web site at http://www.okanogancounty.org/water.

The Upper Columbia Salmon Recovery Board (UCSRB) will release a second draft of the regional Salmon Recovery Plan on March 31. As with the first draft, this second release will not be a complete document, but will include sections revised based on the January 2005 comment period and portions of Section 5 dealing with harvest, hatcheries and hydro. Comments on the plan will be accepted throughout the month of April. Okanogan County will present the draft Upper Columbia Salmon Recovery Plan for public review and comment on April 6th for Okanogan Valley stakeholders and on April 7th for Methow Valley stakeholders. (Both meetings will cover the same information.) Complete information about those meetings will be available next week.

The Okanogan County Water Resources web site includes information about Watershed Planning and Subbasin Planning (as well as Salmon Recovery Planning), and links to the Methow Basin Watershed Plan and current drafts of the Methow and Okanogan Subbasin Plans. Okanogan County produces bi-weekly email updates and monthly newsletters about Salmon Recovery; you may call 509/422-7113 or email ocsr@co.okanogan.wa.us to request that your name be added to either or both mailing lists.

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Methow Valley News
September 8, 2004

Regional Salmon Recovery Planning

Okanogan County

Okanogan County's Water Resources Division will host two public meetings to present an overview of Regional Salmon Recovery Planning and explain the relationship between Regional Salmon Recovery Planning and other planning underway in the county.

Wednesday, September 15th
6:30-8:30 PM
Okanogan County Commissioners' Hearing Room
123 N. 5th Avenue, Okanogan

or

Thursday, September 16th
6:30-8:30 PM
Methow Valley Senior Citizens Center
Twisp

For more information, please call
OKANOGAN COUNTY WATER RESOURCES at
509/422-7113
or email ocsr@co.okanogan.wa.us

MVN 9/8/04

In brief

Candidate forums scheduled

The Methow Valley chapter of the League of Women Voters will be sponsoring two candidate forums next month.

On Oct. 6, the four candidates for the two county commissioner positions on the November ballot will face each other. Then, on Oct. 13, the two candidates for PUD commissioner will face off.

Both forums will start at 7 p.m. in the Twisp Grange. For more information contact Joyce Bergen at 996-7808.

Blood drive slated

The American Red Cross will be sponsoring a blood drive Thursday, Sept. 23, from 2 to 6 p.m. at the Liberty Bell High School cafeteria.

Appointments can be made by calling the Pacific Northwest Blood Services by calling 1-800-787-9691. Walk-ins are also welcome.

For more information about donating blood, visit *www.givelife.org,* or call 1-800-GIVE LIFE.

Salmon meetings set

Okanogan County will host two public meetings this week to kick off regional salmon recovery planning.

Meetings are scheduled for today (Sept. 15) in the Okanogan County Commissioners hearing room in Okanogan, and Thursday (Sept. 16) at the Methow Valley Senior Center in Twisp. Both meetings start at 6:30 p.m. and go for about two hours.

The meetings will introduce the project, explain how it relates to other planning projects and allow the public to ask questions.

For more information call the county Water Resources department at (509) 422-7113, or go online to *http://66.133.20.113/home/*.

Quad City Herald
Septmber 30, 2004
Page 6

Methow Valley News
October 6, 2004

First drafts of salmon plan offered

Okanogan County Water Resources will host a public meeting in Twisp this week to introduce the first draft of the first three sections of the Upper Columbia Regional Salmon Recovery Plan.

The meeting is scheduled for Thursday (Oct. 7), from 6:30 to 8:30 p.m. in the Forest Service Conference Room in Twisp.

Local officials–representatives of Chelan, Douglas and Okanogan counties, the Colville Confederated Tribes, and the Yakama Nation–will ultimately decide what is included in the plan, but public comment will be considered at several steps in the process.

The first drafts of Sections 1 through 3 of the plan have been posted on the Okanogan County Water Resources web site: *http://okanogancounty.org/water/*. You may also request a copy by calling (509) 422-7113).

MVN 10/6/04

Methow Valley News
January 5, 2005

Draft salmon recovery plan ready for comment

By Ann McCreary

Methow Valley residents will have a chance to comment on the first draft of the regional Salmon Recovery Plan during a public meeting next Tuesday (Jan. 11), at the Methow Valley Senior Center.

The Upper Columbia Salmon Recovery Board released the first draft of its regional plan last Thursday (Dec. 30). Okanogan County and representatives of the Upper Columbia Habitat Coordinating Committee will present the draft for public review during the meeting, which begins at 6:30 p.m. and is expected to last about two hours.

A meeting for interested citizens in Okanogan Valley is scheduled for Wednesday, Jan. 12, in the Okanogan County Commissioners' hearing room, also at 6:30 p.m.

Okanogan County is a partner in developing the salmon recovery plan with Chelan and Douglas counties, the Colville Confederated Tribes and the Yakama Nation. The plan will present strategies and actions aimed at recovering at-risk stocks of spring Chinook, steelhead and bull trout in the Methow, Okanogan, Foster Creek, Moses Coulee, Wenatchee and Entiat subbasins.

The plan will be submitted to the governor's Salmon Recovery Office in June for inclusion in the Northwest Salmon Recovery Plan being developed by NOAA Fisheries as a step toward delisting of fish stocks protected under the Endangered Species Act.

The Habitat Coordinating Committee, which will present the draft plan at next week's meetings, is composed of biologists who are working on the technical aspects of the recovery plan. The group also includes representatives of Okanogan County and other government agencies involved in developing the plan, as well as state and federal fish and wildlife agencies.

As the Salmon Recovery Plan is developed, further public comment will be invited. Meetings to review the final draft will be scheduled in April.

For more information about the meetings or the recovery planning process, call Okanogan County Water Resources Division at 422-7113, e-mail *ocsr@co.okanogan.wa.us*, or visit the Water Resources website at *www.okanogancounty.org/water*.

The Okanogan County Water Resources web site also includes information about watershed planning and subbasin planning, and links to the Methow Basin Watershed Plan and current drafts of the Methow and Okanogan subbasin plans. 1/5/05 MVN

Statewide Salmon Recovery Planning

Methow and Okanogan Subbasins

Okanogan County has partnered with Chelan and Douglas counties, the Colville Confederated Tribes, and the Yakama Nation to develop a Salmon Recovery Plan for the Upper Columbia Basin.

Okanogan County and representatives of the Upper Columbia Habitat Coordinating Committee will present the first draft of the Upper Columbia Salmon Recovery Plan for public review and comment:

Tuesday, January 11th
6:30-8:30 PM
Methow Valley Senior Citizens Center
215 Highway 20, Twisp

and

Wednesday, January 12th
6:30-8:30 PM
Okanogan County Commissioners' Hearing Room
123 N. 5th Avenue, Okanogan

The same material will be presented in both sessions
Comments will be accepted until January 31sr. The final draft of the Recovery Plan will be available for review and comment in April

For more information, please call OKANOGAN COUNTY WATER RESOURCES at 422-7113 or email ocsr@co.okanogan.wa.us

1/5/05 MVN

Only three people are worried about salmon recovery?

Comment period on first phase of plan lasts through January

By Ann McCreary

A meeting to review a draft of a regional salmon recovery plan drew only three local residents last week.

The plan as currently drafted provides a historical overview of salmon in the upper Columbia River system, and describes factors that have contributed to the decline of upper Columbia spring Chinook, steelhead and bull trout.

The completed portion of the plan lays the groundwork for determining how recovery will be achieved. The recovery strategy is expected to be written by April, when the document will be presented again for public review and comment.

The overall goal of the plan, as stated in the document, is to remove spring Chinook, steelhead and bull trout from the list of endangered or threatened fish, and to protect them from future listing as endangered.

The "desired outcome" of the recovery plan is described as the "restoration of spring Chinook, steelhead, and bull trout populations such that they become viable and harvestable components of their ecosystem. For all species, recovery requires reducing threats to the long-term persistence of populations, maintaining widely distributed populations across diverse habitats of their native ranges, and preserving genetic diversity and life-history characteristics."

Okanogan County Commissioner Bud Hover, a member of the Upper Columbia Salmon Recovery Board, questioned how that outcome would be achieved.

"To try to bring these runs back to harvestable populations using ESA (Endangered Species Act) as a hammer on water users is not acceptable," Hover said. "I would love to see fishing open up, because it's a large part of the economy."

Other members of the public prsent at the meeting besides Hover were Ben Dennis and Vicky Welch.

This draft of the report attempts to provide accurate information about historical decline and what is currently being done to protect fish, said Sandra Strieby, a consultant working with Okanogan County Water Resources, one of the participating agencies.

The current comment period lasts through the end of the month. The report can be found and comments may be submitted on the Water Resources website, *www.okanogancounty.org/water.*

Copies or CDs of the report can be ordered by mail by calling Okanogan County Water Resources at 422-7113 or e-mailing *ocsr@co.okanogan.wa.us.*

Okanogan County is developing the recovery plan in partnership with Chelan and Douglas counties, the Colville Confederated Tribes and the Yakama Nation.

It will be submitted to the governor's Salmon Recovery Office in June for inclusion in the Northwest Salmon Recovery Plan being developed by NOAA fisheries as a step toward delisting fish stocks.

Wednesday, January 19, 2005

Methow Valley News

Page A4

Methow Valley News
February 16, 2005

MVN 2/16/05

Thursday
2/17

TWISP KIWANIS: Meets at Community Covenant Church. Info: 996-3520. 6:30am

THE MOTHERING GROUP: Community Covenant Church, Twisp. Melissa 997-2050. 10am-noon

CHRONIC PAIN: Support group meets at Twisp Fire Hall. Info: Tammy 997-4254. 10am

SPINNERS & WEAVERS: Meets on Intercity Airport Road (last building on right), Winthrop. 997-5666. 1pm

FOOD BANK DISTRIBUTION: At The Cove, 128 Glover St., Twisp. 997-0227. 1-4pm

4H RIFLERY CLUB: Meets at the Mazama Community Church. New shooters welcome and must bring a parent or guardian. Info: Kenny 996-3179. 5:30pm

INSIGHT MEDITATION (VIPASSANA): Sitting meditation in the meditation room/library above Trail's End Bookstore, Winthrop. 996-3222. 5:30pm

CUB SCOUTS THU

REGIONAL SALMON RECOVERY: Okanogan County Salmon Recovery Advisory Committee meets at the county commissioners' hearing room, 123 Fifth Ave. N., Okanogan. (509) 422-7113. 6:30-8:30pm

WASHINGTON PILOTS ASSOCIATION: Dinner and meeting at Whistler's Restaurant in Tonasket. Info: Bob 997-3853. 6:30pm

CUB SCOUTS: Scouting for first through fifth graders meet at the Twisp Legion Hall. Info 996-8002. 6:30pm

STAGED READING: Miriam Bishop directs *Reclining Figure*, to be read at the Merc Playhouse, Twisp. Donations will benefit the Twisp pool. 997-9699. 7pm

VOLUNTEER FIREFIGHTERS DISTRICT 6: Mazama, Winthrop, Twisp, and Carlton training and meetings at local fire halls. Info: 996-2453. 7pm

Wednesday, March 30, 2005

Methow Valley News

Page B3

Salmon recovery up for public review

A second draft of the Upper Columbia Salmon Recovery Plan will be presented for public review and comment on Thursday, April 7, at 6:30 p.m. in the Methow Valley Senior Center Conference Room in Twisp.

The new draft will include ideas for habitat restoration actions that biologists believe could help with recovery of at-risk salmon populations of spring Chinook, steelhead and bull trout.

Stakeholders are invited to comment on the types of restoration projects proposed in the draft recovery plan.

A meeting covering the same information will be held in Okanogan on Wednesday, April 6, also at 6:30 p.m. in the county commissioners' hearing room.

The feasibility of habitat restoration projects depends on several factors, including cost and landowner cooperation. The plans would apply to several regional sub-basins, including the Methow, Okanogan, Foster Creek, Moses Coulee, Wenatchee and Entiat sub-basins.

Comments on the draft plan will be accepted throughout the month of April.

For information about the meeting or salmon recovery planning, call the Okanogan County Water Resources Division at (509) 422-7113, or e-mail *ocsr@co.okanogan.wa.us*, or visit the Water Resources website at *www.okanogancounty.org/water*. The website includes a comment sheet that can be used to organize comments for efficient review.

Regional Salmon Recovery Planning

Methow and Okanogan Subbasins

Okanogan County has partnered with Chelan and Douglas counties, the Colville Confederated Tribes, and the Yakama Nation to develop a Salmon Recovery Plan for the Upper Columbia Region.

The second draft of the Upper Columbia Regional Salmon Recovery Plan will be presented for public review and comment:

Wednesday, April 6th
6:30-8:30 PM
Okanogan County Commissioners' Hearing Room
123 N. 5th Avenue, Okanogan

and

Thursday, April 7th
6:30-8:30 PM
Methow Valley Senior Center
Twisp

The same material will be presented in both sessions
Comments will be accepted until April 29th. An additional comment period on the complete draft is being considered for early summer.

For more information, please call
OKANOGAN COUNTY WATER RESOURCES
at 422-7113 or email ocsr@co.okanogan.wa.us

MVN 3/30/05

Salmon plan presented

Okanogan County will host two public meetings–one in Twisp and one in Okanogan–to present the Upper Columbia Salmon Recovery Plan draft plan.

The first meeting is scheduled for Wednesday, April 6 at 6:30 p.m. in the Okanogan County Commissioners' hearing room in Okanogan.

Locally, a meeting is scheduled for Thursday, April 7 at 6:30 p.m. in the Methow Valley Senior Center in Twisp.

The two meetings will be identical in content so it is only necessary to attend one.

All interested stakeholders are welcome.

Folks are also welcome to comment on the draft plan whether or not you attend the review meetings.

A draft of the plan along with three appendices has been posted on the Okanogan County Water Resources website, http://okanogancounty.org/water. Follow the links to "Salmon Recovery Planning" then "Draft Review Corner.

MVN 4/6/05

Upper Columbia Salmon Recovery Board reconsiders policy statement

The Upper Columbia Salmon Recovery Board (UCSRB) is reconsidering the policy statement that it adopted on February 24. Board members have decided not to release the statement pending amendment in response to points raised by UCSRB members. Board members stated, "Unfortunately we (Okanogan County) were amiss in stating that the UCSRB is reconsidering the policy statement.

Okanogan County had concerns regarding the policy statement adopted on February 24, 2005 and will be proposing different verbiage for the policy statement. In the near future, we plan to provide the entire UCSRB with Okanogan County's proposed changes to the policy statement adopted by the UCSRB on February 24, 2005."

The Board further stated. "We apologize for any misunderstanding and did not intend to portray that we were speaking on behalf of the entire UCSRB. If you have any questions or comments regarding this issue, please do not hesitate to contact Julie E. Pyper (JDagnon@co.okanogan.wa.us)."

Essential Reading for Okanogan County since 1910 The Chronicle

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Upper Columbia Salmon Recovery Plan discussed

Posted: Tuesday, April 26, 2005 - 11:55 a.m. PDT

By Chris Thew
Chronicle Staff

Chuck Peven, a consultant for Okanogan County, talked about the Upper Columbia Salmon Recovery Plan before the Salmon Recovery Planning Advisory Committee April 21.

Peven, one of the writers of the plan, discussed the language of the draft habitat section of the salmon recovery plan with the audience. People who attended were allowed to suggest additions, deletions and changes to the habitat section of the plan.

Peven went over the short- and long-term goals of the plan, and discussed the specific wording. Many in the group indicated they were encouraged by one of the writers of the plan being in attendance.

In the past, people were allowed to make comments, but not be a part of the process, they indicated.

"I want to make sure you are part of the development team," said Peven. "Not just the review team."

The meeting also allowed people to discuss concerns with the second draft of the plan, which will be closed to public comments at midnight Wednesday, May 4.

Whether the responses raised in the meeting will become part of the final plan is up to the writers of the plan, Peven indicated.

"If I give up, I stop trying," said planner Chris Johnson about the possibility his opinions may not make the final cut. "In the past, it's been frustrating to make comments that have not made it into the document. We're hoping that the comments do end up in the document."

A special meeting has been arranged for Wednesday, April 27, at 6:30 p.m. in the Grainger Administration Building, Okanogan, to discuss more of the habitat section.

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Appendix P

Designing a Monitoring and Evaluation Program to Support Adaptive Management

Introduction

The Northwest Region National Marine Fisheries Service (Portland, Oregon) developed this short summary of *Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance* in June 2006 for use in salmon recovery plans.

Designing a Monitoring and Evaluation Program to Support Adaptive Management

Because of the length and complexity of the salmonid life cycle, there are many uncertainties involved in improving salmonid survival. Simply identifying cause-and-effect relationships between any given management action and characteristics of salmon populations can be a scientific challenge. It is essential to design a monitoring and evaluation program that will answer these basic questions: How will we know we are making progress? How will we get the information we need? And how will we use the information in decision making?

As part of implementing the Upper Columbia salmon recovery plan, a detailed monitoring and evaluation program will be designed and incorporated into an adaptive management framework based on the principles and concepts laid out in the NMFS guidance document, *Adaptive Management for Salmon Recovery: Evaluation Framework and Monitoring Guidance* (available at [weblink TBA]).

Adaptive management means taking an experimental approach to a complex task, making one's assumptions clear, and continuously evaluating them in the light of new information. It works best when the collection of performance data and methods of evaluation are designed to get the information managers need to make sound decisions. As outlined in the NMFS *Adaptive Management* guidance document, several types of monitoring are needed: (1) implementation and compliance monitoring, which is used to evaluate whether the recovery plan is being implemented; (2) status and trend monitoring, which assesses changes in the status of an ESU and its component populations, as well as changes in status or significance of the threats to the ESU; and (3) effectiveness monitoring, which tests hypotheses and determines (via research) whether an action is effective and should be continued. In addition, it's important to build in some research to illuminate the many unknowns in salmon recovery—the "critical uncertainties" that make management decisions all the harder. Critical uncertainty research may seem expensive or unnecessary in light of basic information needs; however, in the long run, it may reduce monitoring and implementation costs.

Implementation and compliance monitoring simply check on whether activities were carried out as planned, and whether specified criteria are being met as a direct result of an implemented action. For example, if a fence is planned for 20 miles of stream corridor to keep livestock off the stream banks so that riparian vegetation will rebound, implementation monitoring would verify the presence of the fence. Compliance monitoring would take note of the presence or absence of livestock in the fenced-off area.

Status and trend monitoring is a simple compilation of data-based descriptions of existing conditions. To be useful in decision making, the raw data, or metrics, must be reduced to a more directly applicable form or indicator. For example, if the question is "What is the annual spawning population size of steelhead in the X River?" the indicator would be total spawning numbers of steelhead over one season for the entire river basin; however, the metric, or directly measured thing, would be something quite different, perhaps steelhead redds sighted on weekly passes over known spawning grounds. Thus, the metric must be processed to translate it from the metric data type (e.g., redds) into the indicator data type (e.g., spawners), and then reduced to generate the indicator required (e.g., list of weekly counts on spawning grounds to annual total for watershed).

Effectiveness monitoring specifically addresses cause-and-effect questions. Demonstrating the direct and indirect impact of management actions requires supporting all steps in the logical chain that connects the action to its expected impact. This chain is rarely short and usually contains several hypotheses. For this reason, it's better to build the effectiveness monitoring into the recovery action strategies, with, for example, pilot-scale tests or other methods carefully thought out beforehand. Monitoring and evaluation will only provide the answers to the questions they were designed to address; they do not provide the framework for revising these questions if they are ill-posed, evaluating the assumptions upon which the strategy was built, or incorporating learning into future decisions on actions and strategies—this is the role of adaptive management.

NMFS' guidance document presents a decision framework that can guide the design of a research, monitoring, and evaluation plan. The framework (Figure 1) contains two basic sorts of questions: (1) questions regarding ESU status (biological viability criteria) and (2) questions regarding statutory listing factors and factors limiting recovery (limiting factor and threats criteria). Evaluating a species for potential delisting requires an explicit analysis of both types of criteria.

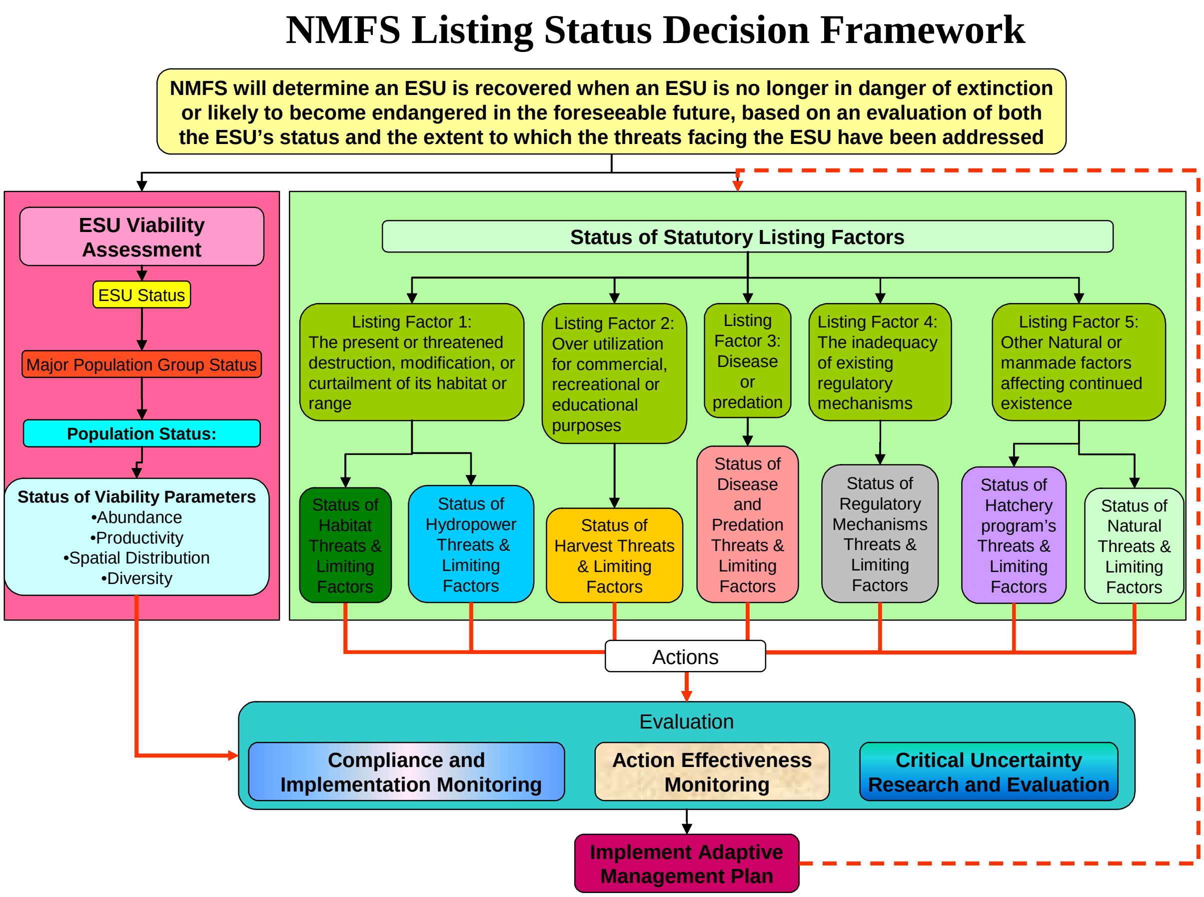
The guidance document contains a more detailed discussion of the framework and identifies the specific questions that must be answered to evaluate ESU status. These specific questions take the form of a series of decision-question sets that address the status and change in status of a salmonid ESU and the risks posed by threats to the ESU. The decision-question sets are designed to elicit the information NMFS needs to make delisting decisions. For recovery planners, the framework can guide future decisions about strategies and actions aimed at achieving recovery goals.

Designing an effective monitoring program for salmon recovery involves the following initial steps:

1. Clarify the questions that need to be answered for policy and management decision making. Include the full ESU and the full salmonid life cycle.
2. Identify entity or entities responsible for coordinating development of this program.
3. Identify:
    - Which populations and associated limiting factors to monitor
    - Metrics and indicators
    - Frequency, distribution, and intensity of monitoring
    - Tradeoffs and consequences of these choices
4. Assess the degree to which existing monitoring programs are consistent with NMFS guidance (e.g., Upper Columbia Monitoring Strategy; Okanogan Basin Monitoring and Evaluation Program; Draft Monitoring and Evaluation Plan for PUD Hatchery Programs; FCRPS monitoring actions; estuary monitoring programs).
5. Identify needed adjustments in existing programs, additional monitoring needs, and strategy for filling those needs.
6. Develop a data management plan (See Appendix B of the NMFS guidance document).
7. Prioritize research needs for critical uncertainties, testing assumptions, etc.
8. Identify entities responsible for implementation.

The Upper Columbia monitoring and evaluation program will build on existing programs designed for monitoring tributary habitat in the Upper Columbia, hydropower actions in the Upper Columbia, Upper Columbia hatchery programs, and actions outside of the Upper Columbia tributary subbasins (e.g., Columbia mainstem hydropower, estuary conditions and salmon use, mainstem and ocean harvest). The Upper Columbia monitoring and evaluation program will provide (1) a clear statement of the metrics and indicators by which progress toward achieving goals can be assessed, (2) a plan for tracking such metrics and indicators, and (3) a decision framework through which new information from monitoring and evaluation can be used to adjust strategies or actions aimed at achieving the plan's goals.

Figure 1



Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead

National Marine Fisheries Service
Northwest Region

January 2011

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
PORTLAND OFFICE
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

NOTE TO READERS:

This *Columbia River Estuary Recovery Plan Module* will be the basis of estuary recovery actions for Endangered Species Act-listed salmon and steelhead in the Columbia River Basin. The module will be incorporated by reference into recovery plans for listed Columbia Basin salmon evolutionarily significant units (ESUs) and steelhead distinct population segments (DPSs). It is important to have a unified set of actions for the Columbia River estuary to address the needs of all listed Columbia Basin ESUs and DPSs.

This *Columbia River Estuary Recovery Plan Module* was prepared for NOAA's National Marine Fisheries Service (NMFS) by the Lower Columbia River Estuary Partnership, (contractor) and PC Trask & Associates, Inc. (subcontractor).

DISCLAIMER:

Recovery plans delineate such reasonable actions as may be necessary, based upon the best scientific and commercial data available, for the conservation and survival of listed species. Plans are published by the National Marine Fisheries Service (NMFS), sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Recovery plans do not necessarily represent the views, official positions, or approval of any individual or agencies involved in the plan formulation, other than NMFS. They represent the official position of NMFS only after they have been signed by the Assistant Administrator. Recovery plans are guidance and planning documents only; identification of an action to be implemented by any public or private party does not create a legal obligation beyond existing legal requirements. Nothing in this plan should be construed as a commitment or requirement that any Federal agency obligate or pay funds in any one fiscal year in excess of appropriations made by Congress for that fiscal year in contravention of the Anti-Deficiency Act, 31 U.S.C. 1341, or any other law or regulation. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery actions.

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Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead

National Marine Fisheries Service
Northwest Region

Prepared for NMFS by the Lower Columbia River Estuary Partnership (contractor) and PC Trask & Associates, Inc. (subcontractor)

January 2011

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Lyndal Johnson	National Marine Fisheries Service, Northwest Fisheries Science Center
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Acronyms and Abbreviations

BACI	before-after-control-impact
BiOp	Biological Opinion
BMP	best management practice
BMPs	best management practices
cfs	cubic feet per second
CRE	Columbia River estuary
CSMEP	Collaborative Systemwide Monitoring and Evaluation Project
DDT	dichlorodiphenyltricholoroethane
DEQ	Oregon Department of Environmental Quality
DPS	distinct population segment
EDT	Ecosystem Diagnosis and Treatment
ENSO	El Niño/Southern Oscillation
EPA	U.S. Environmental Protection Agency
ERME	estuary research, monitoring, and evaluation
ESA	Endangered Species Act
ESU	evolutionarily significant unit
ETM	estuarine turbidity maximum
FCRPS	Federal Columbia River Power System
GIS	geographic information system
HUC	hydrologic unit code
ISAP	Independent Science Advisory Panel
ISRP	Independent Science Review Panel
LCFRB	Lower Columbia Fish Recovery Board
LCRANS	Lower Columbia River Aquatic Nonindigenous Species Survey
LIDAR	Light Detection and Ranging
MMPA	Marine Mammal Protection Act
MR&E	monitoring, research, and evaluation
NASQAN	National Stream Quality Accounting Network
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPCC	Northwest Power and Conservation Council
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls

PDO	Pacific Decadel Oscillation
PIT	passive integrated transponder
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
RM	river mile
RME	research, monitoring, and evaluation
TMDL	total maximum daily load
VGP	vessel general permit
WDF	Washington Department of Fisheries
WDFW	Washington Department of Fish and Wildlife

Glossary

Accretion: The accumulation of sediment deposited by natural fluid flow processes.

Alevins: Salmonids at the life stage between egg and fry.

Amphipods: Benthic invertebrates, particularly the amphipod *Americorophium salmonis,* which is found in intertidal and shallow subtidal habitats of the Columbia River estuary and is seasonally important in the diet of juvenile salmonids.

Ancient marshes: Marshes formed between 6,000 and 10,000 years ago.

Bar: A ridge or succession of ridges of sand or other substances, especially a formation extending across the mouth of a river or harbor that may obstruct navigation.

Bathymetry: The measure of the depths of oceans, seas, or other large bodies of water.

Beach erosion: The carrying away of beach materials by wave action, tidal currents, littoral currents, or wind.

Beach nourishment: The process of replenishing a beach by artificial means, such as through deposition of dredged materials; also called beach replenishment or beach feeding.

Bedload: Sand that rolls and bounces along the surface of the riverbed, usually downstream, although there may be a small displacement toward deeper water caused by the side slopes of the riverbed. In sandy riverbeds, bedload transport shapes the bed into a series of sand waves.

Beneficial use: Placement or use of dredged material for some productive purpose. Examples of beneficial uses include habitat development, beach nourishment, aquaculture, parks and recreation, shoreline stabilization, and erosion control.

Benthic: Of or relating to the bottom of a body of water.

Buffer area: A parcel or strip of land that is designed and designated to permanently remain vegetated in an undisturbed and natural condition to protect an adjacent aquatic or wetland site from upland impacts, to provide habitat for wildlife.

Centennial marshes: Marshes formed over the last century.

Continental shelf: The zone bordering a continent extending from the line of permanent immersion to the depth (usually about 100 to 200 meters) at which there is a marked or steep descent toward greater depths.

Delta: An alluvial deposit, usually triangular, at the mouth of a river. It is normally built up only where there is no tidal or current action capable of removing the sediment as fast as it is deposited.

Deposition: The deposit of sediment in an area through natural means, such as wave action or currents, or mechanical means.

Detritus: A loose mixture of organic material (dead plants and animals) and inorganic material (rock fragments) that results directly from disintegration of the material.

Dikes: Earthen walls constructed to contain water; sometimes constructed around dredged material disposal sites but more commonly constructed as flood protection.

Dredging: The removal or redistribution of sediments from a watercourse.

Ecosystem: A community of organisms in a given area together with their physical environment and its characteristic climate.

El Niño/Southern Oscillation: A shorter term climate effect that alternates between cold and warm phases approximately every 3 to 7 years; is associated with a warm-water current that periodically flows southward along the coast of Ecuador, and the southern oscillation in the atmosphere; affects climatic and ocean conditions throughout the Pacific region.

Emergent marsh: A wet, springy peatland that occurs along the edges of lakes and streams and is covered by grass-like sedges and fed by minerals washing in from surrounding lands.

Emergent vegetation: Rooted plants that can tolerate some inundation by water and that extend photosynthesis parts above the water surface for at least part of the year; emergent vegetation is intolerant of complete inundation over prolonged periods.

Estuarine turbidity maximum (ETM): A circulation phenomenon in an estuary that traps particles and promotes biochemical, microbial, and ecological processes that sustain an important pathway in the estuary's food web.

Estuary: A semi-enclosed coastal body of water with a free connection to the open ocean in which sea water is diluted with runoff from the land.

Exotic species: A non-native plant or animal deliberately or accidentally introduced into a habitat.

Fill: Sand, sediment, or other earth materials that are placed, deposited, or stockpiled.

Fingerling: A juvenile salmonid less than 1 year old.

Floodplain: A flat tract of land bordering a river, mainly in its lower reaches, and consisting of alluvium deposited by the river during flooding.

Fluvial: Involving running water; usually pertains to stream processes.

Forested wetlands: Wetlands that occur in palustrine and estuarine areas and possess an over story of trees, an understory of young trees or shrubs, and a herbaceous layer.

Freshet: High stream flow caused by rains or snowmelt and resulting in the sudden influx of a large volume of freshwater in the estuary.

Fresh water: Water that is less than 0.5 part salt per thousand.

Fry: Juvenile salmonids that have absorbed their egg sac.

Genetic diversity: Variation at the level of individual genes (polymorphism); provides a mechanism for populations to adapt to their ever-changing environment.

Habitat: The physical, biological, and chemical characteristics of a specific unit of the environment occupied by a specific plant or animal; the place where an organism naturally lives.

Habitat capacity: A category of habitat assessment metrics, including "habitat attributes that promote juvenile salmon production through conditions that promote foraging, growth, and growth efficiency, and/or decreased mortality" (Fresh et al. 2005).

Habitat connectivity: A measure of how connected or spatially continuous habitats occur in a larger ecosystem.

Habitat opportunity: A category of habitat assessment metrics that evaluate the capability of juvenile salmon to access and benefit from the habitat's capacity (Fresh et al. 2005).

High marsh: A wetland ecosystem influenced by a marsh surface elevation at approximately mean higher high water that is inundated by only the most extreme high tides and is characterized by salt-tolerant emergent vegetation.

Intertidal: Of or relating to the substrate that is exposed and flooded by tides; includes the associated splash zone.

In-water disposal: Placement of dredged material along the riverbed in or adjacent to the navigational channel or in designated in-water sites; commonly referred to as flow-lane disposal.

Limiting factor: Physical, chemical, or biological features that impede species and their independent populations from reaching viability status.

Littoral: Of, relating to, or situated or growing on or near a shore; especially of the sea.

Littoral current: A current running parallel to the beach and generally caused by waves striking the shore at an angle.

Low marsh: A wetland ecosystem characterized by salt-tolerant emergent vegetation and twice-daily inundation of high tides.

Macroinvertebrates: Invertebrates that are of visible size, such as clams and worms.

Marsh: An area of soft, wet, or periodically inundated land, generally treeless and usually characterized by grasses and other low growth.

Mean high water: The average height of all high waters over 19 years.

Mean higher high water: The average height of the higher of two unequal daily high tides over 19 years.

Mean low water: The average height of all low waters over 19 years.

Mean lower low water: The average height of the lower of two unequal daily low tides over 19 years.

Macrodetritus: Dead or dying matter from a plant or animal that is visible to the unaided eye; usually larger than 1 to 2 mm in diameter.

Microdetritus: Dead or dying matter from a plant or animal; usually smaller than 1 to 2 mm in diameter.

Navigational channels: Channels in estuaries and other water bodies that are created, deepened, and maintained by dredging to enable vessels to navigate safely between, into and out of ports, harbors, and marinas without running aground.

Nearshore: An indefinite zone extending seaward from the shoreline well beyond the breaker zone.

Ocean-type: Of or relating to salmonid juveniles that enter the estuary as fry or fingerlings and stay in the estuary for weeks or months before entering the ocean; examples are chum and subyearling Chinook.

Oligohaline: Of or relating to water having low salinity.

Overbank flooding: Out-of-bank flooding resulting from flow events that exceed the bankfull.

Over-water structures: Human-made structures, such as a pier, that extend over all or part of the surface of a body of water.

Pacific Decadal Oscillation: A longer term climate effect that alternates between cold and warm phases approximately every 30 years.

Pelagic: Pertaining to the open ocean.

Pinnipeds: Seals, sea lions, and walruses that belong to the taxonomic suborder called Pinnipedia, or the "fin-footed." Pinnipeds are carnivorous aquatic mammals that use flippers for movement on land and in the water. The pinnipeds referred to in this document are Pacific harbor seals, California sea lions, and Stellar sea lions.

Pier: A structure, usually of open construction, extending out into the water from the shore, to serve as a landing place, recreational facility, etc., rather than to afford coastal protection.

Piling: A long, heavy timber or section of concrete or metal that is driven into the earth or bottom of a water body to serve as a structural support or protection.

Pile dike: Two parallel rows of piling that are tied together and extend 300 to 500 feet into the river.

Pile dike field: Several pile dikes spaced about 1,200 to 1,500 feet apart, typically built to concentrate flow and stabilize the channel; within the dike field, current velocities are slowed and flow is deflected away from the river bank.

Plume: The layer of Columbia River water in the nearshore Pacific Ocean.

Polychlorinated biphenyls (PCBs): A group of synthetic, toxic industrial chemical compounds that are chemically inert and not biodegradable; they once were used in making paint and electrical transformers.

Polycyclic aromatic hydrocarbons (PAHs): A group of more than 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat.

Population: A distinct breeding unit of a species that exhibits similar life history strategies.

Redds: Spawning nests used by trout and salmon.

Revetment: A facing of stone, concrete, etc., to protect an embankment or shore structure from erosion by wave action or currents.

Salmonid: Any member of the family Salmonidae, which includes the salmon, trout, char, whitefishes, and grayling of North America.

Salmonid population viability: Measure of the status of anadromous salmonids that uses four performance criteria: abundance, productivity, spatial distribution, and diversity.

Sand: An unconsolidated mixture of inorganic soil (possibly including disintegrated shells and coral) consisting of small but easily distinguishable grains ranging in size from about 0.062 mm to 2.0 mm.

Sand waves: Waves of sand on the bottom of a riverbed that move in response to river discharge and bedload transport. In the Columbia, sand waves cover the riverbed and are typically 4 to 8 feet high and 300 to 400 feet long. When the river discharge is less than 300,000 cfs, sand waves move only a few feet per day; however, when discharge exceeds 400,000 cfs, sand wave movement can reach 20 feet per day or more.

Scour: The removal of underwater material by waves and currents, especially at the base or toe of a structure.

Sediment: Material in suspension in water or recently deposited from suspension; in the plural, all kinds of deposits from the waters of streams, lakes, or seas.

Sediment trapping: The capture of sediments behind structures such as dams and shoreline armoring, which restrict sediments from entering systems.

Shallows and flats: Areas from the 6-foot bathymetric contour line up to the edge of tidal marsh or swamp vegetation, or to mean higher high water where vegetation is absent.

Shoaling: A gradual decrease in water depth as the result of the accretion of sediments.

Smolts: Juvenile salmonids that have left their natal stream and are headed downriver toward the ocean.

Stream-type: Of or relating to salmonid juveniles that rear in freshwater for a year or more before entering the ocean.

Threat: A human action or natural event that causes or contributes to limiting factors; threats may be caused by past, present, or future actions or events.

Tidal marshes: Areas dominated by emergent vegetation and low shrubs; are typically found from mean lower low water to slightly above mean higher high water, although they are rare at the lowest elevations.

Tidal prism: The difference in the volume of water covering an area, such as a wetland, during low tide and the volume covering it during the subsequent high tide.

Tidal swamps: Shrub- and forest-dominated wetlands that extend up to the line of non-aquatic vegetation (the line at which excess water ceases to be a factor controlling the composition of the vegetation); tidal swamps may be of sufficiently high elevation that they are inundated only during spring tides, but they may also extend down below mean higher high water.

Tide: The periodic rising and falling of the water that results from gravitational attraction of the moon and sun acting on the rotating earth.

Turbidity: A condition in bodies of water where high sediment loads cause clouding of the water to varying extents; turbidity is an optical phenomenon and does not necessarily have a direct linear relationship to particulate concentration.

Viable salmonid population: An independent population of Pacific salmon or steelhead trout that has a negligible (generally ≤5 percent) risk of extinction over a 100-year timeframe.

Executive Summary

What is the Estuary Recovery Module?

This estuary recovery plan module is one element of a larger regional planning effort to develop recovery plans for Endangered Species Act-listed salmon and steelhead trout in the Columbia River basin. Recovery plans are being developed for each of the 13 listed evolutionarily significant units (ESUs) in the Columbia.[1] Figure ES-1 shows the 13 listed ESUs in the Columbia River basin grouped by region. The regions include the Lower Columbia, Upper Willamette, Middle Columbia, Snake, and Upper Columbia River ESUs. Within each of the regions, the ESUs have unique geographical boundaries that are based on similarities among populations.

This estuary recovery plan module complements other recovery plans in the region. The planning area for the module is all tidally influenced areas of the Columbia River. The upstream boundary of this area is Bonneville Dam, at River Mile 146, and the downstream boundary includes the Columbia River plume.[2] With few exceptions, the module's focus is limited to habitat conditions and processes in the Columbia River estuary and plume, rather than hatchery or harvest practices, hydroelectricity production, or tributary habitats in the Columbia River basin. The goal of the module is to identify and prioritize management actions that, if implemented, would reduce the impacts of limiting factors, meaning the physical, biological, or chemical conditions that impede salmon and steelhead survival during their migration through and rearing in the estuary and plume ecosystems. To accomplish this, changes in the physical, biological, or chemical conditions in the estuary are reviewed for their potential to affect salmon and steelhead. Then, the underlying causes of limiting factors are identified and prioritized based on the significance of the limiting factor and each cause's contribution to one or more limiting factors. These causes are referred to as threats and can be either human or environmental in origin. Finally, management actions are identified that are intended to reduce the threats and increase the survival potential of salmon and steelhead during estuarine rearing and migration. Costs are developed for each of the actions using an estimated level of effort to implement actions.

This estuary recovery plan module is intended to help answer questions about the degree to which the estuary and plume can contribute to salmon and steelhead recovery efforts throughout the Columbia River basin. The state of the science surrounding the estuary and plume is such that quantitative answers to questions about estuarine ecology are not necessarily available at this time. This is true in part because of the complexity of the ecological processes in the estuary and plume. However, it is also true because the Columbia River estuary and plume are only now being studied at a level of detail that

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[1] NOAA's National Marine Fisheries Service (NMFS) has revised its species determinations for West Coast steelhead under the Endangered Species Act (ESA), delineating steelhead-only "distinct population segments" (DPSs). The former steelhead ESUs included both anadromous steelhead trout and resident, non-anadromous rainbow trout, but NMFS listed only the anadromous steelhead. The steelhead DPS does not include rainbow trout, which are under the jurisdiction of the U.S. Fish and Wildlife Service. In January 2006, NMFS listed five Columbia River basin steelhead DPSs as threatened (71 FR 834). To avoid confusion, references to ESUs in this estuary recovery plan module imply the steelhead DPSs as well.

[2] See Figures 1-1 and 1-2 for a depiction of the planning area.

allows knowledge about this portion of the Columbia River ecosystem to be integrated into the understanding of life history patterns that have been well documented in the upstream portions of the basin.

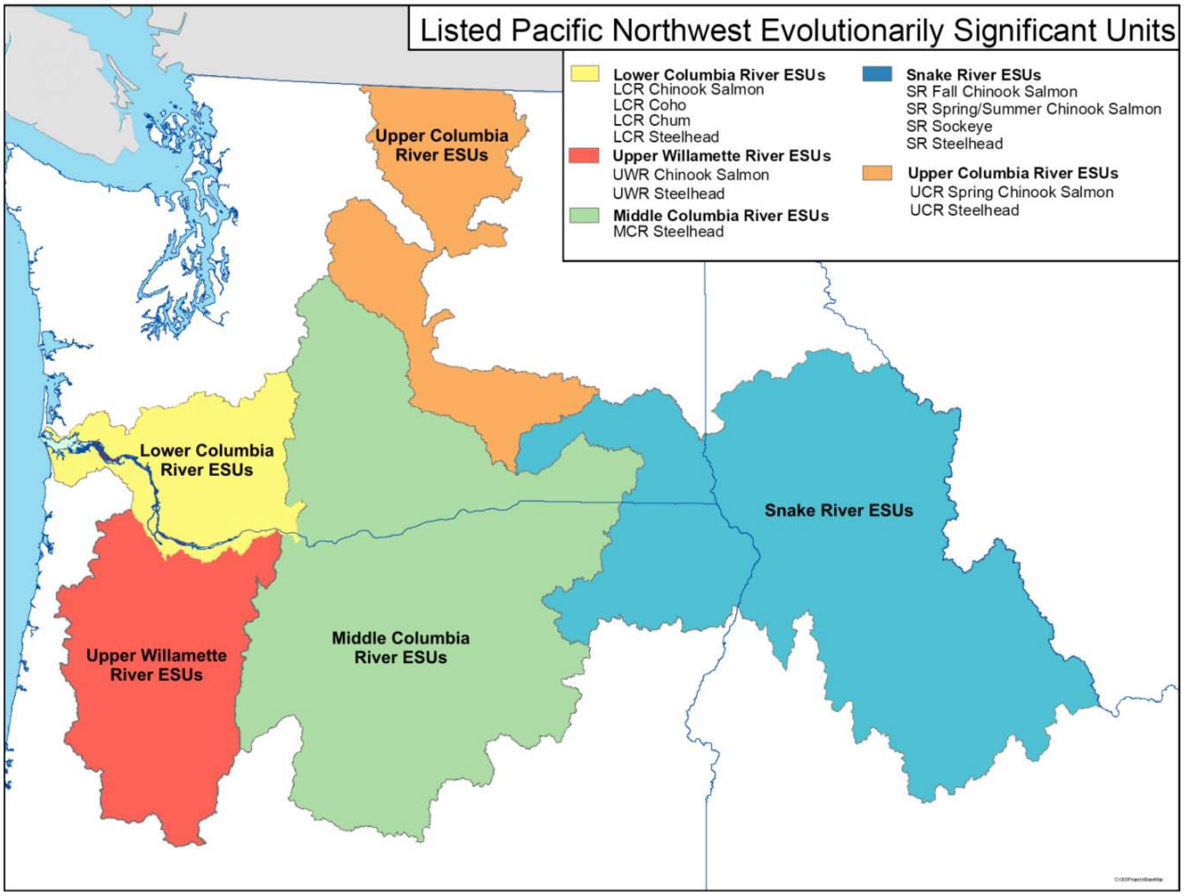

FIGURE ES-1
Listed Pacific Northwest ESUs

This estuary recovery plan module is a synthesis of diverse literature sources and the direct input of estuary scientists. The module was developed by the Lower Columbia Estuary Partnership and a private consultant, PC Trask & Associates, Inc. The primary author was PC Trask & Associates, Inc., with significant involvement from Lower Columbia River Estuary Partnership staff. The author used several key documents as a platform for the module. One of those documents is the "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan," which the Lower Columbia River Estuary Partnership developed, along with its supplement, for the Northwest Power and Conservation Council's *Columbia River Basin Fish and Wildlife Program* (Northwest Power and Conservation Council 2004). In 2005, the Northwest Fisheries Science Center of NOAA's National Marine Fisheries Service (NMFS) produced two important technical memoranda for the estuary: *Salmon at River's End* (Bottom et al. 2005) and *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead* (Fresh et al. 2005). The author used these two memoranda extensively and consulted other sources as well, including many primary sources. Area experts from the

NMFS Northwest Fisheries Science Center and Northwest Regional Office, the Lower Columbia River Estuary Partnership, and the Lower Columbia Fish Recovery Board provided input and advice on scoring and evaluation processes. Additionally, the author briefed the Northwest Power and Conservation Council, Mid-Columbia Sounding Board, Upper Willamette Recovery Planning Stakeholder Team, and Lower Columbia River Recovery Planning Stakeholder Team and took their feedback into account when refining the module. Lastly, PC Trask & Associates, Inc., and Lower Columbia River Estuary Partnership staff worked with NMFS Northwest Regional Office staff to revise the module in response to comments received during the public comment period.

Why Are the Estuary and Plume Important?

The Columbia River estuary and plume represent one of three major stages in the life cycle of salmon and steelhead. In tributaries, adults spawn and juveniles rear in freshwater. In the ocean, juveniles grow to adults as they forage in food-rich environments. The estuary is where juveniles and adults undergo vast physiological changes needed to transition to and from saltwater. In addition, a properly functioning estuary provides high growth opportunities and refugia from predators.

But why are the estuary and plume so important? The answer lies in the very reason that salmonids grew in numbers to an estimated 16 million over the past 4,000 years. Salmon and steelhead were successful because they exploited a wide array of the habitat niches available to them. They did this by employing a variety of strategies that allowed them to use many diverse habitats across a wide geographic space. In fact, the distribution of salmon and steelhead historically spanned thousands of river miles throughout the basin.

If this were not remarkable enough, salmon and steelhead's traits allowed them to use habitats at varying times, and this is one of the primary reasons the estuary and plume are so important. Every downstream-migrating juvenile salmon or steelhead must use the habitats of the estuary to complete its life cycle. If the progeny of the 16 million adult salmon and steelhead that historically made use of the estuary had converged on the estuary at one time, there likely would not have been enough habitat and food to sustain them. So they developed strategies to enter the estuary at different times, at different sizes, using unique habitats. In fact, it has been hypothesized that each individual population's use of estuarine habitats is discrete in terms of time and location of use. The implication of this for the estuary and plume today is that the area's habitats must be available through time and space and at sufficient quantities to support more than 150 distinct salmon and steelhead populations, which represent 13 ESUs that use many diverse life history strategies.

The number of adult salmon and steelhead that return to the Columbia River basin each year varies, but in recent years, average returns have been about 1.7 million, with approximately 65 to 75 percent of those fish being of hatchery origin.[3] For 2006, scientists from the NMFS Northwest Fisheries Science Center estimated that about 168 million juveniles would enter the estuary (Ferguson 2006b). This suggests that only 1 percent of the juveniles entering the estuary will return as adults and 99 percent are lost as a result of all the limiting factors (human and natural) in the estuary, plume, nearshore, and ocean.

[3] This is an informal estimate; determining the ratio of hatchery-origin fish with more certainty would require stock-by-stock run calculations averaged over many years.

Understanding the extent to which the estuary and plume contribute to these losses is essential to the ultimate recovery of salmon and steelhead ESUs throughout the basin.

What Is the Condition of the Estuary Now?

Flows, Dikes and Filling, and Sediment

The estuary and plume are considerably degraded compared to 200 years ago. In terms of absolute size, the estuary tidal prism is about 20 percent smaller than it was when Lewis and Clark camped along the Columbia's shore (Northwest Power and Conservation Council 2004). This reduction in estuary size is due mostly to dike and filling practices used to convert the floodplain to agricultural, industrial, commercial, and residential uses. Instream flows entering the estuary also have changed dramatically—there has been a 44 percent decrease in spring freshets or floods, and the annual timing, magnitude, and duration of flows no longer resemble those that historically occurred in the Columbia River (Jay and Kukulka 2003). Changes to flow volume and timing are attributed to hydrosystem regulation; water withdrawal for agricultural, municipal, and industrial purposes; and climate fluctuations. Further alterations in flow are likely to occur during the next century as a result of global climate change, the effects of which are expected to include more precipitation falling as rain rather than snow, less snow storage, and—in the estuary—higher peak flows and reduced late-summer/early-fall stream flows (Independent Scientific Advisory Board 2007).

Flow alterations and dike and filling practices are significant to salmon and steelhead in several ways. Historically, vegetated wetlands within the floodplain supplied the estuary with its base-level food source: macrodetritus. The near elimination of overbank events and the separation of the river from its floodplain have altered the food web by reducing macrodetrital inputs by approximately 84 percent (Bottom et al. 2005). At the same time, phytoplankton detrital sources from upstream reservoirs now dominate the base of the food chain. The substitution of food sources likely has profound effects on the estuary ecosystem. In addition, access to and use of floodplain habitats by ocean-type ESUs (salmonids that typically rear for a shorter time in tributaries and a longer time in the estuary) have been severely compromised through alterations in the presence and availability of these critical habitats.

The timing, magnitude, and duration of flows also have important ramifications to in-channel habitat availability and connectivity. Sand transport along the river bottom is highly correlated to flow. With reductions in the magnitude and duration of flows, erosion and accretion processes no longer function as they have for thousands of years. This may have far-reaching consequences to the estuary, plume, and nearshore lands north and south of the river's mouth. At the same time, upstream dams have prevented sediments from entering the estuary, while dredging activities have exported sand and gravel out of the estuary. Studies have shown that sand is exported from the estuary at a rate three times higher than that at which it enters the estuary. The full impact of these changes is unknown; however, sediment transport is a primary habitat-shaping force that determines the type, location, and availability of habitats distributed in the estuary and plume. In addition, decreases in sediments have improved water clarity and increased the effectiveness of predators that consume juvenile and adult salmon and steelhead.

Water Quality

Water quality in the estuary and plume has been degraded by human practices from within the estuary and also from upstream sources. Today, elevated water temperatures and toxic contaminants both pose risks to salmon and steelhead in the estuary. Summer water temperatures entering the estuary are on average 4° F (2.2° C) warmer today than they were in 1938 (Lower Columbia Fish Recovery Board 2004). The upper thermal tolerance range for cold-water fish, including salmon and steelhead, is about 20° to 24° Celsius (68° to 75° Fahrenheit). Temperatures exceeding this threshold have been occurring earlier in the year and more frequently since 1938 (as measured at Bonneville Dam). Degradation of tributary riparian habitat caused by forest, residential, commercial, and industrial practices, as well as reservoir heating and global climate change are responsible for increased temperatures. During the next century, it is likely that the expected effects of global climate change will continue to increase water temperatures.

Another important indicator of water quality degradation in the estuary is the presence of toxic contaminants. One study of contaminant impacts on juvenile salmon estimated disease-induced mortalities of 1.5 and 9 percent as a result of contaminant stressors for residencies in the Columbia River estuary of 30 to 120 days, respectively (Loge et al. 2005). If this estimate is accurate, threats from contaminants may exceed those from Caspian tern predation.

Toxic contaminants are widespread in the estuary, both geographically and in the food chain, with the urban and industrial portions of the estuary contributing significantly to juvenile salmon’s toxic load (Lower Columbia River Estuary Partnership 2007). Some of these contaminants are water-soluble agricultural pesticides and fertilizers, such as simazine, atrazine, and diazinon. Industrial contaminants include polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs). Also present are pharmaceuticals, personal care products, brominated fire retardants, and other emerging contaminants. Concentrations of toxic contaminants in the bodies of juvenile salmonids in the estuary sometimes are above levels estimated to cause health effects. In a 2007 study, this was the case for PCBs, PAHs, and DDT, and juveniles showed evidence of exposure to hormone-disrupting compounds (Lower Columbia River Estuary Partnership 2007). Salmon and steelhead experience both short-term exposure to toxic substances and long-term exposure to contaminants that accumulate over time and magnify through the food chain. Even when exposures are sublethal, they can cause significant developmental, behavioral, health, and reproductive impairments. Ocean-type ESUs are more susceptible to bioaccumulation than stream-type ESUs; however, both are equally vulnerable to acute exposures (stream-type ESUs are those ESUs that typically spend longer periods in tributaries and less time in the estuary).

Food Web and Species Interactions

The Columbia River estuary represents a distinct ecosystem that is a unique expression of biological and physical interactions. As physical and biological changes occur in the estuary, the ecosystem responds to those changes. There is general agreement that the estuary ecosystem is degraded and no longer provides the same level of support to native species assemblages that it did historically. Unfortunately, this field of research is perhaps the least understood, and its impact on salmon and steelhead is not well documented or studied.

Limiting factors related to the food web and species interactions can be thought of as the product of all the threats to salmon and steelhead in the estuary. Some examples of food web and species interactions-related limiting factors are easy to understand, but others are subtle and far-reaching. Caspian terns are a good example of an ecosystem shift that is easy to understand. New islands formed through the disposal of dredged materials attracted terns away from their traditional habitats, which may be being degraded. Reduced sediment in the river may have increased terns' efficiency in capturing steelhead juveniles migrating to saltwater at the same time that the birds need additional food for their broods. The result is a predator/prey shift in the estuary that has increased mortality for steelhead juveniles. Double-crested cormorants also prey on juvenile salmonids, in similar numbers as terns.

Other shifts in the ecosystem are more complex, and it can be difficult to understand whether or how they affect salmon and steelhead. For example, the shift in the food base of the estuary—from local macrodetrital sources to imported microdetrital sources such as phytoplankton—has fundamentally changed the food web and species relationships; however, what this means to salmon and steelhead—or, for that matter, to the entire estuarine ecosystem—is unknown. The introduction of exotic species is another poorly understood ecosystem alteration. Examples of exotic species thriving in the estuary include 21 new invertebrates, such as Asian clams and copepods, plant species such as Eurasian water milfoil, and exotic fish such as shad. Shad in particular, because of the sheer tonnage of their biomass, undoubtedly play a large role in the degradation of the estuary ecosystem and may compete with juvenile salmonids for food resources. Natural-origin juvenile salmonids may compete with large pulses of hatchery fish for food and space in the estuary if they overlap in space and time. Given the decreases in habitat opportunity and capacity in the estuary, it may be that too many fish—both salmonids and other species—are competing for too few estuarine resources at key times, with the resulting stressors translating into reduced salmonid survival. It is likely that this density-dependent mortality is manifesting itself in the estuary through limiting factors such as reduced off-channel habitat availability, competition with other fish species, and predation by fish and birds.

Other Threats

The estuary also is influenced by a number of physical structures that contribute to its overall degradation, but the extent of their impacts to salmon and steelhead is poorly understood. Over-water and instream structures in the estuary number in the thousands and alter river circulation patterns, sediment deposition, and light penetration; they also form microhabitats that often benefit predators. In some cases, structures reduce juvenile access to low-velocity habitats. Examples of structures include jetties, pilings, pile dikes, rafts, docks, breakwaters, bulkheads, revetments, groins, and ramps.

Ship wake stranding is an example of another threat to salmon and steelhead in the estuary. A study in 1977 by the Washington Department of Fisheries estimated that more than 150,000 juvenile salmonids, mostly Chinook, were stranded on five test sites as a result of ship bow waves striking shorelines (Bauersfeld 1977). Additional studies since the Bauersfeld study have not documented the same level of mortality. Light Detection and Radar (LIDAR) analysis and results from a new study by the University of Washington and the Portland District of the U.S. Army Corps of Engineers may help characterize this threat in the near future. This threat is most detrimental to ocean-type juvenile fry that are less than 60 millimeters long and that rear inches from shore.

What Can We Do to Improve Salmon and Steelhead Survival?

Identification of Management Actions and Monitoring Activities

This estuary recovery module identifies 23 management actions to improve the survival of salmon and steelhead migrating through and rearing in the estuary and plume environments. Table ES-1 lists these management actions and shows their relationship to threats to salmonid survival; this information is presented by topic, rather than priority.

TABLE ES-1
Management Actions to Address Threats

	Threat	Management Action
Flow-related threats	Climate cycles and global climate change[2]	**CRE[1]-1:** Protect intact riparian areas in the estuary and restore riparian areas that are degraded.[2] **CRE-2:** Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.[2] **CRE-3:** Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.[2]
	Water withdrawal	***CRE-3:*** *Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries*
	Flow regulation	**CRE-4**: Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume. ***CRE-3:*** *Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.*
Sediment-related threats	Entrapment of fine sediment in reservoirs	**CRE-5:** Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.
	Impaired transport of coarse sediment	**CRE-6:** Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially. **CRE-8:** Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health. ***CRE-4:*** *Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.*
	Dredging	**CRE-7:** Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.

[1] CRE = Columbia River estuary.

[2] Study of the impacts of global climate change is an evolving field, and additional research is needed to understand the phenomenon's likely effects on estuarine habitats and processes with specificity. At this time, the Independent Scientific Advisory Board of the Northwest Power and Conservation Council expects that the regional effects of global climate change in the next century will include more precipitation falling as rain rather than snow, reduced snow pack, and late-summer/early-fall stream flows, and associated rises in stream temperature (Independent Scientific Advisory Board 2007). The climate-related management actions in Table ES-1 reflect these expected impacts. Although the management actions clearly would not change the threat of global climate change itself, they have the potential to lessen its impact on salmonids in the estuary. Even if climate cycles and global climate change have effects different from those assumed in this document, the management actions that Table ES-1 associates with climate would provide benefits to salmonids by addressing other threats, such as water withdrawal, urban and industrial practices, and reservoir heating. All three of the management actions associated with climate in Table ES-1 are associated with other threats listed in Table ES-1.

Note: Italics indicate an action's second occurrence in the table, in connection with a different threat.

	Threat	Management Action
Structural threats	Pilings and pile dike structures	***CRE-8:*** *Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health.*
	Dikes and filling	**CRE-9:** Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat. **CRE-10:** Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.
	Reservoir-related temperature changes	***CRE-2:*** *Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.*
	Over-water structures	**CRE-11:** Reduce the square footage of over-water structures in the estuary.
Food web-related threats	Increased phytoplankton production	***CRE-10:*** *Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.*
	Altered predator/prey relationships	**CRE-13:** Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids. **CRE-14:** Identify and implement actions to reduce salmonid predation by pinnipeds. **CRE-15:** Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants. **CRE-16:** Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island. **CRE-17:** Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations. **CRE-18:** Reduce the abundance of shad in the estuary. ***CRE-8:*** *Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health.*
	Ship ballast practices	**CRE-19:** Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations ***CRE-7:*** *Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.*
Water quality-related threats	Agricultural practices	**CRE-20:** Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.[3] ***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.* ***CRE-9:*** *Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.*
	Urban and industrial practices	**CRE-21:** Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants. **CRE-22:** Restore or mitigate contaminated sites. **CRE-23:** Implement stormwater best management practices in cities and towns.[3] ***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.* ***CRE-9:*** *Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.*
Other threats	Riparian practices	***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.*
	Ship wakes	**CRE-12:** Reduce the effects of vessel wake stranding in the estuary.

[3] Unless otherwise noted, the term *best management practices* is used in this document to indicate general methods or techniques found to be most effective in achieving an objective. NMFS envisions that in implementation, specific best management practices would be developed or recommended.

Research, monitoring, and evaluation (RME) needs related to the 23 management actions are discussed in Chapter 6. As noted there, some of these needs are addressed in an existing document, *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program* (Johnson et al. 2008), while others are identified as new needs specific to the management actions in the module. Together, the existing and new RME activities will provide crucial information on salmonid performance in the estuary, the effectiveness of actions that are implemented in the estuary, associated changes in the ecology of the estuary, and scientific uncertainties that affect implementation of the actions.

Evaluating Management Actions: Relationship of Implementation Constraints to Cost and Survival Improvements

Identifying management actions that could reduce threats to salmon and steelhead as they rear in or migrate through the estuary is an important step toward improving conditions for salmonids during a critical stage in their life cycles. However, actual implementation of management actions is constrained by a variety of factors, such as technical, economic, public health and safety, and property rights considerations. In fact, in some cases it will be impossible to realize an action's full potential because its implementation is constrained by past societal decisions that are functionally irreversible. For example, reclaiming off-channel habitats in the lower Cowlitz River floodplain is constrained by the development of the city of Longview decades ago. An important assumption of the estuary recovery plan module is that the implementation of <u>each</u> of the 23 management actions identified in the module is constrained in some manner.

The module makes another important assumption about implementation: although implementation of actions is constrained, even constrained implementation can make important contributions to the survival of salmonids in the estuary and plume.

It is within the context of these two fundamental assumptions that recovery actions are evaluated in the module, in terms of their costs and potential benefits. The evaluation of survival benefits and costs is highly uncertain because it relies on estimates not only of what is technically feasible, but also of what is socially and politically practical. To help characterize survival improvements, the estuary recovery module uses a planning exercise that involves distributing a plausible survival target across the actions to hypothesize a potential amount of improvement that would result from each action. Costs then are developed by identifying projects for each action and units and per-unit costs for each project. Both the survival improvements and costs reflect assumptions about the constraints to implementation and the degree to which those constraints can be reduced given the technical, social, and political context in the Columbia River basin.

Evaluation Results

The estuary recovery plan module estimates the cost of constrained implementation of all 23 actions over a 25-year time period at $528.05 million. This represents an order-of-magnitude increase over the current level of investment in the estuary and reflects a significant level of effort needed to improve ecosystem health in the estuary and plume over the next 25 years. An additional $64.1 million is identified in Chapter 6 for research, monitoring, and evaluation activities. This effort is necessary because (1) scientific understanding of the estuary and how salmonids respond to conditions there is not yet mature, and (2) the module proposes some innovative management actions whose effectiveness should be explored before they are fully implemented. Thus the total implementation costs for the module are $592.15 million.

Table ES-2 shows the most important management actions for ocean- and stream-type salmonids that emerged from the analysis and planning exercises in the estuary recovery plan module. Many of these key actions are the same for ocean and stream types.

Implementing the suite of key actions in Table ES-2 for ocean-type salmonids would cost approximately $392 million and be expected to achieve approximately 88 percent of the survival target for ocean-type juveniles. (See Chapter 5 for a description of survival targets.) Implementing the suite of key actions for stream-type salmonids would cost approximately $408 million and be expected to achieve 90 percent of the survival target. Additionally, an estimated annual gain of about 1,000 adult salmon and steelhead is associated with the implementation of CRE-14, "Reduce predation by pinnipeds." The lists of priority actions in Table ES-2 for ocean- and stream-type salmonids contain eight actions that are predicted to benefit both types of salmonids. Implementing this common set of actions would cost approximately $372 million and would be expected to yield survival improvements of roughly 3 million juveniles.

TABLE ES-2
Management Actions Most Important for Survival of Ocean- and Stream-type Salmonids

For Ocean Types	For Stream Types
CRE-01: Protect/restore riparian areas.	CRE-01: Protect/restore riparian areas.
CRE-04: Adjust the timing, magnitude, and frequency of hydrosystem flows.	CRE-04: Adjust the timing, magnitude, and frequency of hydrosystem flows
CRE-08: Remove or modify pilings and pile dikes.	CRE-08: Remove or modify pilings and pile dikes.
CRE-09: Protect/restore high-quality off-channel habitat.	CRE-09: Protect/restore high-quality off-channel habitat.
CRE-10: Breach, lower, or relocate dikes and levees.	CRE-10: Breach, lower, or relocate dikes and levees.
CRE-13: Manage pikeminnow and other piscivorous fish.	CRE-13: Manage pikeminnow and other piscivorous fish.
CRE-21: Identify and reduce sources of pollutants.	CRE-21: Identify and reduce sources of pollutants.
CRE-22: Restore or mitigate contaminated sites.	CRE-22: Restore or mitigate contaminated sites.
CRE-02: Mitigate/reduce reservoir-related temperature changes.	***CRE-14: Reduce predation by pinnipeds.***
	CRE-16: Redistribute Caspian terns.
	CRE-17: Redistribute cormorants.

Note: Bold-face italics indicate management actions that would benefit primarily ocean- or stream-type salmonids, rather than both types.

Other Implementation Considerations: Life History Diversity, Cost-Effectiveness, and Achieving Maximum Benefit

It is tempting to pick and choose among the management actions, looking for the path of least resistance to achieve the desired survival improvements. For example, using the results of the Chapter 7 survival improvement planning exercise, it appears obvious that significant improvements in the survival of stream-type salmonids can be achieved by reducing threats associated with predators such as terns, cormorants, pikeminnow, and pinnipeds. However, addressing these threats would improve survival primarily for the dominant life-history strategy displayed by stream-type salmonids; in terms of recovery of ESUs, less dominant stream-type life history strategies also must be addressed. This points to the need to implement additional management actions in the estuary not directly related to predation.

For ocean-type juveniles, management actions that improve the health of the estuarine ecosystem appear to be the linchpin. Ocean-type juveniles reside in the estuary longer than stream types do. As a result, they rely more heavily on a healthy estuarine ecosystem to provide them with food and habitat (Bottom et al 2005). Given the challenges of making wide-scale ecosystem change, significant improvements for ocean-type juveniles may depend largely on three of the most constrained actions: adjusting hydrosystem flows (CRE–4), establishing or improving access to off-channel habitats (CRE-10), and restoring contaminated sites (CRE-22). Although these are some of the most expensive actions, their effects could be far-reaching enough that their potential benefits would be at least commensurate with their high costs.

Finally, because the estuary recovery module (by design) takes an optimistic view about what is possible in terms of reducing the constraints to implementation of management actions, in actuality specific actions probably will not be implemented with the level of effort needed to elicit the desired response. In fact, the most important take-home message of the estuary plan module is that recovery of listed ESUs in the Columbia River may not be possible without properly functioning estuary and plume ecosystems. To achieve a meaningful boost in survival from these ecosystems, every ounce of an action's potential benefit should be explored, and serious consideration should be given to implementing all of the 23 management actions to the fullest extent possible.

CHAPTER 1

The Columbia River Estuary and Plume

Purpose and Development of the Estuary Recovery Plan Module

This estuary recovery plan module is a planning document intended to complement other recovery plans in the region. With few exceptions, the module's focus is limited to habitat conditions and processes in the Columbia River estuary and plume, rather than hatchery or harvest practices, hydroelectricity production, or tributary habitats in the Columbia River basin. The purpose of this estuary recovery plan module is to identify and prioritize habitat-related management actions that, if implemented, would reduce threats to salmon and steelhead in the Columbia River estuary and plume.[1]

Chapter 2 provides background information on salmonid use of the estuary and plume within the context of the entire Columbia River basin. Chapter 3 identifies and prioritizes habitat-related salmon and steelhead limiting factors, and Chapter 4 links these limiting factors to the underlying environmental and human threats that have contributed to declines in abundance in the estuary. Chapter 4 also prioritizes threats based on the priority of the limiting factors they contribute to and their relative contribution to those limiting factors. Chapter 5 describes management actions that have the potential to reduce threats and evaluates the actions in terms of their implementation constraints, potential benefits, and costs. Chapter 6 describes research, monitoring, and evaluation needs, while Chapter 7 integrates elements of the earlier chapters to help characterize scenarios for improving the survival of salmonids as they rear in and migrate through the estuary and plume.

This estuary recovery plan module was developed by PC Trask & Associates, Inc., with participation of staff at the Lower Columbia River Estuary Partnership. The author also coordinated closely with staff at NOAA's National Marine Fisheries Service (NMFS) Northwest Regional Office throughout the module development process and obtained additional guidance and input from NMFS Northwest Fisheries Science Center staff and other regional experts (see Acknowledgements).

In drafting the module, the author reviewed and synthesized information from three main source documents:

- *Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon* (Bottom et al. 2005)—Technical memorandum by the NMFS Northwest Fisheries Science Center

[1] Although current scientific information on the effects of limiting factors and actions does not differentiate between hatchery- and natural-origin salmon and steelhead, or between salmon and steelhead that are listed under the Endangered Species Act (ESA) and those that are not, the intent of the module is to improve the survival of ESA-listed salmon and steelhead. ESA recovery is determined by the status of naturally produced salmon and steelhead.

- *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: An Evaluation of the Effects of Selected Factors on Salmonid Population Viability* (Fresh et al. 2005)—Technical memorandum by the NMFS Northwest Fisheries Science Center
- "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" and its supplement—Northwest Power and Conservation Council (2004)

NMFS Northwest Regional Office staff considered these documents to be timely, comprehensive, and accurate summaries of existing scientific knowledge about the estuary; they proved particularly valuable in providing information about threats and limiting factors affecting salmonids in the estuary.

To clarify key points or address topics that were not included in Bottom et al. (2005), Fresh et al. (2005), and Northwest Power and Conservation Council (2004), the author reviewed additional literature and contacted researchers whose findings were relevant but as yet unpublished; this included researchers at the NMFS Northwest Fisheries Science Center. Area experts (see Acknowledgements) reviewed and helped refine the author's draft products; thus, the module relies heavily on expert opinion rather than an expert panel or "Delphi" process. The author also worked with NMFS Northwest Regional Office and Lower Columbia River Estuary Partnership staff to further revise the module based on comments received during a *Federal Register* public review period. In summary, the final module is a broader, more comprehensive document than the three key source documents and has evolved with input from a diversity of scientists, other specialists, and the public.

Although the estuary recovery plan module is scientifically based, it is primarily a planning document and has important relationships to other planning processes and documents in the region. In the context of Columbia River basin recovery planning, the estuary module provides information on how conditions in the estuary and plume affect the 13 listed Columbia Basin evolutionarily significant units (ESUs). It was distributed in draft form to recovery planning forums around the Columbia River basin, and presentations on the module were made to Oregon's Mid-Columbia Sounding Board, the Upper Willamette Recovery Planning Stakeholder Team, and the Oregon Lower Columbia River Recovery Planning Stakeholder Team.

In the context of lower Columbia River management plans, the estuary recovery plan module is consistent with information in the Northwest Power and Conservation Council's "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" (in *Columbia River Basin Fish and Wildlife Program*, Northwest Power and Conservation Council 2004), the Lower Columbia River Estuary Partnership's *Comprehensive Conservation and Management Plan*, and the Columbia River Estuary Study Taskforce's Columbia River Estuary Data Development Program. In addition, information in the module was used in the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion (BiOp) and later incorporated into the 2010 Supplemental BiOp; information from the module also was used in Washington's Lower Columbia Fish Recovery Board planning process, Oregon's Lower Columbia River recovery planning process, and other recovery planning efforts throughout the Columbia River basin.

The process of identifying and prioritizing management actions in the estuary module has inherent difficulties. Although scientific knowledge about the estuary is advancing, it is still incomplete. In addition, effective management solutions must acknowledge irreversible changes in estuary conditions over time, reflect the social and political will of the region, and focus on the biological and physical needs of the fish. In the final analysis, it is likely that science will never fully explain how every action affects the viability of fish. It will be up to current and future residents of the basin to determine how much they are willing to pay or do without in order to return salmon and steelhead to viable levels.

Formation and Current Characteristics of the Estuary

The geographic scope of the estuary recovery module encompasses areas from Bonneville Dam (River Mile [RM] 146; River Kilometer [RKm] 235) to the mouth of the Columbia River, including the Columbia River plume. The scope includes the lower portion of the Willamette River (from Willamette Falls, at RM 26.6 [RKm 42.6], to the Willamette's confluence with the Columbia River), along with the tidally influenced portions of other tributaries below Bonneville Dam. (Tidal portions of tributaries entering the estuary also are addressed in the Lower Columbia Fish Recovery Board's *Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan* [2010] and Oregon's *Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead* [ODFW 2010] in a manner consistent with the overall framework of this module.)

The Columbia River estuary is a former river valley that, during the last ice age, was carved to 110 meters (360 feet) below current sea level. As sea levels subsequently rose, the floor of the valley was submerged and began to fill with sediments—initially from eastern drainages and then from the Cascade Range. The Missoula Floods, which occurred roughly 15,000 to 13,000 years ago, filled the valley with sand. This was followed by rapid sea level rise, which increased the size of the estuary and allowed further accumulation of mud and sand. By about 9,500 years ago, the rate of sea level rise had declined, the former river valley had filled with sediments, and most suspended sediment and bed load sand arriving from the Columbia River were being transported through the estuary to marine areas via the action of ebb tides and spring freshets, with some suspended sediment being deposited in floodplains and peripheral bays. This pattern continued to the historical period (Petersen et al. 2003).

The historical (circa 1880) total surface area of the Columbia River estuary has been estimated at up to 186 square miles (482 square kilometers) (Thomas 1983, Simenstad et al. 1984 as cited in Northwest Power and Conservation Council 2004). The current estuary surface area is approximately 159 square miles (412 square kilometers) (Northwest Power and Conservation Council 2004). The Willamette River is the largest tributary to the lower Columbia River. Other major tributaries originating in the Cascade Mountains include the Sandy River in Oregon and the Washougal, Lewis, Kalama, and Cowlitz rivers in Washington. Coastal range tributaries include the Elochoman and Grays rivers in Washington and the Lewis and Clark, Youngs, and Clatskanie rivers in Oregon. The general geography of the estuary is shown in Figure 1-1.

FIGURE 1-1
The Columbia River Estuary and Its Major Tributaries
(Reprinted from Bottom et al. 2005.)

Tidal impacts in water levels are observed as far upstream as Bonneville Dam at RM 146 (RKm 235). During low flows, reversal of river flow has been measured as far upstream as Oak Point at RM 53 (RKm 84.8). The intrusion of saltwater is generally limited to Harrington Point at RM 23 (RKm 36.8); however, at lower daily flows saltwater intrusion can extend past Pillar Rock at RM 28 (RKm 44.8).

Today, the lowest river flows occur during September and October, when rainfall and snowmelt are lowest (Northwest Power and Conservation Council 2004). The highest flows occur from April to June and result from snowmelt runoff. High flows also occur between November and March and are caused by heavy winter precipitation. Discharge at the mouth of the river typically ranges from 100,000 to 500,000 cubic feet per second (cfs). Historically, unregulated flows were both lower and higher—79,000 and 1 million cfs, respectively (Neal 1972 and Lower Columbia River Estuary Partnership 2002 as cited in Northwest Power and Conservation Council 2004).

Estuary Reaches

For the purposes of this estuary recovery plan module, the estuary is broadly defined to include the entire continuum where tidal forces and river flows interact, regardless of the extent of saltwater intrusion (Fresh et al. 2005, Northwest Power and Conservation Council 2004). For planning purposes, the upstream boundary is Bonneville Dam and the downstream boundary includes the Columbia River plume. These two divisions—the estuary and plume—have been used extensively in this estuary recovery plan module as distinct zones. Further delineation of the estuary has occurred, including efforts by Thomas (1983), Johnson et al. (2003), and the Lower Columbia River Estuary Partnership (2005).

In this estuary recovery plan module, limiting factors, threats, and management actions are identified at the finest reach level possible. In some cases, this may be as general as making a distinction between the estuary and plume. In other cases, additional definition is available at the reach scale. The Lower Columbia River Estuary Partnership, in conjunction with the University of Washington and U.S. Geological Survey, has developed and is continuing to refine several estuary landscape classifications. Of these overlaying classifications, the estuary recovery module uses the Level 3 Stratum, which organizes the estuary between the mouth and Bonneville Dam into eight lettered reaches (Lower Columbia River Estuary Partnership 2005).

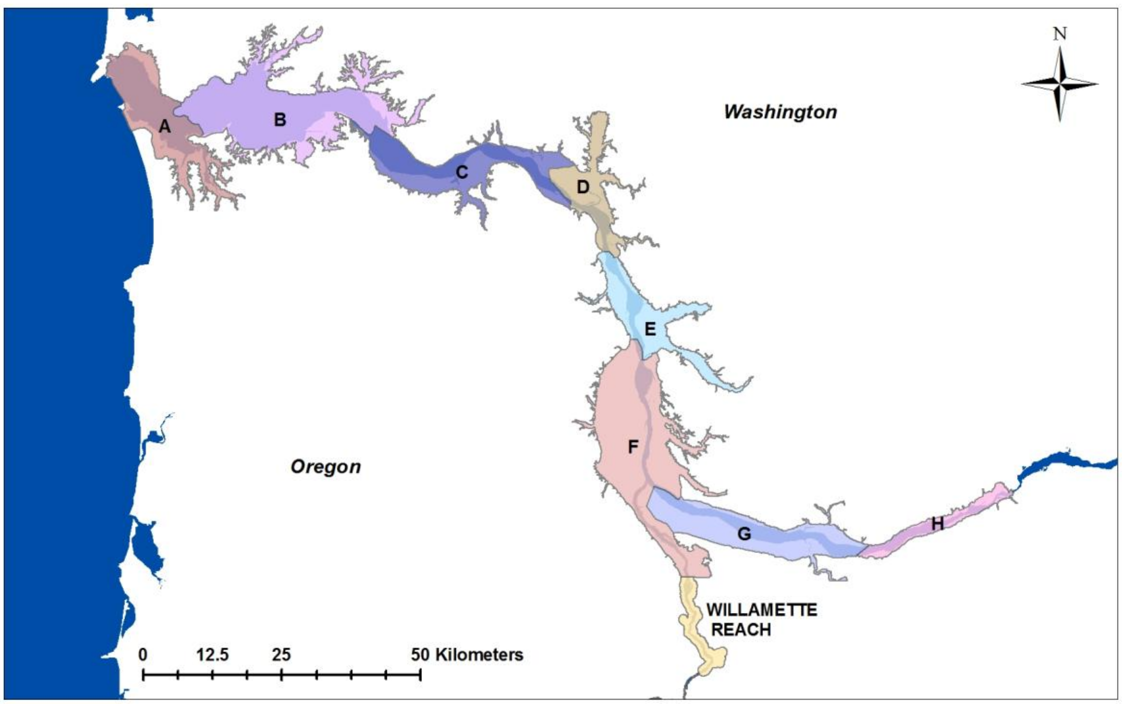

FIGURE 1-2
Lower Columbia River Estuary Reaches
(Adapted from Northwest Power and Conservation Council 2004.)

Figure 1-2 shows these eight reaches, which can be described briefly as follows:

- **Reach A**. This area includes the estuary entrance (Clatsop Spit and Trestle Bay), Bakers Bay, and Youngs Bay. The entrance is dominated by subtidal habitat and has the highest salinity in the estuary. Historically, the estuary entrance was a high-energy area of natural fluvial land forms with a complex of channels, shallow water, and sand bars.

Reach A supports the Columbia River plume, which creates a unique low-salinity, high-productivity environment that extends well into the ocean. The dynamic nature of the entrance area has changed as a result of dredging and the construction of jetties. These activities have limited wave action and the marine supply of sediment.

Historically, ocean currents and wave action made Bakers Bay a high-energy area, but both currents and wave action have been altered by dredging and jetty construction. The migration of mid-channel islands toward the interior of Baker Bay also has sheltered the area from wave action. As a result, tidal marsh habitat has recently started to develop in some areas, although much of the historical tidal marsh and tidal swamp habitat has been lost because of dike construction in the floodplain. Given its proximity to the river mouth, Baker Bay consists primarily of brackish water.

Youngs Bay is characterized by a broad floodplain and historically was abundant in tidal marsh and swamp habitat. Diking and flood control structures have been used to convert floodplain habitat in the area to pasture. The remaining fragmented tidal marsh and tidal swamp habitats in Youngs Bay are thought to be different in structure and vegetative community than historical conditions of these habitats.

- **Reach B**. Reach B generally extends from the Astoria-Meglar Bridge upstream to the westernmost tip of Puget Island. This area includes what has been referred to as the mixing zone (Northwest Power and Conservation Council 2004), along with Grays Bay and Cathlamet Bay. The mixing zone is an area characterized by a network of mid-channel shoals and flats, such as Desdemona and Taylor Sands. It also has the highest variation in salinity within the estuary because of the interactions between tide cycles and river flows. The estuarine turbidity maximum (see p. 3-8), which is created through these interactions, is often located within this area of Reach B. Many islands are found in Reach B, including Tenasillahe, Horseshoe, Marsh, Karlson, Russian, Svensen, Miller Sands, Rice, and Lois islands.

  Grays Bay is found on the Washington side of the river in Reach B. Historically, water circulation in this area was a result of interactions between river flow and tidal intrusion. Pile dike fields constructed adjacent to the main Columbia River navigation channel have decreased circulation in Grays Bay. This circulation change is suspected of causing flooding problems in the Grays and Deep River valley bottoms and may have promoted the beneficial development of tidal marsh habitat in the accreting bay. Dike construction, primarily for pasture conversion, has isolated the main channel from its historical floodplain and eliminated much of the historical tidal swamp habitat.

  Cathlamet Bay is located on the Oregon side of the river in Reach B. This area is characterized by some of the most intact and productive tidal marsh and swamp habitat remaining in the estuary, and a large portion of Cathlamet Bay is protected by the Lewis and Clark National Wildlife Refuge. The western edge of Cathlamet Bay contains part of the brackish oligohaline zone, which is thought to be important during the transition of juvenile anadromous fish from freshwater to saltwater. Portions of Cathlamet Bay have lost substantial acreage of tidal swamp habitat as a result of dike construction. Conversely, tidal marsh habitat has formed along the fringe of dredge disposal locations.

- **Reach C**. This area, which includes deep channels and steep shorelines on the Washington side of the river, extends from the westernmost tip of Puget Island to the western edge of Longview. Historically, Reach C contained significant acres of tidal swamp dominated by sitka spruce. Dike construction and clearing of vegetation have resulted in a substantial loss of tidal marsh habitat on islands and floodplain in the Oregon portion of Reach C. Lord Walker, Hump Fisher, Crims, Wallace and Puget islands are located within Reach C.
- **Reach D**. This area begins west of Longview and ends north of the city of Kalama. Reach D is distinct from the downstream reaches in its geology, vegetation, and climate. It includes flows from the Cowlitz and Kalama rivers. Extensive diking and filling around Longview and the mouth of the Kalama River have significantly reduced access to the floodplain. Islands and shoreline have been extensively modified through the disposal of dredged material. Sediment loading from eruptions of Mount St. Helens have significantly altered hydrology and channel morphology in and downstream of the Cowlitz and Kalama rivers. Dredging and the disposal of sediment from Mount St. Helens have been extensive. The two primary islands in Reach D are Cottonwood and Howard. High levels of polychlorinated biphenyls (PCBs) have been detected in the Longview and Kalama industrial area.
- **Reach E**. This area includes the Columbia River south of the city of Kalama to the confluence with the Lewis River, adjacent to the city of St. Helens, Oregon. The Lewis River system, including the North Fork and East Fork, flows into the Columbia River in Reach E. Sandy, Goat, Deer, Martin, and Burke islands are included in Reach E. Several of these islands, including Sandy and Goat islands, were created through the placement of dredged materials). Extensive diking has occurred on Deer Island and around the city of Woodland, Washington.
- **Reach F**. This area includes the Columbia River south of the confluence with the Lewis River up to and including the mid-point of Hayden Island. Reach F also extends into the Willamette River, to the downstream tip of Ross Island. Reach F is generally rural in character; however, it is located immediately downstream of the most urban/industrial areas in the entire Columbia River. Reach F contains the largest historical floodplain lakes below Bonneville Dam: Sturgeon Lake, at about 3,600 acres, and Vancouver Lake, which is approximately 2,400 acres. The historical floodplain was very wide in Reach F relative to the narrow and constricted channel through the Columbia River Gorge. Islands included in this reach are Bachelor and Sauvie islands. Sloughs include the 13-mile Lake River system and the more than 20-mile-long Multnomah Channel. Scappoose Bay is relatively undiked; however, Sauvie Island and Bachelor Island have been extensively diked. Reach F also includes Portland Harbor, a heavily industrialized stretch of the Willamette River located north of downtown Portland that was listed as a Superfund site in December 2000. Sediments in the river at this site are contaminated with various toxic compounds, including metals, polycyclic aromatic hydrocarbons (PAHs), PCBs, chlorinated pesticides, and dioxin (Oregon Department of Environmental Quality 2008).
- **Reach G**. This area includes the Columbia River west of Hayden Island and extends to just east of Reed Island. Major tributaries include the Washougal and Sandy rivers. The cities of Portland and Vancouver straddle the Columbia River in this reach. Islands included in this reach are Hayden Island, Government Island, Lady Island, and Reed

Island. Extensive diking has reduced the floodplain throughout the reach. Smith and Bybee lakes represent a large floodplain lake system similar to that of Vancouver and Sturgeon lakes in Reach F. Significant numbers of industrial piers and over-water structures line the Columbia rivers in this reach.

- **Reach H**. This area includes the Columbia River from east of Reed Island to the Bonneville Dam. This reach receives flow from many small tributaries, including Gibbons, Duncan, Hamilton, Hardy, and Multnomah creeks. Notable islands in this reach include Ackerman and Skamania islands. Reach H includes the entrance to the Columbia River Gorge, which is characterized by steep slopes. Little diking has occurred in this area, primarily because the steep adjacent slopes on both side of the river have naturally constrained the floodplain.
- **Lower Willamette Reach**. This reach extends upstream from the northern tip of Ross Island to Willamette Falls at RM 26.6 (RKm 42.6). The Lower Willamette reach is highly urbanized, bisecting the city of Portland and flowing past the cities of Milwaukie, Lake Oswego, Gladstone, and Oregon City. Notable islands in the Lower Willamette reach include Ross and Hardtack, Elk Rock, Hog, Cedar, and Goat islands. The primary tributary entering the Lower Willamette reach is the Clackamas River just downstream of Willamette Falls. Other smaller tributaries include Johnson, Tryon, Kellogg, Miller, and Stephens creeks. The shoreline of the Lower Willamette reach has been highly modified for industry, flood control, and other uses. Twelve transportation bridges cross the Willamette River in this reach.

GIS maps of each of the reaches are presented in Appendix A. The maps show additional information such as the locations of pile dikes and some tide gates, the navigation channel, the historical floodplain, diked areas, and dredged material placement sites.

Columbia River Plume

The Columbia River plume is generally defined by a reduced-salinity contour near the ocean surface of approximately 31 parts per thousand (Fresh et al. 2005). In high flows, the plume front is easily recognized by the sharp contrast between the sediment-laden river water and the clearer ocean (see Figure 1-3). The plume's location varies seasonally with discharge, prevailing near-shore winds, and ocean currents. In summer, the plume extends far to the south and offshore along the Oregon coast. During the winter, it shifts northward and inshore along the Washington coast. Strong density gradients between ocean and plume waters create stable habitat features where organic matter and organisms are concentrated (Fresh et al. 2005). The Columbia River plume can extend beyond Cape Mendocino, California, and influences salinity in marine waters as far away as San Francisco (Northwest Power and Conservation Council 2000). For the purposes of this estuary recovery plan module, the plume is considered to be off the immediate coasts of both Oregon and Washington and to extend outward to the continental shelf.

Major Land Uses

A variety of land uses are found adjacent to the Columbia River estuary. The area contains multiple cities and political jurisdictions, including Portland, which is Oregon's largest city, and Vancouver, the fourth largest Washington city. Smaller cities include Astoria, Cathlamet, Longview, Kalama, Woodland, and Camas. Approximately 2.5 million people live in the vicinity of the estuary, and more are coming. Five deep-water ports in the area support a shipping industry that transports 30 million tons of goods annually (Lower Columbia Fish Recovery Board 2004), worth $13 billion each year (Columbia River Channel Improvement Reconsultation Project). Timber harvest occurs throughout the basin—six major pulp mills contribute to the region's economy. Until the early 2000s, aluminum plants along the river produced more than 40 percent of the country's aluminum. Agriculture is widespread throughout the floodplain and includes fruit and vegetable crops along with beef and dairy cattle. Commercial and recreational fishing activity plays an important role in local economies, bringing in millions of dollars of revenue each year. Primary outdoor recreational activities include fishing, wildlife observation, hunting, boating, hiking, and windsurfing.

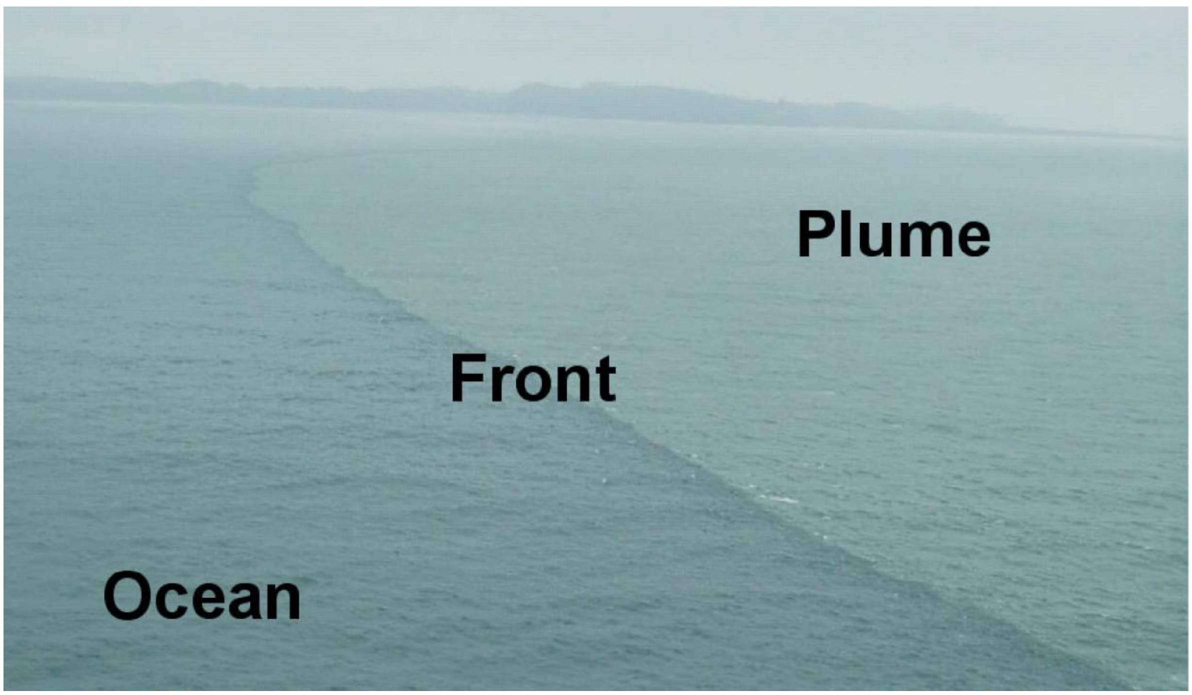

FIGURE 1-3
Plume Front
(Photo courtesy of NMFS.)

Two Centuries of Change

Before Euro-American settlement of the Pacific Northwest, the Columbia River estuary and plume served as a physical and biological engine for salmon. Juveniles from hundreds of populations of steelhead, chum, Chinook, and coho entered the estuary and plume every month of the year, with their timing honed over evolutionary history to make use of habitats rich with food. A beach seine survey during any month of the year would likely have yielded salmon of all species and many populations, with individuals of many sizes. This genetic variation in behavior was an important trait that allowed salmon and steelhead to occupy many habitat niches in time and space. It also guarded populations against catastrophic events such as volcanic eruptions (Bottom et al. 2005).

Today the Columbia River estuary and plume are much different. Notably, the North and South jetties at the mouth of the river restrict the marine flow of nutrients into the estuary. Dikes and levees lining the Washington and Oregon shores prevent access to areas that once were wetlands. New islands have been formed by dredged materials, and pile dike fields reach across the river, redirecting flows. Less visible but arguably equally important are changes in the size, timing, and magnitude of flows that, 200 years ago, regularly allowed the river to top its banks and provide salmon and steelhead with important access to habitats and food sources. Flow factors, along with ocean tides, are key determinants of habitat opportunity and capacity in the estuary and plume.

Salmon have thrived in the Columbia River for up to 1 million years (Lichatowich 1999). In the last 100 years, the entire Columbia River has undergone tremendous change as a direct result of people living and working in the basin. While the threats to salmon persistence are very diverse, at some level it is the increase in human population in the Northwest that underlies every human threat. There are an estimated 5 million people in the Columbia River basin today, and somewhere between 40 million and 100 million people are predicted to be living in the basin by the end of the twenty-first century (National Research Council 2004). If we want healthy salmon runs at the same time that our population is multiplying, our interactions with land and water must pose fewer threats to salmonids than they have in the last 100 years. Before identifying management actions that could do just that, this document discusses which salmonids currently use the Columbia River basin, and how.

CHAPTER 2

Salmonid Use of the Estuary and Plume

The estuary and plume provide salmonids with a food-rich environment where they can undergo the physiological changes needed to make the transition from freshwater to saltwater habitats, and vice versa. Every anadromous salmonid that spawns in the Columbia River basin undergoes such a transformation twice in its lifetime—the first time during its first year of life (or soon after) when migrating out to sea, and the second time 1 to 3 years later, as an adult returning to spawn. The transition zone where juvenile salmonids undergo this transformation is thought to extend from the estuary itself to the near-shore ocean and plume habitats and into rich upwelling areas near the continental shelf (Casillas 1999).

The estuary and plume also serve as rich feeding grounds where juveniles have the opportunity for significant growth as they make the important transition from freshwater to seawater. Studies have shown that juvenile salmon released within the estuary and plume returned as larger adults and in greater numbers than juveniles released outside the transition zone (Emmett and Schiewe 1997 as cited in Casillas 1999). Thus, although juvenile salmonids face risks from a variety of threats in the estuary and plume (see Chapter 4), these environments can be highly beneficial. In the salmon life cycle, successful estuarine and plume residency by juveniles is critical for fast growth and the transition to a saltwater environment.

Clearly, the Columbia River estuary and plume are uniquely important to salmonids, and conditions in the estuary and plume undoubtedly affect salmonid survival. Yet the estuary and plume represent just one in a series of ecosystems that salmon use in their complex life cycle. Exploring the connections among these ecosystems, the habitats they provide, the salmonid species that use them, and the variety of life histories those salmonids display sheds further light on the role of the estuary and plume in the salmonid life cycle.

Salmonid Species in the Columbia River Basin

Before Euro-American settlement, the Columbia River basin was used extensively by six species of the family Salmonidae and the genus *Oncorhynchus*: Chinook, chum, coho, and sockeye salmon plus two trout species: steelhead and sea-run cutthroat (Lichatowich 1999). Within these six species, 13 ESUs,[1] representing more than 150 populations of salmon and steelhead, have been listed as threatened or endangered under the Federal Endangered Species Act (Bottom et al. 2005). All 13 of the ESUs use the estuary and plume as an essential link in their far-reaching life cycles.

[1] NMFS has revised its species determinations for West Coast steelhead under the Endangered Species Act (ESA), delineating steelhead-only “distinct population segments” (DPSs). The former steelhead ESUs included both anadromous steelhead trout and resident, non-anadromous rainbow trout, but NMFS listed only the anadromous steelhead. The steelhead DPS does not include rainbow trout, which are under the jurisdiction of the U.S. Fish and Wildlife Service. In January 2006, NMFS listed five Columbia River basin steelhead DPSs as threatened (71 FR 834). To avoid confusion, references to ESUs in this estuary recovery plan module imply the steelhead DPSs as well.

It is estimated that historically up to 16 million salmon from perhaps hundreds of distinct populations returned to the Columbia River each year (Lichatowich 1999). This contrasts markedly with recent returns of salmon and steelhead adults, which have averaged about 1.7 million, with 65 to 75 percent of those fish being of hatchery origin.[2] For 2006, scientists from the NMFS Northwest Fisheries Science Center estimated that about 168 million juveniles would enter the estuary (Ferguson 2006b).[3] This suggests that only 1 percent of the juveniles entering the estuary will return as adults and 99 percent are lost as a result of all the limiting factors (human and natural) in the estuary, plume, nearshore, and ocean.

Life History Types and Strategies

In discussing salmonids, fish scientists commonly refer to ocean type and stream type to distinguish two main freshwater rearing strategies. Ocean-type salmonids are characterized by migration to sea early in their first year of life, after spending only a short period in freshwater (Fresh et al. 2005). Ocean types may rear in the estuary for weeks or months, making extensive use of shallow, vegetated habitats such as marshes and swamps, where significant changes in flow and habitat have occurred (Fresh et al. 2005). Conversely, stream-type salmonids are characterized by migration to sea after rearing for more extended periods in freshwater, usually at least 1 year (Fresh et al. 2005). Table 2-1 shows the general characteristics of ocean-type and stream-type ESUs.

TABLE 2-1
Characteristics of Ocean- and Stream-Type Salmonids

Attribute	Ocean-Type Fish: fall Chinook, chum	Stream-Type Fish: coho, spring Chinook, steelhead
Residency time	Short freshwater residence Longer estuarine residence Longer ocean residence	Long freshwater residence (>1 year) Shorter estuarine residence Shorter ocean residence
Size at estuary entry	Smaller	Larger
Primary habitat use	Shallow-water estuarine habitats, especially vegetated ones	Deeper, main-channel estuarine habitats; use plume more extensively

Adapted from Fresh et al. 2005.

In the Columbia River estuary, both ocean- and stream-type salmonids experience significant mortality. However, because the two types typically spend different amounts of time in the estuary and plume environments and use different habitats, they are subject to somewhat different combinations of threats and opportunities.

For ocean-type juveniles, mortality is believed to be related most closely to lack of habitat, changes in food availability, and the presence of contaminants, including persistent, bioaccumulative contaminants present in sediments in the shallow-water habitats where ocean-type juveniles rear in the estuary. Stream types are affected by these same factors, although presumably to a lesser degree because of their shorter residency times in the

[2] This is an informal estimate; determining the ratio of hatchery-origin fish with more certainty would require stock-by-stock run calculations averaged over many years.

[3] 2006 was a normative year and is considered representative.

estuary. However, stream types are particularly vulnerable to bird predation in the estuary because they tend to use the deeper, less turbid channel areas located near habitat preferred by piscivorous birds (Fresh et al. 2005), and they are subject to pinniped predation when they return to the estuary as adults (see Chapter 3). Also, scientists at the NMFS Northwest Fisheries Science Center now hypothesize that larger numbers of stream-type yearling juveniles are susceptible to predation by northern pikeminnow than was previously thought; this predation occurs as the juveniles move into the shallows behind structures such as pilings or pile dikes to forage (Casillas 2007); this and related hypotheses are in the process of being tested through a program initiated by the Federal action agencies (the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and Bonneville Power Administration) and the Lower Columbia River Estuary Partnership. Additionally, stream-type salmonids are thought to use the low-salinity gradients of the plume to achieve growth and gradually acclimate to saltwater. Changes in flow and sediment delivery in the plume may affect stream-type juveniles in a way similar to how estuary conditions affect ocean-type juveniles; however, additional research is needed to determine more precisely how stream types use the plume (Casillas 2006).

Fish scientists also describe salmonids in terms of the life history strategies they employ, meaning a population’s unique pattern of preferred spawning substrate, habitat use, migration timing, length of estuarine and marine residency, and so on. For thousands of years, Columbia River salmonids exhibited great diversity in life history strategies, exploiting a wide array of the habitat niches available to them. This rich diversity in life history strategies allowed salmonids to persist as species for millennia even when individual populations were wiped out by disease or natural disturbances such as volcanic eruptions.

Table 2-2 identifies the six basic life history strategies used by salmon and steelhead in the Columbia River and their general attributes.

Changes in Life History Diversity

The 13 listed ESUs in the Columbia River express much less diversity in life history strategies now than they did historically. Formerly, both ocean- and stream-type salmonids entered the estuary and plume throughout the year, at a great variety of sizes, which reflected the various life history strategies in Table 2-2. Today juveniles tend to arrive in pulses and are more uniform in size.

Table 2-3 shows losses in life history diversity in the Columbia River. The table identifies the dominant life history type (ocean vs. stream) and strategies for each ESU, the prevalence of each life history strategy, and whether that prevalence has changed from historical times to the present. The number of life history strategies employed by some ESUs, such as Columbia River chum, have not changed. But for other ESUs—notably the Lower Columbia River coho—several life history strategies that used to exist have been lost. In a research project studying outmigration of juvenile Chinook salmon in the lower Willamette River, results indicated the presence of fry and fingerling juveniles in all months of the year. Although the specific ESUs of these juvenile salmon have not been confirmed, the results indicate more contemporary life history stages present than indicated in Table 2-3 (Friesen et al. 2007).

Losses in life history diversity can also be seen in Figure 2-1, which compares historical and current estuarine life history types for one brood year of Chinook salmon. The figure shows a reduction in the number of strategies available in the contemporary versus historical estimates.

Some of the losses in salmonid life history diversity are attributable to habitat alterations throughout the Columbia River basin that have eliminated entire populations of salmon and steelhead. In other cases, hatcheries and harvest impacts have reduced the health and genetic makeup of species. As a result, many of the populations currently using the estuary and plume are significantly different than the fish that historically used the various habitats available to them, and some existing habitats may not be being used by salmonids at all.

TABLE 2-2
Life History Strategies and Their Attributes

Life History Strategy	Attributes
Early fry	Freshwater rearing: 0 - 60 days Size at estuarine entry: <50 mm Time of estuarine entry: March - April Estuarine residence time: 0 - 40 days
Late fry	Freshwater rearing: 20 - 60 days Size at estuarine entry: <60 mm Time of estuarine entry: May - June, present through Sept. Estuarine residence time: <50 days
Early fingerling	Freshwater rearing: 60 - 120 days Size at estuarine entry: 60 - 100 mm Time of estuarine entry: April - May Estuarine residence time: <50 days
Late fingerling	Freshwater rearing: 50 - 180 days Size at estuarine entry: 60 - 130 mm Time of estuarine entry: June - October, present through winter Estuarine residence time: 0 - 80 days
Subyearling (smolt)	Freshwater rearing: 20 - 180 days Size at estuarine entry: 70 - 130 mm Time of estuarine entry: April - October Estuarine residence time: <20 days
Yearling	Freshwater rearing: >1 year Size at estuarine entry: >100 mm Time of estuarine entry: February - May Estuarine residence time: <20 days

Adapted from Fresh et al. 2005.

TABLE 2-3
Linkage between Salmonid ESU, Dominant Life History Type, and Life History Strategy in the Columbia River Estuary

ESU	Life History Type	Historical and Current Life History Strategies					
		Early Fry	Late Fry	Early Fingerling	Late Fingerling	Sub-yearling	Yearling
Columbia River chum salmon	Ocean	Abundant	Abundant	—	—	—	—
Snake River sockeye salmon	Stream	—	—	—	—	Rare	Abundant
Lower Columbia River coho salmon	Stream	Historically rare, currently absent	Historically rare, currently absent	Historically rare, currently absent	Historically rare, currently absent	Rare	Abundant
Upper Columbia River steelhead	Stream	—	—	—	—	Historically rare, currently absent	Abundant
Snake River steelhead	Stream	—	—	—	—	Historically rare, currently absent	Abundant
Lower Columbia River steelhead	Stream	—	—	—	Historically rare, currently absent	Historically medium, currently rare	Abundant
Middle Columbia River steelhead	Stream	—	—	Historically rare, currently absent	Historically rare, currently absent	Historically medium, currently rare	Abundant
Upper Willamette River steelhead	Stream	—	—	—	—	Historically rare, currently absent	Abundant
Snake River fall Chinook salmon	Ocean	—	—	Historically medium, currently rare	Historically medium, currently rare	Abundant	Historically rare, currently medium
Upper Willamette River Chinook salmon	Ocean	Historically rare, currently absent	Historically rare, currently absent	Historically medium, currently rare	Historically medium, currently rare	Historically rare, currently medium	Abundant
Lower Columbia River Chinook salmon	Ocean	Historically medium, currently rare	Historically medium, currently rare	Historically medium, currently rare	Historically medium, currently rare	Historically medium, currently abundant	Rare
Upper Columbia River spring Chinook salmon	Stream	—	—	Historically rare, currently absent	Historically rare, currently absent	Rare	Abundant
Snake River spring/summer Chinook salmon	Stream	—	—	Historically rare, currently absent	Historically rare, currently absent	Rare	Abundant

"—" = historically and currently absent.
Adapted from Fresh et al. 2005.

Relationship of the Estuary to the Columbia River Basin

In 2005, scientists working at the NMFS Northwest Fisheries Science Center published a technical memorandum that establishes an ecologically based conceptual framework for understanding the estuary within the larger context of the Columbia River basin. In *Salmon* *at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon*, Bottom et al. (2005) hypothesize that Columbia River salmon's resilience to natural environmental variability is embodied in population and life history diversity, which maximizes the ability of populations to exploit available estuarine rearing habitats. Bottom et al.'s conceptual framework is based on Sinclair's (1988) member/vagrant theory, which proposes general principles for understanding marine species with complex life cycles. The member/vagrant theory serves as a useful tool for evaluating salmon's specific needs in estuaries in relation to the entire continuum of their habitat needs throughout their complex life cycles (Bottom et al. 2005).

Bottom et al. (2005) hypothesize that how an individual salmon or steelhead uses the ecosystems it encounters—when juveniles migrate, how big they are, what habitats they use, and how long they stay in a particular habitat—correlates directly to the discrete population of fish that individual is part of. In other words, different populations within ESUs employ different life history strategies. For example, two populations of steelhead within an ESU may produce juveniles of different sizes that enter the estuary at different times, and these juveniles may use distinct habitats that may be available only at that particular time.

Considering that the estuary is just one of three major ecosystems used by salmon and steelhead, the member/vagrant theory implies that how juveniles migrate and use estuarine habitat may depend as much on the status of upriver habitats and corresponding populations as on environmental conditions in the estuary itself (Bottom et al. 2005). In other words, if there is a close relationship between particular geographical features in the estuary and the life history of a discrete salmonid population, use of the estuary may reflect the abundance and life history strategy of the associated population, which is in part a function of upstream conditions. Thus, if salmonid migration and rearing behaviors in the estuary are linked to specific geographic features and those features are reduced or eliminated, mortality in the population that uses those features increases (Bottom et al. 2005). By the same token, if salmonid populations are lost because of other factors (such as blockage by dams), habitats in the estuary may be left unoccupied.

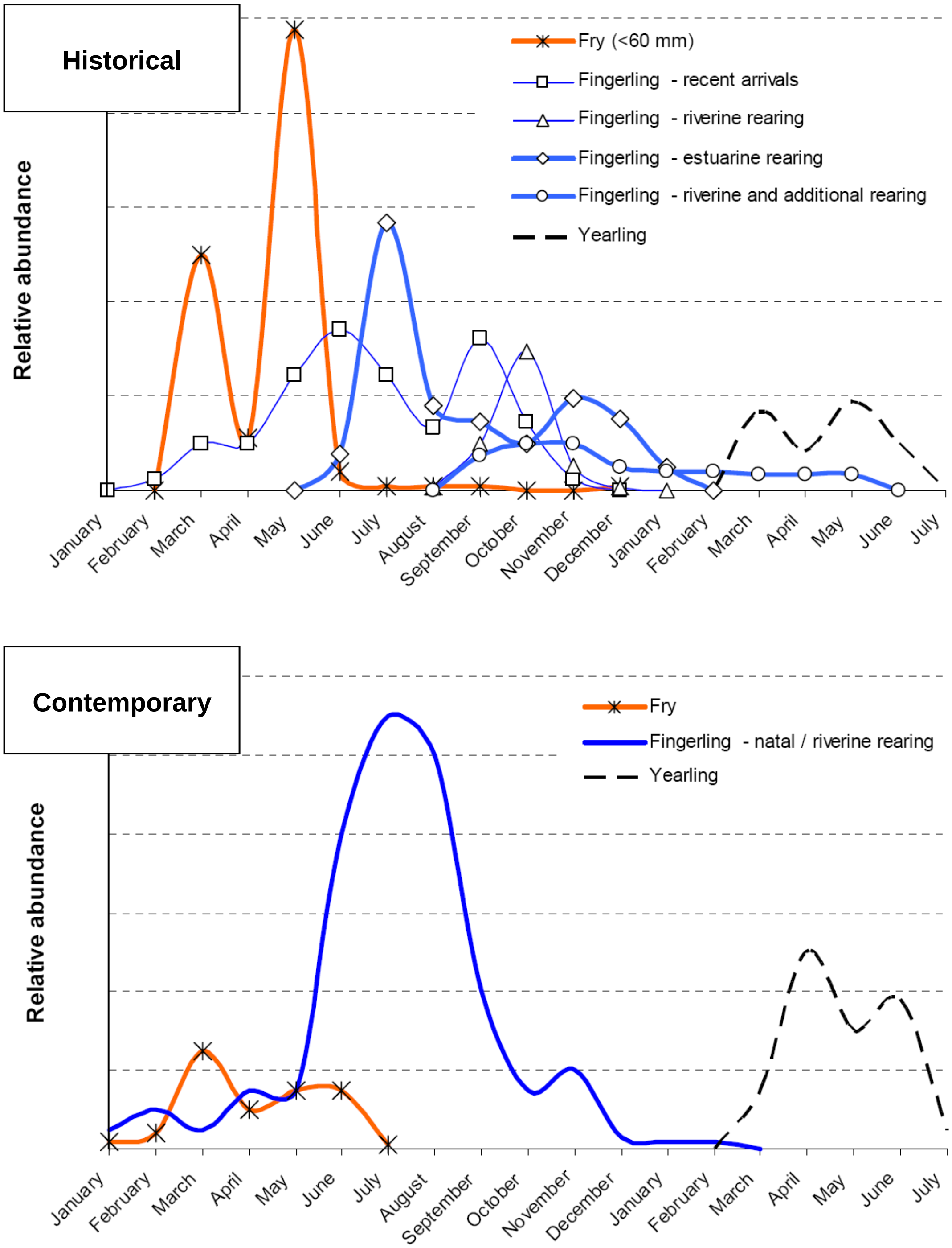

FIGURE 2-1
Historical and Contemporary Early Life History Types of Chinook Salmon in the Columbia River Estuary
(Reprinted from Fresh et al. 2005.)

The implication for salmon recovery in the Columbia River basin is that habitat use by salmonids must be considered from a multi-ecosystem perspective if we are to understand which components of each ecosystem—tributaries, mainstem, estuary, plume, nearshore, and ocean—are limiting the overall performance of salmon.

Summary

Since 1991, 13 Columbia River ESUs have been listed as threatened or endangered under the Federal Endangered Species Act. During their complex life cycles, salmon and steelhead rely on many diverse ecosystems, from tributaries to ocean environments, that span hundreds or thousands of miles. For recovery efforts to be successful, it is necessary to understand salmonids' requirements during all stages of their life cycles. Thus, although the estuary and plume represent important stages in the salmonid life cycle, these ecosystems must be considered within the context of other life cycle stages if management actions are to be effective. Perhaps most central to the recovery of listed ESUs is the importance of conserving biological diversity and the native ecosystems it depends on (Bottom et al. 2005).

CHAPTER 3

Limiting Factors

Chapter 3 identifies and prioritizes the key habitat-related physical, chemical, or biological features that scientific literature and area experts suggest are affecting the viability of ESUs and their component populations in the estuary. These features are referred to as limiting factors.[1] The discussion of limiting factors in this chapter pertains to the estuary and plume; however, upstream limiting factors in some cases have a direct bearing on conditions in the estuary. Discussion of limiting factors in this chapter generally relates to specific factors that limit salmonid productivity; however, it is recognized that the effects of multiple limiting factors may have a compounding effect. The estuary module does not address this compounding effect because of a lack of technical information to address the topic.

Determining Estuary Habitat Limiting Factors

Sources

It would be desirable to know with certainty which factors are responsible for the highest losses of salmon and steelhead in the estuary so that recovery actions could be focused on activities to address those factors. But as described below, researchers have quantified salmonid mortality in the estuary for only a few limiting factors, and additional research on mortality is needed to understand which factor (or factors) is most limiting salmonid viability in the estuary. In the absence of more comprehensive mortality data, the estuary recovery module relies on expert opinion and available information in the literature to identify and prioritize limiting factors.

PC Trask & Associates, Inc., based this chapter on a thorough review and synthesis of pertinent literature, supplemented by input from staff at the NMFS Northwest Fisheries Science Center and Northwest Regional Office, the Lower Columbia River Estuary Partnership, and the Lower Columbia Fish Recovery Board. The following documents, among others, provided consistent guidance:

- *Salmon at River's End: The Role of the Estuary in the Decline and Recovery of Columbia River Salmon* (Bottom et al. 2005)—Technical memorandum by the NMFS Northwest Fisheries Science Center
- *Role of the Estuary in the Recovery of Columbia River Basin Salmon and Steelhead: An Evaluation of the Effects of Selected Factors on Salmonid Population Viability* (Fresh et al. 2005)—Technical memorandum by the NMFS Northwest Fisheries Science Center
- "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" and its supplement—Northwest Power and Conservation Council (2004)

These three literature sources, and others, identified and evaluated limiting factors in a similar manner. But it should be noted that the three sources have separate goals, and this

[1] In this module, the term "limiting factors" is used to indicate the full range of factors that are believed to be affecting the viability of salmon and steelhead in the estuary and not to indicate the single factor that is most limiting.

affects each document's structure and content. Thus, the depth and breadth of information were not always consistent across documents. To develop a relatively comprehensive list of factors that are limiting ESUs' viability in the estuary and to weigh the probable effect of each factor, the author had to synthesize information from multiple sources.

Mortality Estimates

Estimates of salmon and steelhead mortality in the estuary and mainstem are not well supported in the literature, especially in the case of indirect mortality. (There are more reliable estimates of direct impacts to salmonids populations than indirect or combined impacts.) However, some modeling efforts have made assumptions about estuary mortality. One example is Ecosystem Diagnosis and Treatment (EDT), a life-cycle model that accounts for the estuarine stage of salmon and steelhead in tributaries of the Columbia River. For lower Columbia River ESUs, EDT assumes 18 to 58 percent mortality for various populations.

In addition, research is under way by NMFS, the U.S. Army Corps of Engineers, and Battelle Laboratories to estimate the survival rate of juvenile salmonids in the lower Columbia River. This research involves technologies for miniaturizing acoustic tags to a size capable of tracking yearling and subyearling juveniles. Current technology developed for the project allows for the tracking of subyearlings of sizes down to approximately 90 mm. Data from 2005 indicated an approximate range of survival of 65 to 75 percent for subyearlings and yearlings during their residency in the estuary (Ferguson 2006a).[2] It is probable that actual survival rates are lower than these estimates suggest because the research did not address mortality among juveniles smaller than 90 mm, mortality occurring in the plume and nearshore, or delayed mortality.

There are reliable mortality estimates for a few limiting factors. For example, Caspian tern predation was estimated to be responsible for the mortality of about 5.5 million smolts in 2007 (Roby et al. 2008)—up to 14.1 percent of in-river migrant steelhead smolts and 7.7 percent of transported steelhead smolts (Roby et al. 2008). Double-crested cormorants appear to be consuming approximately 6 percent of steelhead, 6 percent of subyearling Chinook, 2 percent of yearling Chinook, and 1 percent of sockeye salmon entering the estuary (Fredricks 2010).

Other limiting factors, such as pinnipeds (primarily affecting adult survival), ship wake stranding, and toxic contaminants, have incomplete mortality estimates associated with them. Toxic contaminants, for instance, can have lethal and sublethal impacts to salmonids, resulting in direct and indirect mortality, both of which are difficult to quantify. In most cases it is very difficult to point to a specific limiting factor and then estimate mortality. This is because of the inherent complexity associated with connecting the physical, chemical, and biological features that limit the productivity of salmon and steelhead.

[2] The mean yearling survival estimate for the years 2005 to 2009 is 75.8 percent (standard deviation = 5.4 percent), while the mean subyearling survival estimate for the same period is 67.6 percent (standard deviation = 9.0 percent) (Casillas 2010). Because these more current survival estimates are very close to the estimates used when the module was initially drafted, and because local recovery planners in the Washington and Oregon Lower Columbia region incorporated the 2005 estimates into their salmon recovery plans, the module was not updated with the most current numbers. In future revisions of the module and the Lower Columbia tributary plans, needed updates will be made.

Density-Dependent Mortality

In the Columbia River estuary, limiting factors such as off-channel habitat availability, competition with native and exotic fish for food and space, disease, and predation by piscivorous fish and native birds may in part be manifestations of density dependence. Density dependence refers to changes in the size of a population that are themselves a result of the size of the population, such as when a population declines because it has exceeded the amount of resources available to support it. Density-dependent mortality can occur through several mechanisms, such as direct competition for limited food and habitat and changes in the foraging activity of predators. With salmon and steelhead, density-dependent mortality can occur at any stage in the animal's life cycle and may be exacerbated by the introduction of large numbers of hatchery fish released over a relatively short period of time, or by the cumulative effects of such releases on natural-origin salmon.[3]

How much density-dependent mortality is taking place in the estuary compared to in the ocean is unclear. There is some evidence that density-dependent mortality is occurring in the open ocean. For example, during years when salmon are especially numerous in the ocean, their growth rates are reduced (Peterman 1984 as cited in Ford 2007). One study found that, during years when nearshore ocean productivity was low, survival of wild Snake River Chinook decreased as releases of hatchery Chinook increased (Levin et al. 2001 as cited in Ford 2007). However, another study found no connection between ocean conditions and density-dependent mortality, which appeared to be occurring among wild Snake River Chinook as hatchery steelhead were released (Levin and Williams 2002 as cited in Ford 2007). The authors suggested that the apparent density-dependent mortality could be better explained by interactions in the tributaries or estuary than by interactions in the ocean.

There is growing awareness among scientists studying the Columbia River estuary that mechanisms related to density dependence may limit salmon and steelhead while they are using estuary and plume habitats. Scientists studying Skagit River fall Chinook have documented density dependence-related mortality as a result of loss of habitat in the Skagit estuary and believe that such mortality can be attributed to a 75 percent loss of tidal delta estuarine habitat (Beamer et al. 2005). With similar habitat losses in the Columbia River estuary, it is possible that too many fish are competing for limited habitat and associated resources in the estuary at key times, and that the resulting stressors translate into reduced salmonid survival. The NMFS Northwest Fisheries Science Center currently is investigating potential density-dependent mortality in the estuary. The "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" raised the specter of density dependence in the estuary and recommended continued research to analyze conditions there (Northwest Power and Conservation Council 2004). Thus, although the occurrence of density dependence-related mortality in the Columbia River estuary has not been proven, given the dramatic changes in habitat opportunity and capacity in the estuary over the last 200 years, it is likely that some of the mortality associated with the limiting factors described in this chapter is related to increased density of juveniles in the estuary.

3 It is also possible that inverse density dependence processes occur in some situations. For example, large numbers of adult salmon could swamp marine mammal predators at Bonneville Dam, and the adult survival rates could be higher than in scenarios with smaller numbers of adult fish.

Consistent with this concern, the NMFS Northwest Region Salmon Recovery Division and Northwest Fisheries Science Center are working to better define and describe the scientific uncertainty associated with ecological interactions between hatchery-origin and natural-origin salmon in freshwater, estuarine, and nearshore ocean habitats. Needs include an assessment of the state of the science to help identify priority research on the ecological interactions between hatchery-origin and natural-origin salmon in these habitats and to better define the ecological risks of such interactions. A conference on ecological interactions between hatchery-origin and natural-origin salmon held in May 2010 in Portland, Oregon, contributed to describing the state of the science on these interactions. Conference proceedings will be published and priority research needs identified. Follow-up workshops will help refine the assessment, develop specific research plans, and identify funding sources.

The estuary recovery plan module assumes that density-dependent mortality that may be occurring in the estuary is manifested in part through limiting factors related to habitat availability, competition for food and space, disease, and predation. Given the uncertainty about the mechanisms and effects of density dependence in the estuary, density dependence itself is not included as a limiting factor in the module. Neither are the effects of hatchery fish. Although it is likely that hatchery fish influence the estuarine survival of naturally produced fish (possibly through mechanisms of competition, predation, and disease transfer), the focus of this estuary recovery plan module is the effects of habitat conditions and processes in the estuary and plume, rather than the effects of hatchery or harvest practices. But the degree of density-dependent mortality occurring in the estuary, the role of large releases of hatchery fish, and the cumulative impact of hatchery releases on density-dependent mechanisms are worth exploring through further research.

Habitat-Related Limiting Factors

Salmonid populations exhibit diverse strategies that guide them through various habitats and ecosystems in specific sequences and patterns. If those sequences and patterns are interrupted, increased mortality may result. Thus, mismatches between the needs of salmonid populations and the availability of habitats to meet those needs can limit salmonid performance in the estuary and plume. The member/vagrant theory discussed in Chapter 2 underscores the need to consider relationships between ESUs' life history strategies and the quality, quantity, and availability of habitats in the estuary and other ecosystems that are interconnected via the salmon and steelhead's complex life cycle.

The habitats that salmonids occupy during their residency in the estuary and plume are formed through the interaction of ocean forces, land, and river flow (Fresh et al. 2005). Flows entering the estuary govern the general availability of habitats, along with sediment transport, salinity gradients, and turbidity, which are themselves aspects of habitat or habitat formation. Over the last 200 years, the magnitude, timing, and frequency of flows have changed significantly, with corresponding effects on the formation and availability of salmonid habitats. Some habitat has been removed, which has reduced the total acreage of the estuary by approximately 15 percent (Fresh et al. 2005). In other cases, particular habitat types have been transformed into other habitat types, and the resulting mosaic of habitats may not be meeting the needs of salmonids as well as the historical pattern of habitats did. For example, approximately 77 percent of historical tidal swamp has been lost (Northwest

Power and Conservation Council 2004), while other shallow-water habitats have increased significantly. The loss of tidal swamps and other forested or vegetated wetlands represents a loss of habitat that ocean-type salmonids use during their estuarine residence. In short, habitat opportunity and capacity have been degraded in the estuary and plume, and alterations in flow have contributed significantly to losses in in-channel, off-channel, and plume habitat. An accurate accounting of specific habitat type changes from pre-European settlement to the present day has not been initiated estuarywide. This measurement of change is important to guiding restoration priorities and represents a significant data gap in the estuary.

An important goal of this estuary recovery module is to describe the various habitats and limiting factors that both ocean- and stream-type juvenile salmonids encounter in the Columbia River estuary and plume. However, current scientific understanding of how stream-type juveniles use the various habitats they encounter in the estuary and plume is less robust than what is known about ocean types' habitat use. To fill this important knowledge gap, the NMFS Northwest Fisheries Science Center and others are exploring how stream-type juveniles expressing all the different possible life history strategies use individual estuarine habitats.

Affected salmonids: Because of their longer estuary residence times and tendency to use shallow-water habitats, ocean-type ESUs are more affected by flow alterations that structure habitat and/or provide access to wetland or floodplain areas than are stream-type ESUs. Stream types have relatively short estuary residence times and use the plume much more extensively than ocean types do. Thus stream-type salmonids are affected by habitat elements such as the shape, behavior, size, and composition of the plume (Fresh et al. 2005).

Reduced In-Channel Habitat Opportunity

In-channel habitat opportunity in the estuary is a function of the size of river flows, the timing of river flows, incoming and outgoing tides, and the amount and patterns of sediment accretion. Together, tidal action, river flow, and sediment movement create a constantly changing mosaic of channel habitats as water levels rise and fall, sands shift, and salinity gradients move in response to tides. To support salmonids, the various habitats in the estuary need to be connected both spatially and in time. With twice-daily tidal fluctuations, areas that are accessible at one point during the day can be inaccessible 6 hours later or can trap salmonids, exposing them to higher water temperatures and lower dissolved oxygen levels that can result in stress or mortality. Changes in both flow and sediment transport have reduced in-channel habitat opportunity.

Limiting Factor: Flow-Related Estuary Habitat Changes. The ability of juvenile salmon to access and benefit from habitat depends greatly on instream flow (Fresh et al. 2005). Changes in the quantity and seasonality of flows in the estuary have a direct bearing on whether key habitats are available to salmonids, when and how long those habitats are available, and whether and how they connect with other key habitats. In addition, juvenile salmonids have physiological or behavioral traits that set the timing for their transformation to saltwater, and changes in flows may interrupt this timing.

Both the quantity and timing of instream flows entering the Columbia River estuary and plume have changed from historical conditions (Fresh et al. 2005). Jay and Naik (2002) reported a 16 percent reduction of annual mean flow from 1878 to the present and a 44 percent reduction in spring freshet flows. Jay and Naik also reported a shift in flow patterns in the Columbia to 14 to 30 days earlier in the year, meaning that spring freshets are occurring earlier in the season.[4] In addition, the interception and use of spring freshets (for irrigation, reservoir storage, etc.) have caused increased flows during other seasons (Fresh et al. 2005). These changes in the volume and timing of Columbia River flow are limiting factors for salmon and steelhead and have affected habitat opportunity and capacity in the estuary and plume. It is likely that global climate change will contribute to further flow-related changes in estuary habitat. However, changes in flow entering the estuary as a result of climate change are expected to be less than those caused by construction of the hydrosystem (Independent Scientific Advisory Board 2007).

Limiting Factor: Sediment/Nutrient-Related Estuary Habitat Changes. The transport of sediment is fundamental to habitat-forming processes in the estuary through sediment deposition and erosion (Fresh et al. 2005). An estuary's form is altered primarily through the deposition of sediment—either sediment that is reworked from other parts of the estuary or sediment that enters the estuary from the watersheds or ocean. Sediment moves among each of the components within the estuary, allowing the estuary as a whole to continually be adjusting toward some long-term equilibrium form in response to changes in physical or geomorphic processes (Philip Williams & Associates and Farber 2004). Sediment from the estuary and upstream sources also affects the formation of nearshore ocean habitats north and south of the Columbia River entrance.

Since the late nineteenth century, sediment transport from the interior basin to the Columbia River estuary has decreased about 60 percent and total sediment transport has decreased about 70 percent (Jay and Kukulka 2003). This reduction in the amount of sediment transport in the Columbia River has affected habitat-forming processes in the estuary and plume (Bottom et al. 2005) and is presumed to be a limiting factor for salmon and steelhead because it limits the accretion of sediment and thus the formation of shallow-water habitats. Although the consequences of the reduced transport of sediment through the estuary and plume are not fully understood, the magnitude of change is very large compared to historical benchmarks (Fresh et al. 2005).

Sediment also provides important nutrients that support food production in the estuary and plume. Microdetrital food particles adhere to sediment suspended in the water column, making different food sources available to different species than was the case historically. Currently, organic matter associated with fine sediments supplies the majority of estuarine secondary productivity in the food web (Simenstad et al. 1984 as cited in Northwest Power and Conservation Council 2004).

Reduced Off-Channel Habitat Opportunity

Columbia River access to its historical floodplain is an important factor for rearing ocean-type juvenile salmonids. Stream-type juvenile salmonids also are believed to benefit from access to off-channel habitats, which support less dominant stream-type life histories and provide food resources for stream types during downstream migration (Bottom et al. 2005).

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[4] These analysis were calculated by comparing observed flow (data from a gauge), estimated adjusted flow (observed flow corrected for reservoir manipulations), and estimated virgin flow (estimate of river flow without human alteration).

Historically, flows that topped the river's bank provided juvenile salmonids with access to low-velocity areas in the lower river and estuary that juveniles used as refugia and for rearing; many of these areas were dominated by Sitka spruce tidal swamps, which were an integral component of the estuarine ecosystem. Overbank flows contributed key food web inputs to the ecosystem and influenced wood recruitment, predation, and competition in the estuary (Fresh et al. 2005).

Today, mainstem habitat in the Columbia and Willamette rivers has, in many cases, been reduced to a single channel (Northwest Power and Conservation Council 2004), and channelization of the estuary has eliminated access to an estimated 77 percent of historical tidal swamps (Fresh et al. 2005). In fact, over the past 200 years the surface area of the estuary has decreased by approximately 20 percent (Fresh et al. 2005).

The near elimination of overbank flooding is a function of both reductions in peak freshet flows (as a result of flow regulation for electricity generation, storage for irrigation and municipal use, and flood control) and increases in the bankfull level of the Columbia River (as a result of dikes and levees), among other factors.

Figure 3-1 shows diked areas from the estuary mouth to Bonneville dam. This map was generated from a GIS database developed by the University of Washington, U.S. Geological Survey, and Lower Columbia River Estuary Partnership that provides statistics and maps depicting the historical floodplain, diked areas, dredged material disposal sites, over-water structures, contaminant monitoring sites, and other key features in the estuary. Some of these features are shown in GIS-based reach maps presented in Appendix A.

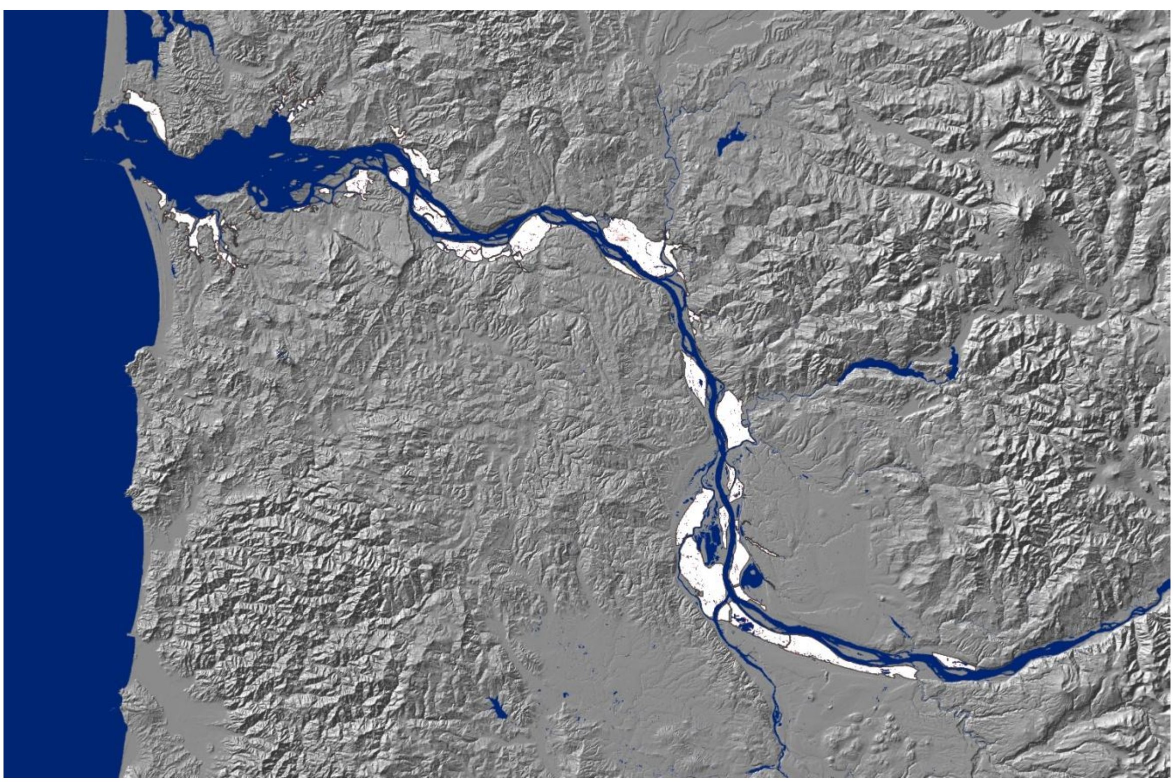


FIGURE 3-1
Diked Areas in the Columbia River Estuary
(Source: Lower Columbia River Estuary Partnership 2005.)

Limiting Factor: Flow-Related Changes in Access to Off-Channel Habitat. Reduced access to off-channel habitats is a limiting factor for salmon and steelhead because of impacts on food webs and the reduced availability of habitats preferred by fry and fingerlings. Typically, overbank flows were driven by spring freshets, which occurred at the time of year when there was the greatest variety of juvenile salmon and steelhead using the estuary (Fresh et al. 2005). Overbank flows occur much less frequently now than they did historically, in part because climate changes and human alterations have reduced the number of high flows in the Columbia (Jay and Kukulka 2003).

Limiting Factor: Bankfull Elevation Changes. The construction of levees also has reduced the frequency of overbank flows because more river water is needed to cause overbank flow. Historically the bankfull level was 18,000 $m^3 s^{-1}$, while today it is 24,000 $m^3 s^{-1}$—fully one-third more. Only five overbank events have occurred since 1948 (Jay and Kukulka 2003). The reduction in overbank events is a limiting factor because it reduces the availability of food and refugia for ocean-type juveniles rearing in the estuary. Less dominant stream-type juveniles are affected in the same manner.

Reduced Plume Habitat Opportunity

Evidence suggests that the plume supports ocean productivity by increasing primary plant production during the spring freshet period, distributing juvenile salmonids in the coastal environment, concentrating food sources such as icthyoplankton (megalopae, for example) and zooplankton, and providing refugia from predators in the more turbid, low-salinity plume waters (Fresh et al. 2005). Changes in the volume and timing of Columbia River flow have altered both the size and structure of the plume during the spring and summer months (Northwest Power and Conservation Council 2000).

Limiting Factor: Flow-Related Plume Changes. For juvenile salmonids preparing for ocean life, the plume is believed to function as habitat, as a transitional saltwater area, and as refugia. As mentioned earlier, stream-type ESUs in particular are affected by the size, shape, behavior, and composition of the plume (Fresh et al. 2005).

Over the past 200 years characteristics of the plume have been altered, and conditions caused by reductions in spring freshets and associated sediment transport processes may now be suboptimal for juvenile salmonids (Casillas 1999). Plume attributes affected by changes in flow include surface areas of the plume, the volume of the plume waters, the extent and intensity of frontal features, and the extent and distance offshore of plume waters (Fresh et al. 2005).

Limiting Factor: Sediment/Nutrient-Related Plume Changes. It is believed that the sediment and nutrients transported in the plume fuel salmon productivity in the ocean and provide relief from predation (Casillas 1999). This is particularly true for stream-type ESUs, who use the plume more extensively than ocean types do and thus are more affected when the amount of plume habitat is reduced.

Limiting Factor: Water Temperature

Higher water temperatures have reduced habitat quality for salmonids that use the estuary during summer months. Since 1938, average summer water temperatures at Bonneville Dam have increased 4° F (2.2° C) (Lower Columbia Fish Recovery Board 2004). Among-year variability in temperature has been reduced by 63 percent since 1970 (Lower Columbia Fish Recovery Board 2004). As shown in Figure 3-2, temperatures entering the estuary (as measured at Bonneville Dam) have increased steadily since 1938. Temperatures also exceed 20° C (68° F) earlier during the year and more frequently than they did historically (National Research Council 2004).

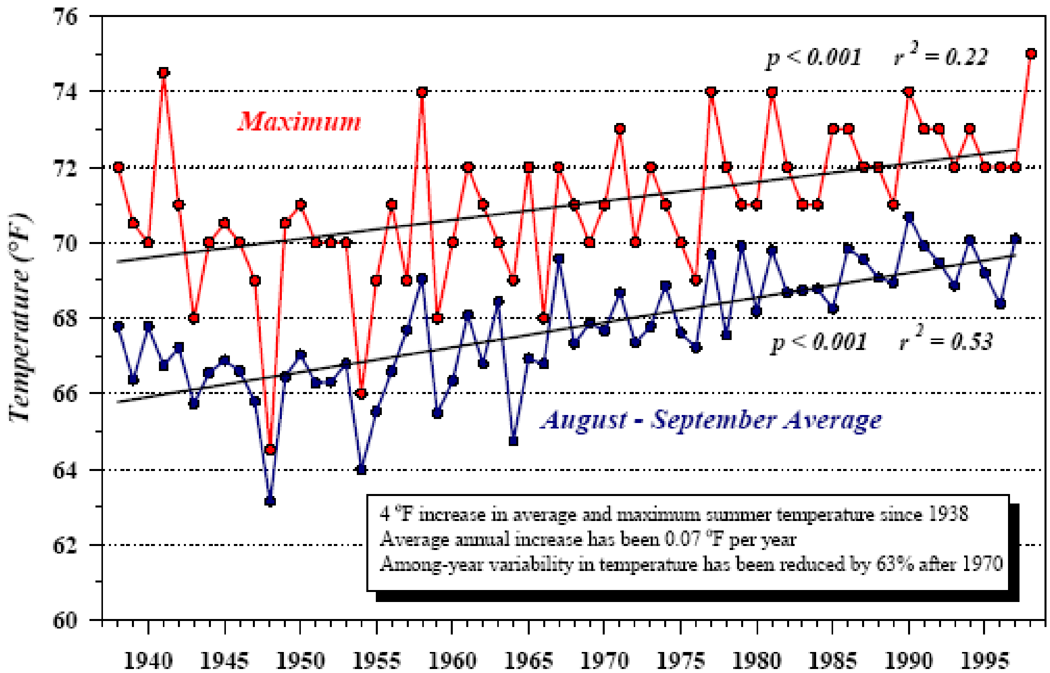


FIGURE 3-2
Temperatures of Water Entering the Estuary
(Reprinted from Lower Columbia Fish Recovery Board 2004.)

(Water temperatures of 20° C (68° F) are considered the upper thermal tolerance limit for cold-water species such as salmonids (National Research Council 2004). Pacific salmon can suffer adverse physiological and behavioral effects as a result of persistent, intermittent, or cumulative exposure to high water temperatures, or from increased daily variation in water temperature (McCullough 1999). Temperatures above 18° C (64.4° F) can impair the metabolism, growth, and disease resistance of salmonids, as well as alter the timing of adult migrations, fry emergence, and smoltification (McCullough et al. 2001, Sauter et al. 2001). Other effects of high water temperatures include adult mortality, reduced pre-spawning survival of eggs and sperm, difficulty competing with non-salmonid fish, prevention or reversal of smoltification, and harmful interactions with certain other habitat stressors (Marine 2004, McCullough 1999, Dunham et al. 2001, Materna 2001, McCullough et al. 2001, and Sauter et al. 2001). For example, the toxicity of some contaminants increases at high water temperatures, and levels of dissolved oxygen go down. Adult sockeye have been known to suffer stress and disease as they are exposed to warm water in estuaries, waiting for cool runoff conditions in their natal stream (Independent Scientific Advisory Board 2007). Warmer temperatures may also enhance conditions for warm-water fish that prey on or compete with juvenile salmonids (Independent Scientific Advisory Board 2007) and cause other changes in the estuarine food web.

During the next century, it is likely that global climate change will contribute to continued water temperature rises in the Columbia River basin as precipitation increasingly falls as rain rather than snow, snow pack diminishes, peak flows increase, and late-summer/early-fall flows are reduced (Independent Scientific Advisory Board 2007). (See Chapter 4 for more on the expected effects of global climate change in the Columbia River basin and estuary.)

Limiting Factor: Stranding

In the estuary, large ships passing through the navigational channel produce bow waves that crash against shorelines in Oregon and Washington. Small ocean-type fry and fingerlings rear within inches of shore and may become stranded as waves intersect the bank and recede (Ackerman 2002), although the extent of this problem is unclear. A 1977 study by Washington Department of Fisheries (WDF) observed 2,397 juvenile salmonids—mostly Chinook—stranded as a result of passage of 216 deep draft vessels (Bauersfeld 1977).

A NOAA technical memorandum (Hinton and Emmett 1994) published in 1994 concluded that the problem was not as significant as documented in the WDF report. Hinton and Emmett found only five juvenile salmonids stranded after observing 145 vessels. A third study, conducted for the U.S. Army Corps of Engineers, observed 21 juvenile Chinook salmon stranded at two sites (Ackerman 2002). In one occurrence, 10 juveniles were stranded by one vessel. As part of the channel deepening project being conducted by the U.S. Army Corps of Engineers, a two-part study of stranding was initiated by the University of Washington and the Portland District of the Corps. The study is designed to measure differences in stranding events before and after channel deepening activities. The first study was published in February 2006 (Pearson et al. 2006). In general, the report documents mortality attributed to stranding events for three test sites; it also builds on other work to determine the conditions that increase the likelihood of stranding events.

Early in 2008, the Port of Vancouver enlisted Entrix, Inc., to perform a spatial analysis of beach susceptibility for the stranding of juvenile salmonids by ship wakes (Pearson 2008). The study examined wave characteristics and the geomorphology of the lower river but did not examine nearshore fish density. The purpose of the study was to estimate the number of miles of shoreline that exhibit traits expected to potentially cause stranding. The study concluded that approximately 33 miles of shoreline between the mouth of the river and the city of Vancouver have shoreline characteristics consistent with stranding (Pearson 2008).

Food Web-Related Limiting Factors

Energy released from the Columbia River and the ocean converges in the estuarine and plume environments where, combined with the biological energy of primary plant production, it forms the basis for life in the estuarine ecosystem. Ultimately, energy that is transferred through the estuarine food web begins with sunlight; sunlight, minerals, and nutrients lead to plant growth in primary production; plants are eaten by animals and animals are preyed upon by other animals in secondary production; and dead plants, animals, and their material are broken down and re-integrated into the base of the food web. Salmon and other native species have evolved together in response to the basic inputs of energy and their circulation through the ecosystem. The result has been the development of an intricately structured food web in the estuary that encompasses food sources, food availability, and inter- and intra-species relationships. Alterations in any one of the elements of the food web, such as food sources or availability, can ripple throughout the ecosystem, reducing habitat capacity and having potentially far-reaching effects on salmonids and other species.

As part of the food web, decomposing materials known as detritus are consumed by juvenile salmonids, either directly or indirectly through other organisms that feed on the detritus (Northwest Power and Conservation Council 2004). There is evidence that a shift in the food base of the estuary—from macrodetrital to microdetrital—has significantly changed the food web and that complex inter- and intra-species relationships have been permanently altered (Northwest Power and Conservation Council 2004). Microdetrital sources favor production of planktonic copepods and other deep-water organisms that are not typically consumed by juvenile salmon (Bottom et al. 2005). Juvenile salmon that rear extensively in the estuary preferentially consume invertebrates from shallow-water and vegetated habitats, where decomposing plant tissue from emergent plants in estuarine wetlands creates macrodetritus (Bottom et al. 2005). Reductions of wetland and foraging habitat, simplification of habitats, and altered sediment inputs have contributed to the changes in detrital sources in the estuary. By disrupting the food web, these conditions have increased competition and predation (Bottom et al. 2005).

Most studies of prey preferences of juvenile salmon using the estuary focus on stream-type fish, which are less likely than ocean types to rear in estuarine habitats for extended periods. Studies that focus on ocean-type salmonids demonstrate that juvenile salmon appear to feed selectively within particular regions of the estuary (Bottom et al. 2005). In freshwater and brackish habitats, juvenile salmon feed extensively on emergent insects such as chironomids (midges) and epibenthic crustaceans such as mysid shrimp and gammarid amphipods (Macneale et al. 2009 and Miller and Simenstad 1997). Farther downstream in higher salinity portions of the estuary, salmon consume epibenthic crustaceans such as gammarid amphipods and harpaticoid copepods (Bottom et al. 2005). According to a University of Washington master's thesis that demonstrated the importance of midge insects in the diet of juvenile Chinook salmon occupying shallow-water habitats in the Columbia River estuary, emerging chironomids were the dominant prey for Chinook of all sizes (Lott 2004). Additionally, the Oregon Department of Fish and Wildlife found migrating yearling Chinook actively feeding on daphnia. The same study found subyearling Chinook and coho feeding on daphnia year-round in the lower Willamette River (Friesen 2005).

Affected salmonids: Ocean-type ESUs are more likely than stream-type juveniles to be affected by food web alterations because of their use of estuary habitats and their longer residency times. Stream-type ESUs are more influenced in the plume environment because of reduced fine-sediment inputs leaving the estuary.

Food Source Changes

As described below, changes in the detrital sources that form the base of the estuarine food web have been significant and represent a limiting factor for salmonids. Figure 3-3 shows a conceptual model of the estuary food web developed by the U.S. Army Corps of Engineers. The historical tidal marsh macrodetritus-based food web is displayed at the top of Figure 3-3, while the current food web, which is based on imported microdetritus, is shown at the bottom.

Limiting Factor: Reduced Macrodetrital Inputs. The estuarine food web formerly was supported by macrodetrital inputs that originated from emergent, forested, and other wetland rearing areas in the estuary (Northwest Power and Conservation Council 2004). Today, detrital sources from emergent wetlands in the estuary are approximately 84 percent less than they were historically (Bottom et al. 2005). The reduction of macrodetritus in the estuary reduces the food sources for juvenile salmonids. As a result, juveniles may have reduced growth, lipid content, and fitness prior to ocean migration or may need to reside longer in the estuary.

Macrodetrital plant production has declined as a result of the construction of revetments along the estuary shorelines, the disposal of dredged material in what formerly were shallow or wetland areas where plant materials or insects could drop into the water, simplification of habitat through the removal of large wood, and reductions in flow. Flow reductions affect detrital sources by limiting the amount and availability of wetlands—areas that normally would be contributing macrodetritus to the food web—and cutting the number of overbank flows. Historically, much of the detrital inputs occurred during overbank events, which provided additional shallow-water habitat for juvenile salmonids and resulted in significant detrital inputs to the estuary. As mentioned earlier, overbank events occur much less frequently today than they did historically.

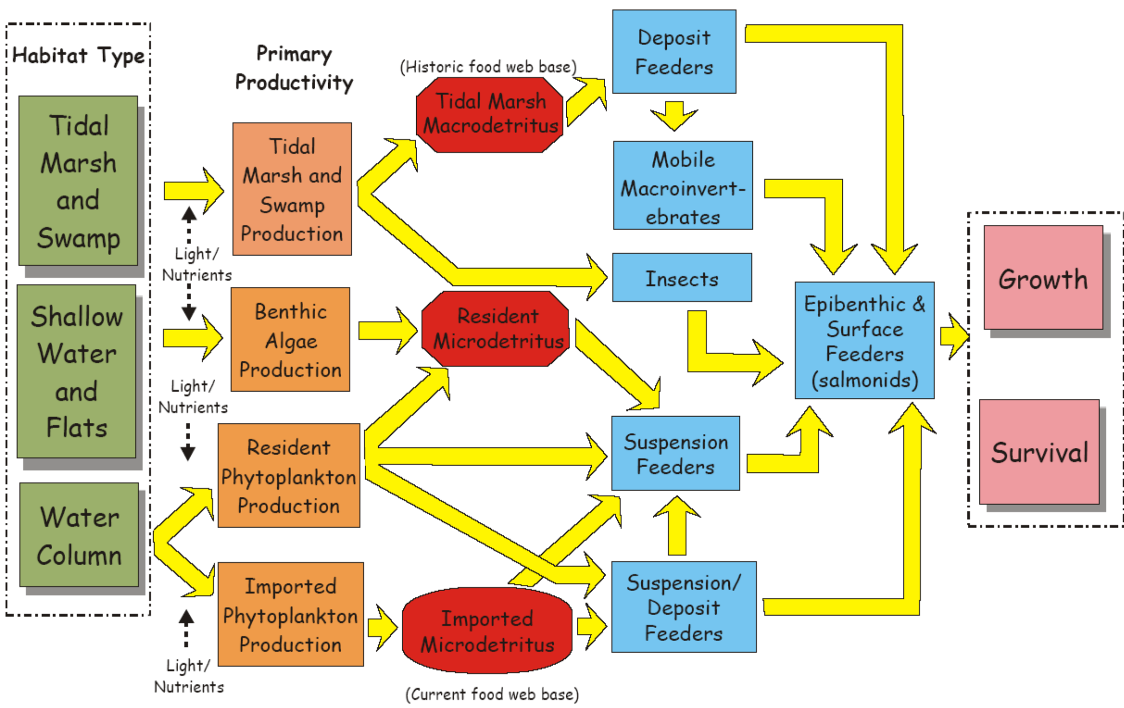


FIGURE 3-3
Conceptual Model of the Columbia River Estuary Food Web

Limiting Factor: Increased Microdetrital Inputs. The current food web is based on decaying phytoplankton delivered from upstream reservoirs and nutrient inputs from urban, industrial, and agricultural development. The amount of this microdetritus has increased dramatically (Bottom et al. 2005). The switch in the estuarine food web from a macrodetritus-based source to a microdetritus-based source has altered the productivity of the estuary (Bottom et al. 2005).

The substitution of detrital sources in the estuary also has contributed to changes in the spatial distribution of the food web (Bottom et al. 2005). Historically the macrodetritus-based food web was distributed evenly throughout the estuary, including in the many shallow-water habitats favored by ocean-type salmonids. But the contemporary microdetrital food web is concentrated within the estuarine turbidity maximum in the middle region of the estuary (Bottom et al. 2005). This location is less accessible to ocean-type ESUs that use peripheral habitats and more accessible to species such as American shad that feed in deep-water areas.

Pelagic fish such as shad may also benefit from the fact that the estuarine turbidity maximum traps particles and delays their transport to the ocean up to 4 weeks, compared to normal transport of around 2 days (Northwest Power and Conservation Council 2004). The estuarine turbidity maximum is thought to contain bacteria that attach to detritus. Together these represent the primary food source in the estuary today (Northwest Power and Conservation Council 2004).

Competition and Predation

Predation and competition for habitat and prey resources limit the success of juvenile salmonids entering the estuary and plume. Both spatial and energetic losses can involve either density-dependent or density-independent processes (Bottom et al. 2005). Spatial and temporal losses of habitat and large pulses of hatchery juveniles may, under some conditions, result in density-dependent salmonid mortality (Bottom et al. 2005).

Competition among salmonids and between salmonids and other fish may be occurring in the estuary (Lower Columbia Fish Recovery Board 2004), with the estuary possibly becoming overgrazed when large numbers of ocean-type salmonids enter the area. Food availability may be reduced as a result of the temporal and spatial overlap of juveniles from different locations (Bisbal and McConnaha 1998 as cited in Lower Columbia Fish Recovery Board 2004).

Ecosystem-scale changes in the estuary have altered the relationships between salmonids and other fish, birds, and mammal species, both native and exotic. Some native species' abundance levels have decreased from historical levels—perhaps to the point of extinction—while others have increased to levels far exceeding those in recorded history, with associated changes in predation of salmon and steelhead juveniles.

The presence of non-indigenous fish, invertebrates, and plants in species assemblages indicates major changes in aquatic ecosystems (Northwest Power and Conservation Council 2004). Globally the introduction of such species is increasing, a fact that is attributable to the increased speed and range of world trade, which facilitates the transport and release—whether intentional or not—of non-indigenous species (Northwest Power and Conservation Council 2004). In the estuary, the introduction of exotic species has altered the ecosystem through competition, predation, disease, parasitization, and alterations in the food web.

Non-native species affect ocean-type ESUs more than they do stream-type ESUs because of the ocean types' longer juvenile estuary residency times and use of shallow-water habitats.

Limiting Factor: Native Fish. The northern pikeminnow is a native piscivorous fish that preys on juvenile salmonids in the estuary. Although pikeminnows have always been a significant source of mortality for juvenile salmonids in the Columbia River, changes in physical habitats may have created more favorable conditions for predation (Northwest Power and Conservation Council 2004). These changes include reduced flows and favorable micro-habitats formed by pilings, pile dikes, and other over-water structures. The diet of pikeminnows varies with age, with the largest adults representing the biggest risk to juvenile salmonids. Both ocean-type ESUs and stream-type ESUs are affected, but for different reasons. Ocean-type juveniles are susceptible because of their longer estuary residency times and use of shallow-water habitats. Stream-type juveniles are susceptible because they are leaving faster, deeper water to forage for food in shallow areas that are frequented by pikeminnow.

Limiting Factor: Native Birds. As a result of estuary habitat modifications, the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species has increased (Fresh et al. 2005). In 1997 it was estimated that avian predators consumed 10 to 30 percent of the total estuarine salmonid smolt production in that year (Northwest Power and Conservation Council 2004). The 2007 season summary of *Research, Monitoring, and Evaluation of Avian Predation on Salmonid Smolts in the Lower and Mid-Columbia River* (Roby et al. 2008) estimates that 5.5 million juvenile salmonids were consumed by terns in 2007. Stream-type juvenile salmonids are most vulnerable to avian predation by Caspian terns because the juveniles use deep-water habitat channels that have relatively low turbidity and are close to island tern habitats (Roby et al. 2008). Double-crested cormorants are estimated to have consumed an average of 7 million juvenile salmonids annually over the years 2001 to 2009. Cormorant predation has increased in the past several years and has been as high as 11 million, in 2009 (Fredricks 2010).

Limiting Factor: Native Pinnipeds. The abundance of native pinnipeds has steadily increased since passage of the Marine Mammal Protection Act in 1972. Harbor seals, Steller sea lions, and California sea lions all prey on salmon and steelhead in the estuary (Northwest Power and Conservation Council 2004). Diet studies indicate that pinnipeds consume both juvenile and adult salmonids. U.S. Army Corps of Engineers' annual estimates of adult mortality that occurs at Bonneville Dam because of pinnipeds (primarily California sea lions) ranged from 0.4 percent (2002) to 4.2 percent (2007) during the study period ending in 2010 (U.S. Army Corps of Engineers 2010).[5] Other, radio telemetry-based studies suggest that annual pinniped predation on spring Chinook and winter steelhead at Bonneville Dam may be as high as 8.5 percent and 20 percent, respectively (NMFS 2008b, Appendix G). These estimates do not account for pinniped mortality occurring downstream of Bonneville Dam. There are no official estimates of downstream mortality on adult spring Chinook and winter steelhead (both of which are stream-type salmonids); however, unsubstantiated estimates are as high as 10 percent.

Limiting Factor: Exotic Fish. At least 37 exotic fish species are now found in the Columbia River estuary (Northwest Power and Conservation Council 2004). American shad were introduced into the Columbia River in the 1880s, and adult returns now exceed 4 million in

[5] Estimated consumption of adult salmonids ranged from a low of 1,010 in 2002 to a high of 6,081 in 2010; the percent of run consumed varied among reporting years because of changes in run size.

a single year (Northwest Power and Conservation Council 2004). While shad do not eat salmonids, they exert tremendous pressure on the estuary food web given the sheer weight of their biomass. Some evidence suggests that planktivorous American shad have an impact on the abundance and size of *Daphnia* in Columbia River mainstem reservoirs (Haskell et al. 2006 in Independent Scientific Advisory Board 2008), thereby reducing this important food source for subyearling fall Chinook. Other exotic fish in the estuary, such as smallmouth bass, walleye, and catfish, are piscivorous; however, their abundance levels are relatively small.

Limiting Factor: Introduced Invertebrates. Twenty-seven non-native invertebrate species have been observed in the estuary and documented by the Lower Columbia River Aquatic Non-indigenous Species Survey (Sytsma et al. 2004). Surveys have documented that the estuarine copepod community has changed from a system dominated by a single introduced species, *Pseduodiaptomis inopinus*, to a system dominated by two newly introduced Asian copepods: *Pseudodiaptomis forbesi* and *Sinoclaanus doerri* (Santen 2004). In some cases, the abundance of non-native invertebrates can alter food webs through their wide distribution and key role in the food chain (Northwest Power and Conservation Council 2004).

Limiting Factor: Exotic Plants. The introduction of non-indigenous plant species also has altered the estuary ecosystem. Exotic plant species often out-compete native plants, which results in altered habitats and food webs (Northwest Power and Conservation Council 2004). About 18 aquatic plants have been introduced into the estuary since the 1880s (Sytsma et al. 2004). Examples of non-indigenous plant species include purple loosestrife, Eurasian milfoil, parrot feather, and Brazilian elodea. In addition to out-competing native plants, introduced plant species can contribute to poor water quality and create dense, monospecific stands that represent poor habitat for native species (Northwest Power and Conservation Council 2004). In turn, these new plant communities may alter insect and detritus production in and around vegetated wetlands.

Toxic Contaminants

The quality of habitats and the food web in the Columbia River estuary is degraded as a result of past and current releases of toxic contaminants (Fresh et al. 2005, Lower Columbia River Estuary Partnership 2007), from both estuary and upstream sources. Historically, levels of contaminants in the Columbia River were low, except for some metals and naturally occurring substances (Fresh et al. 2005). Today, contaminant levels in the estuary are much higher, as the estuary receives contaminants from more than 100 point sources and numerous non-point sources, such as surface and stormwater runoff from agricultural and urban sources (Fuhrer et al. 1996). With the cities of Portland, Vancouver, Longview, and Astoria on its banks, the Columbia River below Bonneville Dam is the most urbanized section of the river. In 2000, Portland Harbor was placed on the National Priorities List, which designates Superfund sites. Sediments in the river at Portland Harbor are contaminated with various toxic compounds, including metals, PAHs, PCBs, chlorinated pesticides, and dioxin (Oregon Department of Environmental Quality 2008). Work in recent decades has detected contaminants in aquatic insects, resident fish species, salmonids, river mammals, and osprey, reinforcing that contaminants are widespread throughout the estuary's food web (Tetra Tech 1996, Fuhrer et al . 1996, Lower Columbia River Estuary Partnership 2007).

Depending on concentration, exposure to toxic contaminants can kill aquatic organisms outright or have sublethal effects that compromise their health and behavior. Sublethal concentrations of contaminants affect the survival of aquatic species by increasing stress, decreasing fitness, predisposing organisms to disease, delaying development, and disrupting physiological processes such as reproduction and smoltification.

Acute lethal effects of toxic contaminants, such as fish kills in response to accidental discharges or spills, have been reported but are generally rare. However, research by the NMFS Northwest Fisheries Science Center has revealed some notable exceptions in which toxic contaminants may lead to the direct mortality of salmonids, such as the following situations:

- Coho pre-spawn mortality. For the past several years, NMFS has been documenting the recurrent die-offs of adult coho salmon returning to spawn in restored lowland urban streams in the Puget Sound Basin, at rates ranging from 30 to 90 percent of local coho runs (McCarthy et al. 2008). The weight of evidence to date suggests that pollutants in runoff from urban landscapes are causing the fish kills, and the phenomenon is correlated with high densities of roads and vehicle traffic. Based on findings from Puget Sound, coho spawners are likely at risk in urbanizing watersheds in the greater Columbia Basin (particularly the lower Columbia River).

- Synergistic toxicity of pesticide mixtures. A study by NMFS, in collaboration with Washington State University, has shown that common current-use pesticides (organophosphate and carbamate insecticides) produce unexpectedly synergistic toxicity and death in juvenile salmon following short-term exposure (Laetz et al. 2007). These agricultural pesticides are used in most of the major subbasins, and they reach rearing and migration habitats for salmon via spray drift, surface runoff, and irrigation return flows. In a 10-year study by the U.S. Geological Survey, Gilliom (2007) found that mixtures of pesticide compounds are prevalent in streams in watersheds that are dominated by agricultural, urban, or mixed land use.

- Salmon egg mortality. Increased mortality has been observed in salmon eggs exposed to PAHs in oil, such as at sites in Alaska following the Exxon Valdez oil spill (Heintz et al. 1999, Carls et al. 2005). An unpublished study by NMFS suggests that salmon embryos incubated in urban stream water also show relatively high rates of developmental defects and mortality when compared to embryos raised in the same water passed though an in situ streamside filtration system. At this time, the contaminants in the urban stream water are unidentified contaminants that are toxic to salmon embryos and likely pose an important early life stage threat to salmon in urbanizing watersheds.

Although the lethal effects described above are of concern, sublethal effects of contaminants are probably the greatest threat to juvenile salmon in the Columbia River. In juvenile salmonids, contaminant exposure can result in decreased immune function and generally reduced fitness (Northwest Power and Conservation Council 2004, Arkoosh and Collier 2002). Exposure can also impair growth, development, and reproduction and disrupt olfaction; salmonids depend on olfaction for migration, imprinting on natal streams, homing, and detecting predators, prey, potential mates, and spawning cues. These sublethal effects of contaminant exposure may indirectly increase mortality from other factors like infectious disease, parasites, predation, exhaustion, and starvation by suppressing salmonid immune systems and impairing necessary behaviors such as swimming, feeding, responding to stimuli, and avoiding predators (Lower Columbia River Estuary Partnership 2007). Contaminants that affect growth can have significant effects. Juvenile growth is necessary for ocean survival (Zabel and Williams 2002 as cited in Lower Columbia River Estuary Partnership 2007), and adult fish size has been correlated to reproductive success and egg size (Healey and Heard 1983, Beacham and Murray 1987). Low lipid content, which has been observed in outmigrating juvenile Chinook salmon in the Columbia River estuary (Johnson et al. 2007b, Lower Columbia River Estuary Partnership 2007), is another sign of poor growth that is correlated with an increased risk of juvenile mortality (Biro et al. 2004). Thus, toxic contaminants that impair salmonid growth can reduce juvenile survival, adult returns, and individual reproduction. Although many effects of contaminants require an exposure period of weeks to months, some impacts, especially those on behavior, can occur very quickly. For example, effects of pesticides and copper on the salmon olfaction system can be seen after exposure periods of only a few hours (Sandahl et al. 2004 and 2007, Hecht et al. 2007).

Toxic contaminants can also indirectly affect salmon via the food web, especially prey such as aquatic and terrestrial insects. Insect bodies accumulate contaminants, which salmon in turn ingest when they consume insects. Additionally, many toxic contaminants are specifically designed to kill insects and plants, reducing the availability of insect prey or modifying the surrounding vegetation and habitats. The availability of prey species is one of the primary determinants of salmonid growth, and reductions in the prey base can affect salmonid survival and productivity (Chapman 1966 and Mundie 1974 as cited in Lower Columbia River Estuary Partnership 2007). Changes in vegetative habitat can shift the composition of biological communities; create favorable conditions for invasive, pollution-tolerant plants and animals; and further shift the food web from macrodetrital to microdetrital sources.

A study by Loge et al. (2005) in the Columbia River will likely bring more attention to the effects of contaminants on salmonids in the estuary. The study documents infectious disease in outmigrating juvenile salmonids attributed to abiotic stressors, such as chemicals, that influence host susceptibility to infection. The study estimates disease-induced mortalities in Chinook salmon related to exposure to contaminants at 1.5 percent and 9 percent for estuary residence times of 30 to 120 days, respectively (Loge et al. 2005).

Other contaminants, including endocrine-disrupting substances such as synthetic hormones, are beginning to be characterized in the estuary, and these contaminants could have substantial effects on salmon and steelhead (Fresh et al. 2005). A study by the Lower Columbia River Estuary Partnership, aided by NMFS and the U.S. Geological Survey, found emerging contaminants such as caffeine, acetaminophen, and human and veterinary antibiotics in the water column of the estuary and evidence of exposure to estrogenic compounds in the blood of juvenile Chinook salmon (Lower Columbia River Estuary Partnership 2007). Several suspected hormone disruptors were detected in the water column, including bisphenol A (a plasticizer), HHCB (a synthetic musk), and polybrominated diphenyl ethers (PBDEs, which are synthetic flame retardants used in everyday products like plastic, cushions, and fabrics). Although some forms of PBDEs have been banned, PBDE concentrations in the environment have increased exponentially during recent decades. In the Columbia River estuary, they have been found in the water column, on suspended sediment, and in the tissue and stomach contents of juvenile Chinook salmon, which indicates that salmon prey also are contaminated (Lower Columbia River Estuary Partnership 2007). PBDEs are similar to PCBs in their chemical structure and sublethal effects, such as neurotoxicity and hormone disruption.

Affected salmonids: Contaminant exposure by stream-type and ocean-type salmon likely reflects contaminants present in rearing habitats. Stream-type salmon are apt to have contaminant loads that reflect conditions in the upper Columbia River and its tributaries, while ocean-type salmon are apt to have loads that reflect conditions in the lower river and estuary (Leary et al. 2006, Johnson et al. in prep, Dietrich et al in prep a). It is likely that both stream-type and ocean-type juvenile salmonids are affected by short-term exposure to waterborne contaminants such as organophosphate pesticides and dissolved metals that can have acute effects on salmon olfactory function and behavior (Fresh et al. 2005, Johnson et al. in prep a), and both types could be affected by bioaccumulative legacy pesticides, such as DDTs, that are present throughout the Columbia Basin. Additionally, ocean-type juveniles likely experience adverse effects and possibly mortality from urban and industrial bioaccumulative toxics such as PCBs and PBDEs that are present in the Columbia River estuary and are absorbed during longer estuarine residence times (Fresh et al. 2005). Both life history types could be affected by contaminant impacts on prey resources (Johnson et al. in prep). Preliminary data tend to support the hypothesis that contaminant body burdens are generally higher in ocean-type stocks than in stream-type stocks (Johnson et al. 2007a) and higher in outmigrating subyearling Columbia River Chinook than in yearlings, especially for industrial contaminants such PCBs and PBDEs that are present at higher concentrations in the Columbia River estuary (Lower Columbia River Estuary Partnership 2007, Dietrich et al. 2008). However, more work is needed on contaminant uptake and impacts on salmon of different stocks and life history types.

Limiting Factor: Bioaccumulation Toxicity. Bioaccumulative and potentially toxic waterborne contaminants, trace metals, and chlorinated compounds have been observed in the estuary (Fuhrer et al. 1996, Fresh et al. 2005, Lower Columbia River Estuary Partnership 2007). DDT and PCBs have been detected in juvenile salmon from the estuary at concentrations above threshold levels for health effects, and in salmon stomach contents and water quality samples from sites throughout the estuary (Lower Columbia River Estuary Partnership 2007). DDT, PCBs, and trace metals such as copper all bioaccumulate and concentrate in animals near the top of the food chain.

Loge et al. (2005) estimated disease-induced, contaminant-related mortalities at 1.5 percent and 9 percent for juvenile Chinook residing in the Columbia River estuary for 30 to 120 days, respectively (Loge et al. 2005). Figures 3-4 and 3-5 show concentrations of PCBs and DDTs found in the stomach contents of subyearling fall Chinook in several locations of the Columbia River estuary, other Pacific Northwest sites, and hatcheries.

Limiting Factor: Non-Bioaccumulative Toxicity. A variety of organochlorines (including trichlorobenzene, the insecticides aldrin and dieldrin, and PAHs) in the estuary are above state and Federal guidance levels (Northwest Power and Conservation Council 2004). These contaminants tend not to bioaccumulate in salmon and steelhead (although PAHs do bioaccumulate in invertebrates), but they are readily absorbed and can have sublethal effects. Copper also was detected in juvenile salmon, at concentrations that can impair olfaction (Lower Columbia River Estuary Partnership 2007). In addition, copper can interact with other toxic contaminants—mercury, aluminum, iron, and certain pesticides—to cause synergistic effects, such that the combined toxicity is greater than the toxicity predicted based on the sum of the contaminants present (Eisler 1998 as cited in Lower Columbia River Estuary Partnership 2007).

As mentioned above, sublethal concentrations of contaminants can affect the survival of aquatic species by increasing stress, predisposing organisms to disease, delaying development, and disrupting physiological processes (Northwest Power and Conservation Council 2004). Exposure to PAHs may be a particular problem for salmon in the urbanized portions of the estuary, as these contaminants are very common in stormwater as well as in industrial discharges. Although salmonids can break down PAHs, the metabolites of PAHs can be mutagenic and carcinogenic, especially in cases of chronic exposure. PAHs also can contribute to immune dysfunction in juvenile salmon (Arkoosh and Collier 2002, Bravo et al. 2008) and cause alterations in growth and metabolism that could increase the risk of mortality (Meador et al. 2006 and 2008). Figure 3-6 shows concentrations of PAHs in the stomach contents of subyearling fall Chinook in various locations of the Columbia River estuary, other Pacific Northwest sites, and hatcheries.

One study detected numerous currently used pesticides present in water quality samples from sites throughout the estuary, with the most frequently detected pesticides being the suspected hormone disruptors atrazine, simazine, and metolachlor (Lower Columbia River Estuary Partnership 2007). Exposure to individual pesticides has sublethal effects on salmon behavior, interfering with predator avoidance, altering homing and migration, and reducing egg fertilization. Health effects include reduced olfactory function, impaired growth, and immune suppression. Pesticides also can be toxic to salmon prey.

Although the concentrations of the individual pesticides detected in the study were lower than threshold levels for health effects in juvenile salmonids, pesticides often were found in combination (Lower Columbia River Estuary Partnership 2007). This is of concern because some pesticides are known to have additive effects. For example, when common pesticides such as diazinon, chlorpyrifos, and carbaryl occur together, even if each is at a relatively low concentration, their combined concentration can have toxic effects on fish and wildlife (Scholz et al. 2006 as cited in Lower Columbia River Estuary Partnership 2007). Among salmonids, carbamate and organophosphate pesticides can have additive effects on olfactory function (Scholz et al. 2006 as cited in Lower Columbia River Estuary Partnership 2007). Some studies suggest that synergistic effects may also be occurring when current-use pesticides occur together in the environment (Anderson and Zhu 2004 and Denton et al. 2003 as cited in Lower Columbia River Estuary Partnership 2007). This is a reminder that the effects of toxic contaminants in the estuary may not be directly proportional to measured concentrations.

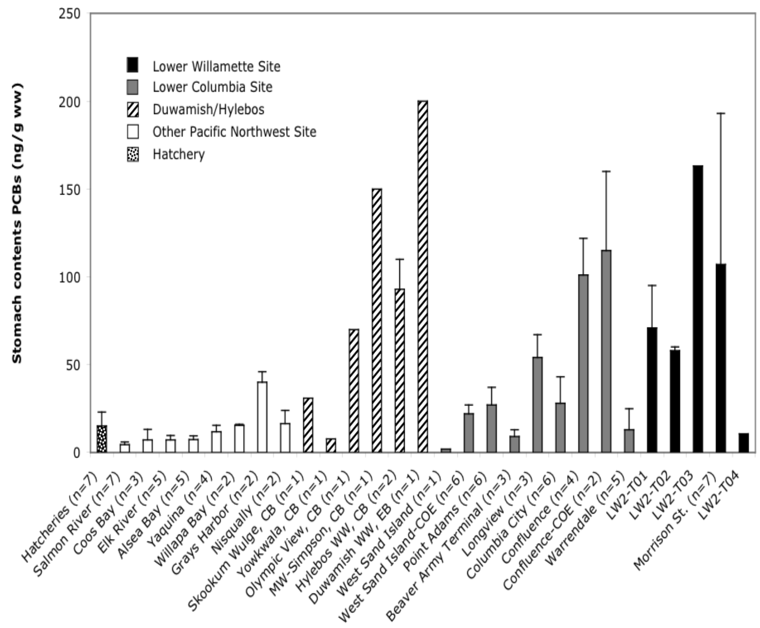


FIGURE 3-4

Concentrations of PCBs in the Stomach Contents of Subyearling Fall Chinook

(From Johnson et al. 2007a and 2007b, Lower Columbia River Estuary Partnership, Olson et al. 2008, Stehr et al. 2000, and Lower Willamette Group 2007)

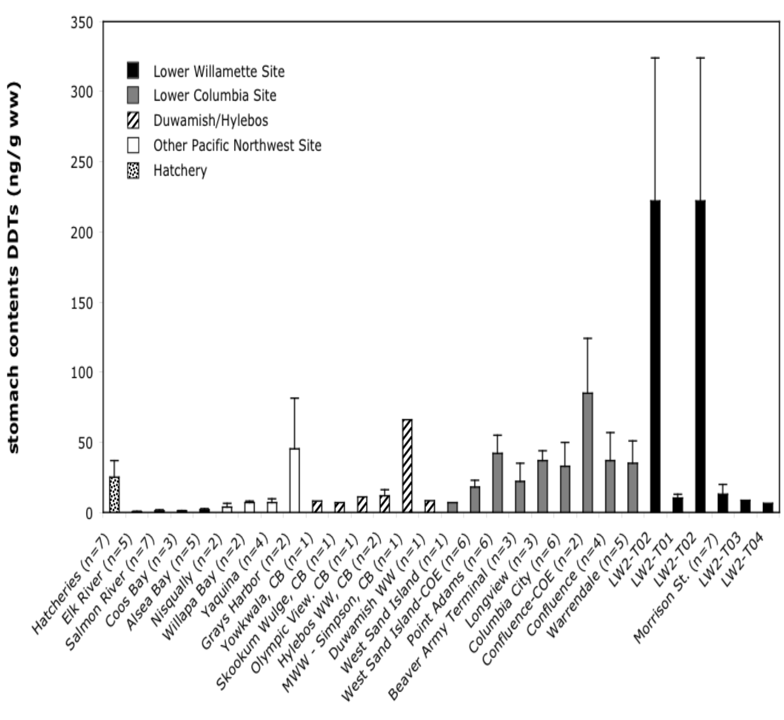


FIGURE 3-5

Concentrations of DDTs in the Stomach Contents of Subyearling Fall Chinook

(From Johnson et al. 2007a and 2007b, Lower Columbia River Estuary Partnership, Olson et al. 2008, Stehr et al. 2000, and Lower Willamette Group 2007)

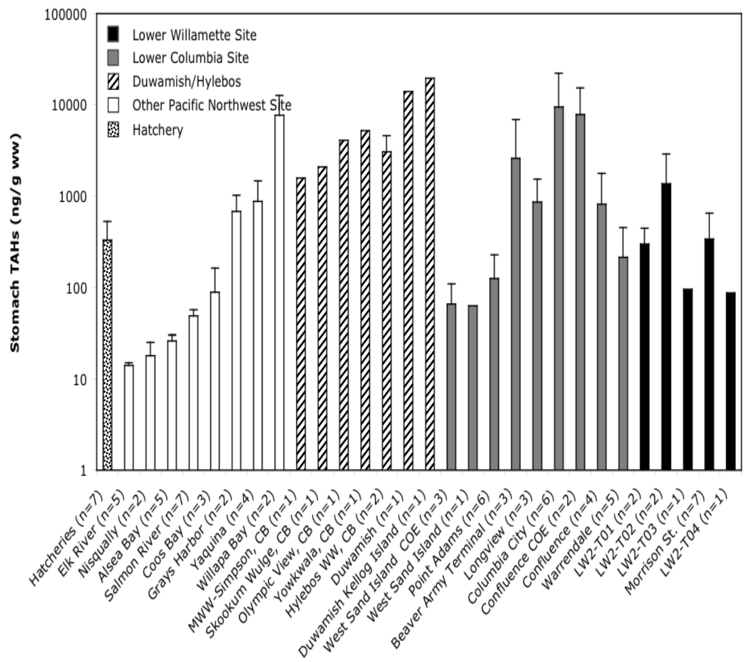


FIGURE 3-6

Concentrations of Total Aromatic Hydrocarbons (PAHs) in the Stomach Contents of Subyearling Fall Chinook

(From Johnson et al. 2007a and 2007b, Lower Columbia River Estuary Partnership, Olson et al. 2008, Stehr et al. 2000, and Lower Willamette Group 2007)

Habitat Opportunity, Habitat Quality, and Synergistic Effects

A lack of habitat opportunity and reduced habitat quality both play a role in limiting the viability of salmon and steelhead in the Columbia River estuary. In terms of habitat opportunity, changes in the timing and volume of Columbia River flows, combined with higher bankfull elevations, have reduced the amount and accessibility of in-channel, off-channel, and plume habitat. Overbank flooding that normally would aid juveniles in accessing off-channel refugia and food resources has been virtually eliminated, and sediment transport processes that structure habitat have been impaired.

Meanwhile, the quality of the habitat available to salmon and steelhead in the estuary has been compromised. Water temperatures are relatively high for cold-water species such as salmon and steelhead and are expected to continue to climb. Researchers have found a variety of toxic contaminants in water, sediments, and salmon tissue in the estuary. With changes in vegetation and flow, juvenile salmonids' traditional macrodetrital food sources have become scarcer and the food base has switched to a microdetritus-based source, thus altering the productivity of the estuary. Predation by northern pikeminnow, pinnipeds, Caspian terns, and cormorants has increased, and it is likely that the presence of native and exotic fish, introduced invertebrates, and invasive plant species is further altering food web dynamics. These and other changes in habitat quality make the estuary a very different place for salmon and steelhead than it was historically.

Habitat quality often is influenced by features that this analysis considers aspects of habitat opportunity, such as river flow and sediment processes. As one example, alterations in flow have eliminated much of the vegetated wetlands that ordinarily would supply insect prey for juvenile salmonids and macrodetrital inputs to the estuarine food web. In some cases it may not be not be possible to improve habitat quality without reducing limiting factors related to habitat opportunity. Likewise, it may be necessary to address habitat quality issues, such as toxic contaminants, before increasing access to habitat that could be contaminated.

This type of interplay between habitat opportunity and habitat quality is a reminder of how connected limiting factors in the estuary are, even though this chapter describes them discretely. It is possible that some of the limiting factors have synergistic effects, in which the cumulative negative impact of two or more limiting factors is greater than the sum of the impacts of the individual limiting factors. This likely is the case with flow reductions and increases in bankfull elevation, which combine to limit juveniles' access to off-channel habitats. Although synergistic effects are difficult to identify and quantify, the estuary recovery plan module assumes that they exist and that they can be taken advantage of to enhance the beneficial impacts of management actions in the estuary. Chapter 7 addresses the implications of potential synergistic effects more directly.

Prioritization of Limiting Factors

This estuary recovery module uses a 1-to-5 rating system to prioritize limiting factors by ocean- and stream-type salmon and steelhead, at the estuary scale. PC Trask & Associates, Inc., performed an initial prioritization, based on a synthesis of the three main literature sources (Bottom et al. 2005, Fresh et al. 2005, and Northwest Power and Conservation Council 2004), supplemented by additional literature. (See the discussion of each limiting factors for specific source material.) Staff from the Lower Columbia River Estuary Partnership, NMFS Northwest Fisheries Science Center, NMFS Northwest Regional Office, and Lower Columbia Fish Recovery Board reviewed and provided input on the prioritization.

All three of the main literature sources used in this estuary recovery module identify flow, sediment, water quality, and food web alterations as limiting factors. *Salmon at River's End* (Bottom et al. 2005) analyzes each of the limiting factor categories in the context of habitat opportunity and capacity and how the limiting factor fits within the member/vagrant conceptual framework. The Fresh technical memorandum evaluates selected limiting factors (tern predation, toxics, habitat, and flow) for their impacts on ocean- and stream-type ESUs (Fresh et al. 2005). Finally, the "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" and its supplement (Northwest Power and Conservation Council 2004) evaluate limiting factors for their impacts to salmonids and the level of certainty that the factor is limiting. Of the limiting factors identified in this module, the only one not identified in at least one of the three main documents is stranding, which the author researched at the suggestion of Washington Department of Fish and Wildlife staff.

In prioritizing limiting factors, the author considered the following: (1) how the three main literature sources evaluated and/or prioritized limiting factors, (2) the magnitude or severity of limiting factors as described in the source documents, (3) estimates of mortality caused by a limiting factor, which were available only for predation-related limiting factors, and (4) the frequency with which a limiting factor was identified in the source documents.

Limiting factors were prioritized individually, without trying to account for potential negative synergistic effects, which are difficult to evaluate.

Table 3-1 shows the results of the limiting factor rating process. Each limiting factor received two scores—one for ocean-type salmonids and one for stream-type salmonids. One simplifying assumption in scoring is that both ocean- and stream-type salmonids express a diversity of life history strategies within ESUs and their constituent populations. Relative scores between ocean- and stream-type salmonids generally reflect the dominant life history stage by providing extra weight to the dominant life history strategy; however, less dominant strategies are considered. For example, reduced off-channel habitat is primarily a limiting factor for ocean-type juveniles because the dominant life history strategy is subyearlings that use shallow-water habitats extensively to feed and rear. However, some ocean-type populations and subpopulations also express a yearling strategy as part of the overall genetic makeup of the population. As a result, both ocean- and stream-type salmonids received scores (albeit lower) for other less dominant life history strategies. The far right-hand column of the table is the total score, which adds ocean- and stream-type impact scores into a single composite score. The assumption that within healthy ESUs there is expression of less-dominant life history strategies is central to *Salmon at River's End* (Bottom et al. 2005) and the Fresh technical memorandum.

Table 3-2 organizes limiting factors into groups based on total score. Top-priority limiting factors are those that have the greatest impact on both ocean- and stream-type ESUs, while lowest priority limiting factors have the least combined impact to ocean- and stream-type ESUs. An important assumption in the rating system is that all limiting factors had an effect on one or both ESU types.

The prioritization of limiting factors in this module should be considered a working hypothesis to be tested and refined through research and evaluation (including a formal expert opinion, or "Delphi," process). Future planning efforts would also be enhanced by a limiting factors analysis at the reach or sub-reach scale, although information is generally not available at this time to consistently identify limiting factors at these finer scales. (In Chapter 5, priority reaches are identified for the 23 management actions.)

Summary

The identification of limiting factors in the Columbia River estuary is well supported in a variety of literature sources, although additional research is needed to understand the relative impacts of the limiting factors and their interactions. Source documents take different approaches to lumping limiting factors together or splitting them apart for the purposes of evaluation, but all of the documents generally agree that channel confinement and alterations to flows and sediment have significantly degraded the estuary ecosystem in far-reaching ways. Water quality and food web limiting factors also are well documented.

The interconnectedness of these limiting factors suggests the use of ecosystem-based analysis to understand more exactly their effects on salmonids; however, at this point modeling efforts cannot fully explain the complex relationships among limiting factors.

The next chapter examines human actions and natural events that cause or contribute to the limiting factors described in Chapter 3.

TABLE 3-1
Impact of Limiting Factors on Ocean- and Stream-Type Salmonids

Limiting Factor	Level of Impact		
	Ocean Type*	Stream Type*	Total Score
Habitat-Related Limiting Factors			
Reduced in-channel habitat opportunity			
Flow-related estuary habitat changes	5	3	8
Sediment/nutrient-related estuary habitat changes	4	3	7
Reduced off-channel habitat opportunity			
Flow-related changes in access to off-channel habitat	5	3	8
Bankfull elevation changes	5	2	7
Reduced plume habitat opportunity			
Flow-related plume changes	3	5	8
Sediment/nutrient-related plume changes	2	3	5
Water temperature	5	3	8
Stranding	3	2	5
Food Web-Related Limiting Factors			
Food Source Changes			
Reduced macrodetrital inputs	5	3	8
Increased microdetrital inputs	3	2	5
Competition and Predation			
Native fish	3	3	6
Native birds	2	5	7
Native pinnipeds	2	5	7
Exotic fish	2	2	4
Introduced invertebrates	2	2	4
Exotic plants	2	2	4
Toxic Contaminants			
Bioaccumulation toxicity	4	2	6
Non-bioaccumulative toxicity	4	3	7

*Significance of limiting factor to life history strategy:
1 = No likely effects.
2 = Minor effects on populations.
3 = Moderate effects on populations.
4 = Significant effects on populations.
5 = Major effects on populations.

TABLE 3-2
Limiting Factor Prioritization

Limiting Factor	Limiting Factor Score[a]	Limiting Factor Priority[b]
Flow-related estuary habitat changes	8	Top
Flow-related changes in access to off-channel habitat	8	
Flow-related plume changes	8	
Water temperature	8	
Reduced macrodetrital inputs	8	
Sediment/nutrient-related estuary habitat changes	7	High
Bankfull elevation changes	7	
Native birds	7	
Native pinnipeds	7	
Non-bioaccumulative toxicity	7	
Native fish	6	Medium
Bioaccumulation toxicity	6	
Sediment/nutrient-related plume changes	5	Low
Stranding	5	
Increased microdetrital inputs	5	
Exotic fish	4	Lowest
Introduced invertebrates	4	
Exotic plants	4	

[a]From Table 3-1.
[b]Limiting factors have been prioritized in groups, rather than individually, to avoid a false sense of precision in this qualitative analysis.

CHAPTER 4

Threats to Salmonids

Chapter 4 identifies and prioritizes threats to ESUs in the Columbia River basin. Threats are the human actions or natural events, such as volcanic eruptions or floodplain development, that cause or contribute to limiting factors (Gaar 2005). Threats may be caused by past, present, or future actions or events.

PC Trask & Associates, Inc., identified and prioritized threats using the same process and sources used to identify and prioritize limiting factors—that is, a thorough review and synthesis of pertinent literature (particularly Bottom et al. 2005, Fresh et al. 2005, and Northwest Power and Conservation Council 2004), supplemented with input from staff at the NMFS Northwest Fisheries Science Center and Northwest Regional Office, Lower Columbia River Estuary Partnership, and Lower Columbia Fish Recovery Board. The module's three key source documents and a number of other sources document both limiting factors and threats. In most cases the literature addresses limiting factors and threats together, and it required substantial effort to separate them for the purposes of this estuary recovery plan module.

The one threat presented in this chapter that the three main source documents do not mention is ship wakes, which can cause stranding of juvenile salmonids. Although the topic of stranding was first raised in a 1977 report (Bauersfeld 1977), the extent of stranding remains unclear. Washington Department of Fish & Wildlife staff suggested that the topic be addressed in this recovery plan module.

The relationship between limiting factors and threats is not necessarily one-to-one. A single threat can contribute to several limiting factors, and in many cases a limiting factor exists because of the effects of multiple and varied threats. (Table 4-1, which is presented later in this chapter, shows the linkages between the limiting factors in Chapter 3 and the threats described in Chapter 4.) For ease of understanding, this chapter organizes threats to salmonids into the following groupings: flow, sediment, structures such as dikes and jetties, ship wakes, food web (including species relationships), and water quality in the estuary. The presentation of threats as discrete activities or phenomena is an oversimplification of complex physical and biological relationships that affect salmon survival. The threats related to flow, sediment transport, and food webs are particularly difficult to tease apart and discuss discretely. Thus the reader should bear in mind that describing threats individually does not fully capture the dynamic interplay of forces that are currently putting salmonids in the estuary at risk. The complexity of these forces is illustrated in Figure 4-1, which is a representation of a conceptual model of the Columbia River estuary developed by the U.S. Army Corps of Engineers (Diefenderfer et al. 2005). The model provides in-depth detail on the relationships between limiting factors and threats.

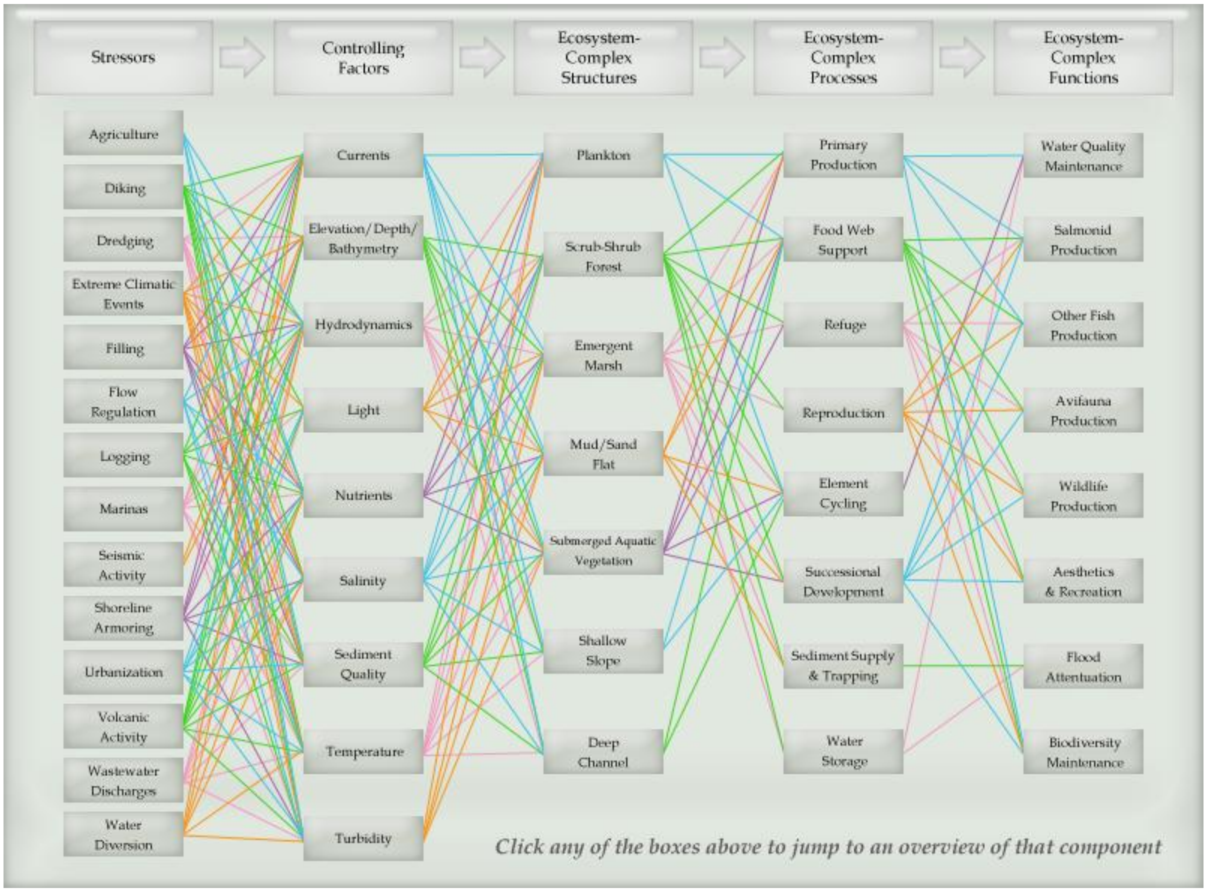


FIGURE 4-1
Conceptual Model of the Columbia River Estuary
(Note: "Stressors" are equivalent to threats as defined in this module.)
(Figure provided courtesy of the U.S. Army Corps of Engineers.)

Most of the human threats described in this chapter are the result of the cumulative impacts of European Americans living in the Northwest. From an ecological perspective these impacts have taken place relatively quickly. Consider that in 1770, when American Robert Gray first crossed the Columbia River bar, about 100,000 Native Americans lived in the Columbia River basin (Oregon State University 1998). Today the population of the Columbia Basin is approximately 5 million (National Research Council 2004). In the early years of Euro-American settlement, the area's abundant natural resources supported farming, mining, logging, fishing, and other activities that modified the landscape into productive uses for people. Later, the availability of cheap hydroelectric power helped fuel expanded agriculture, manufacturing, and development and the rise of urban centers such as Portland. The impacts of these activities on salmonids in the estuary have been substantial.

Flow-Related Threats

Over the last 4,000 years, salmon thrived in the Columbia River by adapting to habitats created by characteristics of the land and water flow (Fresh et al. 2005). Key attributes of flow include magnitude and timing, both of which have changed significantly in the

Columbia River over the last two centuries. Today the mean flow to the estuary is about 16 percent less than it was in the latter part of the nineteenth century (Jay and Kukulka 2003), and spring freshet peak flows have declined about 44 percent in that same time period (Jay and Kukulka 2003). In addition, the timing of peak flows occurs about 14 to 30 days earlier than it did historically (Jay and Kukulka 2003). Reductions in the spring freshet flows are shown in Figure 4-2, which presents simulated mean monthly discharge at Bonneville Dam before development of the hydrosystem and under current hydrosystem configurations and operations.

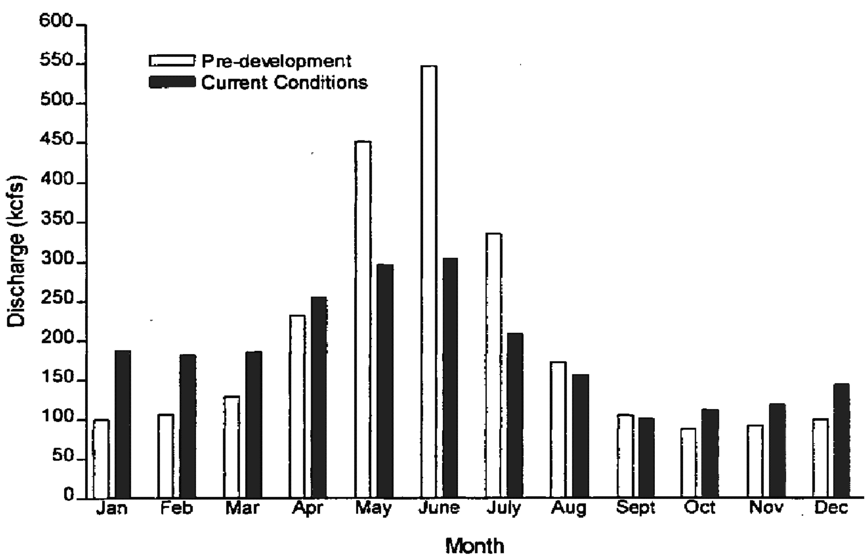


FIGURE 4-2
Changes in the Annual Columbia River Flow
(Adapted from National Marine Fisheries Service 2000.)

Flow alterations, in connection with other factors, can increase or decrease salmonids' ability to access habitats and the capacity of habitats to sustain salmonids (Bottom et al. 2005). In the case of the Columbia River, alterations in the timing, magnitude, and duration of flows are responsible for dramatic changes in habitat opportunity and capacity in the estuary, including effects on groundwater recharge, cold-water upwelling, flooding, off-channel habitat quality and quantity, and water quality. Climate fluctuations, the withdrawal of water, and regulation of river flow have altered the amount and timing of instream flows entering the estuary and plume.

Affected salmonids: Alterations in the magnitude and timing of Columbia River flows affect both ocean- and stream-type juvenile salmonids. Ocean-type juveniles spend more time in the estuary, where they rely on shallow vegetated marsh habitats and upland swamp habitats (Northwest Power and Conservation Council 2004). Chum salmon (ocean-type) also spawn in the mainstem and are affected by low flows during the spawning and egg incubation life stages. In extreme cases, redds may have been dewatered; however, a minimum flow now has been administratively set from November through April to reduce the potential for dewatering of chum redds located immediately below Bonneville Dam. Ocean-type salmonids also rely on seasonal overbank flows to access habitats and preferred food sources.

Stream-type juveniles do not spend much time in the estuary, but research indicates that they may use the Columbia River plume habitat as they adjust to saltwater conditions (Fresh et al. 2005). Columbia River flows have a direct effect on the plume's surface area, volume, frontal features, and extent offshore (Fresh et al. 2005). Flow alterations also affect sediment transport processes and water quality.

Threat: Climate Cycles and Global Climate Change

Natural variations in Columbia River flow as a result of long- and short-term climate fluctuations have occurred throughout history. The Pacific Decadal Oscillation (PDO) alternates between cold and warm phases approximately every 30 years (Fresh et al. 2005). The cold, rainy phase is typical of the Northwest and increases flows, while the warm phase is drier and decreases flows (Fresh et al. 2005). The El Niño/Southern Oscillation (ENSO) is a shorter, 3- to 7-year phenomenon that similarly has cold and warm phases that may magnify or reduce the effects of the PDO.

Climatic fluctuations have a significant effect on the amount and timing of water flowing to the estuary (Fresh et al. 2005). Since 1878, climatic changes have reduced Columbia River flows by 9 percent (Jay and Kukulka 2003). The NMFS Northwest Fisheries Science Center has observed changes in PDO and ENSO indicators that suggest that changes in ecosystem structure can be expected that are unfavorable for salmon and steelhead (Varanasi 2005). These changes may continue over the next several years.

Scientists believe that the release of high levels of carbon dioxide as a result of human activities is contributing to global climate change. The source of these releases includes the use of fossil fuels to run cars, heat homes and offices, and power factories. Over the past century, global climate change has caused sea levels to rise about 4 to 5 inches (10 to 13 centimeters), worldwide precipitation to increase by about 1 percent, and the frequency of extreme rainfall events to increase in much of the United States (U.S. Environmental Protection Agency 2005). Sea level rise is predicted to accelerate worldwide in the coming decades as a result of global climate change (Intergovernmental Panel on Climate Change 2007). The Intergovernmental Panel on Climate Change has observed that sea levels rose at an average rate of 1.8 millimeters per year from 1961 to 2003 and may be 0.18 to 0.59 meter (0.6 to 1.9 feet) higher at the end of the 21st century than they were during the baseline period of 1980 to 1999 (Intergovernmental Panel on Climate Change 2007).

The Independent Scientific Advisory Board for the Northwest Power and Conservation Council (2007) reports that the Pacific Northwest has warmed about 1° C (1.8° F) since 1900 (this is about 50 percent more than the global average for the same time period) and is projected to warm at a rate of 0.1 to 0.6° C (0.18 to 1.1° F) per decade during the next century. Over the long term, winter precipitation is expected to increase, and summer precipitation is expected to decrease. Within the Columbia River basin, expected effects of rising temperatures include more precipitation falling as rain rather than snow, diminished snow pack, associated reductions in late-summer/early-fall flow, altered timing of flows, increased peak flows, and continued rises in water temperatures. In the estuary, these factors could lead to changes in flooding and ecosystem processes and conditions that already are considered limiting factors for salmon and steelhead—namely, flow-related habitat changes, sediment transport, food web dynamics, populations of non-native species, and water temperature (Independent Scientific Advisory Board 2007). Increasingly, water temperatures in the estuary are approaching the upper thermal limit for salmonids that use the estuary during summer months (National Research Council 2004). Further increases in water temperature could render some current estuarine habitat unsuitable for salmonids, enhance conditions for warm-water fish that prey on or compete with juvenile salmonids, and alter physiological processes such as growth and metabolism among juveniles (Independent Scientific Advisory Board 2007). Some evidence suggests that salmonid response to climate change varies among populations (Crozier and Zabel 2006 as cited in Independent Scientific Advisory Board 2007). Other potential impacts of global climate change in the estuary may include continued rises in sea level and associated effects on intertidal habitat formation and maintenance.

Study of the impacts of global climate change is an evolving field, and additional research is needed to understand the phenomenon’s likely effects on estuarine habitats and processes with specificity. Although the estuary recovery plan module does not consider global climate change separately from other climate-related impacts in the estuary, the topic should receive increasing attention for its potential to affect fish management in the Columbia River basin as a whole. As additional scientific information on global climate change becomes available, it will be incorporated into any updates of the estuary recovery plan module and implementation of associated management actions.

Limiting factors this threat contributes to: Flow-related estuary habitat and plume changes, flow-related changes in access to off-channel habitat, water temperature, and reduced macrodetrital inputs.

Threat: Water Withdrawal

Reduction in the amount of instream flow in a river system is an important measure of alterations to the system (Fresh et al. 2005). Water withdrawals affect both the magnitude and timing of flows entering the estuary and plume.

Historically, flow conditions in the estuary were determined by seasonal climate effects (such as precipitation) and hydrology. Since the early 1900s and to a larger degree since the 1960s, irrigation practices have reduced flows in the Columbia River. Water withdrawals as a result of agricultural irrigation and other water uses are estimated to have reduced flows of the Columbia River by 7 percent since the latter part of the nineteenth century (Jay and Kukulka 2003).

Other human activities that reduce flows are the result of upstream use of surface water and groundwater for commercial, industrial, municipal, domestic, and other purposes (National Research Council 2004).

Irrigation withdrawals of surface water account for approximately 96 percent of total water used, while municipal and other uses account for only 4 percent (National Research Council 2004). On the other hand, about 75 percent of all groundwater withdrawals support irrigation and the remaining 25 percent are used for other purposes (National Research Council 2004).

Limiting factors this threat contributes to: Flow-related estuary habitat and plume changes, flow-related changes in access to off-channel habitat, and reduced macrodetrital inputs.

Threat: Flow Regulation

The timing and magnitude of spring freshets have been drastically altered by management of the Columbia River hydrosystem (Fresh et al. 2005). Jay and Kukulka (2003) estimate that 26 percent of the overall reduction of freshet season flow since the late nineteenth century is attributable to flow regulation. Together with irrigation storage and withdrawal, flow regulation has increased fall and winter flows (winter flows have increased because of pre-release before the freshet season), and much of the seasonal timing of flows in the estuary can be attributed to flood control and hydroelectric operations.

Flow regulation is a function of the hydrosystem in the United States and Canada. The first hydroelectric facility in the lower Columbia Basin—the T.W. Sullivan Dam in Oregon City—was constructed in 1888. Since then, more than 450 dams have been built in the Columbia River basin (Columbia Basin Trust). These dams supply British Columbia with 50 percent of its electricity, while the American Northwest relies on hydropower for about two-thirds of its electricity (Columbia Basin Trust). Columbia River dams also provide flood control, enhance irrigation, and improve navigation.

The total active storage of water in the Columbia River Basin is 42 million acre-feet (Northwest Power and Conservation Council 2001), with dams in Canada accounting for about half of the total storage (Northwest Power and Conservation Council 2001). Major Canadian dams include the Duncan, Arrow, and Mica dams. Major U.S. hydroelectric facilities with significant storage include the Grand Coulee, Dworshak, Hungry Horse, and Libby dams. In addition, the U.S. Bureau of Reclamation owns and operates dozens of water storage dams in the Snake and Yakima rivers. The U.S. Army Corps of Engineers also operates many large flood control projects in the Willamette River.

Several recent changes in hydrosystem operations have been implemented to benefit salmonids throughout the basin. These include increasing flows by minimizing winter flood control drafts and reducing the amount of water needed to refill projects during the spring—measures that benefit spring juvenile salmonid migration in the mainstem Snake and Columbia rivers. Also, summer flows have been augmented to cool Snake River temperatures and assist migration of Snake River salmon and steelhead. Finally, a minimum flow has been administratively set from November through April to reduce the potential for dewatering of chum redds, primarily in Reach G in the estuary.

Limiting factors this threat contributes to: Flow-related estuary habitat and plume changes, flow-related changes in access to off-channel habitat, increased microdetrital inputs, and reduced macrodetrital inputs.

Sediment-Related Threats

Changes to seasonal flows, dredging, and the entrapment of sediment in reservoirs have altered those habitat-forming processes in the Columbia River estuary and plume that relate to sediment.

As described in Chapter 3, the transport of sediment is fundamental to habitat-forming processes in the estuary. Sediment helps create and maintain and promote wetlands, which are important to carbon cycling in the estuary and provide habitat for juvenile salmonids. Sediment also provides important minerals and nutrients that support food production in the estuary and plume. And suspended sediments contribute to turbidity, which is important to salmonids because of the protection it provides from predators. Although the effects of impaired sediment processes on salmonids in the estuary are not fully understood, the magnitude of change and the key role that sediments play in habitat- and food-related processes are significant.

Entrapment of sediment in reservoirs, reduced downstream transport of sediment as a result of altered spring freshets, and dredging are the primary sediment-related threats to salmonids in the estuary. Ocean-type juvenile salmonids are affected by sediment-related changes in habitat in the estuary and by reduced turbidity (which can increase predation). Stream-type juveniles are affected by reduced turbidity in deeper waters in the estuary and plume.

Threat: Entrapment of Fine Sediment in Reservoirs

Reduction in water velocity as a result of upstream reservoirs has altered the transport of organic matter associated with fine sediments such as silt and clay. Fine sediments entering the estuary originate in the upper watersheds of the Snake River (Northwest Power and Conservation Council 2004). Reduced velocities behind upstream reservoirs cause reservoirs to act as a sink to fine sediments and likely reduce amounts delivered to the estuary (Northwest Power and Conservation Council 2004). Currently, organic matter associated with fine sediments supplies the majority of estuarine secondary productivity in the food web (Simenstad et al. 1984 as cited in Northwest Power and Conservation Council 2004). Additionally, reductions in the quantity of fine sediments can increase water clarity and thus contribute to increased predation by piscivorous fish and birds.

Limiting factors this threat contributes to: Flow-related plume changes, sediment/nutrient-related estuary habitat changes, native birds, native fish, and exotic fish.

Threat: Impaired Transport of Coarse Sediment

Historically, the force of spring freshets moved sand down the river and into the estuary, where it formed shallow-water habitats that are vital for salmonids, particularly ocean types. Today, alterations to spring freshet flows have reduced sand discharge in the Columbia River estuary to 70 percent of nineteenth-century levels (Jay and Kukulka 2003). It is likely that the magnitude of change in sand transport affects habitat-forming processes and reduces turbidity, which results in increased predation in the estuary and plume environments.

Limiting factors this threat contributes to: Flow-related plume changes and sediment/nutrient-related estuary habitat changes.

Threat: Dredging

Dredging and the disposal of sand have been a major cause of estuarine habitat loss over the last century (Northwest Power and Conservation Council 2004). Currently, three times more sand is dredged from the estuary than is replenished by upstream sources (Northwest Power and Conservation Council 2004). In addition to causing habitat loss, dredging may have impaired sediment circulation in nearshore ocean areas and resulted in impacts to benthic organisms through disturbance. Still other impacts include the entrainment of crab, juvenile salmonids, sturgeon, and other fish and wildlife species.

Additional losses of vegetated wetlands in the Columbia River estuary are attributable to filling activities, with deposition of dredged materials accounting for most of the filling activities in the estuary (Fresh et al. 2005). Most dredged materials result from maintenance of the shipping channel. Dredged materials are disposed of in-water, along shorelines, or on upland sites; some dredged material disposal sites are shown in the reach maps in Appendix A. Annual maintenance dredging since 1976 has averaged 3.5 million cubic yards per year (Northwest Power and Conservation Council 2004). Significantly more dredged material has resulted from the U.S. Army Corps of Engineers' 43-foot channel deepening project. Dredge fill and diking activities have significantly reduced the availability of wetlands to the river, while placement of dredged material in several areas has increased nesting habitat for Caspian terns and cormorants.

Limiting factors this threat contributes to: Sediment/nutrient-related estuary habitat and plume changes and native birds.

Structural Threats

The development of instream and over-water structures has altered circulation patterns, sediment deposition, sediment erosion, and the formation of habitats in the estuary. Examples of instream and over-water structures include jetties, pile dikes, tide gates, docks, breakwaters, bulkheads, revetments, seawalls, groins, and ramps (Williams and Thom 2001). Such structures create favorable conditions for predators such as northern pikeminnow and walleye, and they can reduce circulation in areas outside of the channel. Instream and over-water structures are found in all reaches of the estuary (for locations, see the reach maps presented in Appendix A).

Another structural threat is reservoirs associated with the hundreds of dams in the Columbia River basin. The construction and operation of these reservoirs has contributed to changes in the temperature of water entering the estuary.

Affected salmonids: Structural threats primarily affect ocean-type juvenile salmonids because of their longer residency time in the estuary and their wider use of off-channel habitats; however, scientists are now hypothesizing that stream-type juveniles forage outside of deeper channels in shallow-water habitats, where they may fall victim to predators that congregate near instream and over-water structures.

Threat: Pilings and Pile Dike Structures

Construction of the North and South jetties has altered sediment accretion and erosion processes near the mouth of the Columbia River. Sediment accretion in the marine littoral areas adjacent to the mouth has decreased the inflow of marine sediments into the estuary (Northwest Power and Conservation Council 2004), while the extensive use of pilings, pile dikes, and other structures to maintain the shipping channel has affected natural flow and sedimentation patterns. Pile dikes maintain the navigation channel by reducing the cross section of the river, increasing the velocity of the river within the channel, and at times slowing velocities immediately downstream of the dike. Development of the navigation channel has reduced flow to side channels and peripheral bays (Northwest Power and Conservation Council 2004). In addition, pile dikes and similar structures may create conditions that increase predation on juvenile salmonids by northern pikeminnow and other piscivorous fish.

Limiting factors this threat contributes to: Sediment/nutrient-related estuary habitat and plume changes and exotic fish.

Threat: Dikes and Filling

Dikes and filling activities have significantly altered the size and function of the Columbia River estuary. Since the early 1900s, dikes have been built to allow agricultural and residential uses (Fresh et al. 2005). Dikes are thought to have caused more habitat conversion in the estuary than any other human or natural factor (Thomas 1983, as reported in Northwest Power and Conservation Council 2004). The effects of diking on estuarine habitats are directly proportional to elevation, with the greatest impacts on the highest elevation estuarine habitats: forested wetlands, followed by tidal swamps and tidal wetlands. Diking-related impacts to these habitats have reduced their availability to juvenile salmon and steelhead (Thomas 1983, as reported in Northwest Power and Conservation Council 2004). Figure 4-3 shows the various zones found in typical estuaries. The emergent vegetation, diked marsh, shrub wetlands, and forested wetlands are the zones most affected by dike and filling practices (reprinted from Thom 2001). Diked areas and the historical floodplain in the Columbia River estuary are shown in the reach maps presented in Appendix A.

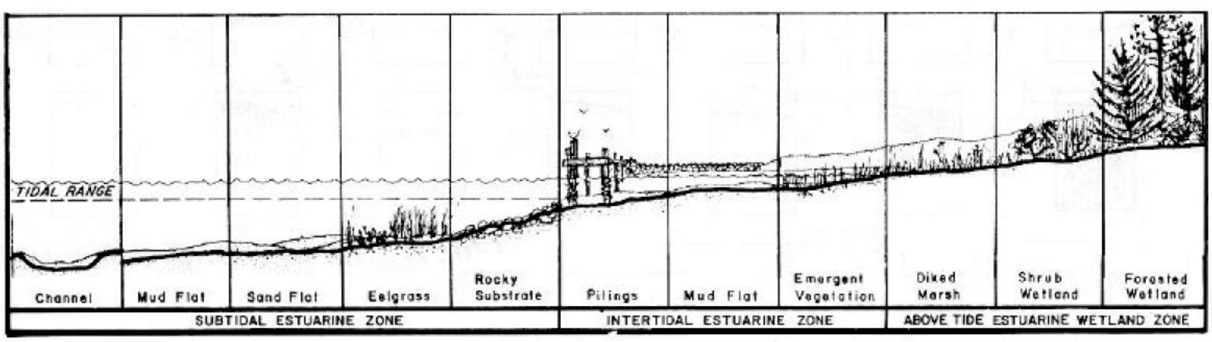


FIGURE 4-3
Subtidal, Intertidal, and Above-Tidal Estuarine Wetland Zones

Before development of the Columbia River hydrosystem and diking and filling, the estuary was dominated by macrodetrital inputs that originated from vegetated wetlands within the estuary. As a result of diking and filling practices and flow alterations (such as changes in the number and timing of spring freshets), emergent plant production in the estuary has decreased by 82 percent and macroalgae production has decreased by 15 percent (Northwest Power and Conservation Council 2004). The availability of insect prey for ocean-type salmonids has been reduced as vegetation has been removed via diking and filling activities and associated dike vegetation maintenance.

Limiting factors this threat contributes to: Reduced macrodetrital inputs, sediment/nutrient-related estuary habitat and plume changes, bankfull elevation increases, and exotic plants.

Threat: Reservoir-Related Temperature Changes

More than 450 dams have been built in the Columbia River basin (Columbia Basin Trust). The associated impoundment of water in upstream reservoirs increases the surface area of the Columbia River, allowing more solar heating of river water than occurs in free-flowing river stretches. This solar heating, combined with the reduced flows from upstream impoundments, has contributed to increased water temperatures in the Columbia River. Measurements at Bonneville Dam indicate that periods of increased temperatures are lasting longer than they did historically (National Research Council 2004). Currently, during summer months, average and maximum values of Columbia River water temperatures are often above 20° C (68°F), which approaches the upper limits of thermal tolerance for cold-water fishes such as salmon (National Research Council 2004). (For additional information on increases in water temperature in the lower Columbia River, see Figure 3-2 and the text that precedes the figure.)

The dynamics of reservoir-related temperature changes in the estuary are complicated and are affected by factors such as thermal inertia, which, among other things, contributes to delayed fall cooling and spring warming of downstream waters. Additional study is needed to better understand reservoir-related temperature changes and their effects on salmonids rearing in the estuary.

Limiting factors this threat contributes to: Water temperature.

Threat: Over-Water Structures

Over-water structures refer to docks, piers, transient moorage, log rafts, and other structures. These structures block sunlight, reduce flow, and trap sediments downstream of pilings (Kahler, Grassley, and Beauchamp 2000; Nightingale and Simenstad 2001). They also change circulation patterns and reduce edge habitats for ocean-type salmonids. Over-water structures contribute to predation on salmonids by altering habitat, creating microhabitats and favorable conditions for predators, especially the northern pikeminnow and non-native species such as small-mouth bass (Kahler, Grassley, and Beauchamp 2000; Nightingale and Simenstad 2001).

Although the actual square footage of over-water structures in the Columbia River estuary has never been inventoried, the structures themselves number in the thousands. Some research has occurred on the effects of breakwaters and over-water structures in the context of marinas. Salmon fry tend to concentrate in higher densities around these structures, thus increasing the risk of predation (Williams and Thom 2001).

Limiting factors this threat contributes to: Sediment/nutrient-related estuary habitat changes, and exotic fish.

Food Web-Related Threats

As described in Chapter 3, changes in the estuarine food web can ripple through the ecosystem, altering energy pathways, feeding patterns, predator/prey relationships, and competition within and among species. As a result of increased nutrients, elevated water temperatures, slower passage of water through reservoirs, and entrapment of organic matter in reservoirs, concentrations of phytoplankton at the base of the food web in the estuary are higher than they were historically. The introduction of exotic species such as shad may have accelerated the pace of ecological change in the estuary by permanently altering food webs. Food webs also have been altered by sediment transport, in that microdetrital food particles adhere to sediment suspended in the water column, making different food sources available to different species than was the case historically.

Affected salmonids: Both stream- and ocean-type salmonids are affected by energy-related threats—stream types primarily through increased predation in deep-water habitats and ocean types primarily through food web changes in the estuary. Ocean-type juveniles also are affected by reduced availability of insect prey as a result of the construction and maintenance of dikes.

Threat: Increased Phytoplankton Production

A reduction in macrodetrital inputs has shifted the food base in the estuary to phytoplankton produced in and imported from upstream reservoirs (Northwest Power and Conservation Council 2004), or produced as a result of augmented levels of nutrients from urban, industrial, and agricultural development. Phytoplankton support a food web that is less accessible to ocean-type salmonids occupying shallow edge habitats than the historical food web (Northwest Power and Conservation Council 2004). A shift from a generally animal-based salmonid diet to a generally plant-based diet may impair caloric inputs (Garman 1991; Cloe and Garman 1996; Nakano, Miyasaka, and Kuhara, 1999; Henschel, Mahsberg, and Stumpf 2001), and thus the fitness of salmonids that rely on estuarine rearing habitats to grow and prepare for ocean migration. The shift in food sources from a macrodetrital base to a microdetrital base provides different food sources than salmonids historically were accustomed to, in different places within the estuary, and this may favor different species. Because this area of study is immature in the estuary, it is difficult to establish which species benefit more than others.

Limiting factors this threat contributes to: Increased microdetrital inputs.

Threat: Altered Predator/Prey Relationships

Although predation has always occurred in the estuary ecosystem, the cumulative effect of altered flows, changes in sediment transport processes and food sources, introduced species, hatcheries, upstream habitat impacts, hydroelectric impacts, and contaminants have recast estuary and plume environments such that predator/prey relationships have changed significantly. As a result, significant numbers of salmon are lost to fish, avian, and marine mammal predators during migration and residency in the estuary (Northwest Power and Conservation Council 2004). Fish predators include northern pikeminnow, walleye, smallmouth bass, and catfish; avian predators include Caspian terns, double-crested cormorants, and gull species; and marine mammal predators include Steller and California sea lions and harbor seals.

Degraded conditions (loss of habitat and altered food web) in the Columbia River estuary and the timing of large hatchery releases have increased the likelihood that mortality from competition may occur under some circumstances (Northwest Power and Conservation Council 2004). Mortality from intra-species competition has been documented in the Skagit River estuary (Beamer et al. 2005), and there is speculation that it may be a factor in the Columbia River as well (Northwest Power and Conservation Council 2004). If inter-species competition is occurring, it is likely to have the greatest impact on ocean-type salmonids because of their longer residence time in the estuary (Northwest Power and Conservation Council 2004). If density dependence is affecting stream-type juveniles, it likely happens in the plume.

As the result of human alterations of the estuary environment, native species such as Caspian terns and double-crested cormorants have significantly increased in number, with measurable impacts on stream-type salmonids (Bonneville Power Administration, U.S. Bureau of Reclamation, and U.S. Army Corps of Engineers 2004). These increases in population in the Columbia River estuary are attributed to the deposition of dredged materials in the estuary that represent high-quality habitat for the birds (Bottom et al. 2005) and predation opportunities for cormorants created through the placement of pilings, pile dikes, and other structures. The loss of habitat elsewhere has contributed to terns and cormorants effectively relocating to the Columbia River estuary, with the populations there now representing the largest nesting colonies in the world.

Similarly, the new microdetritus-based food web in the estuary has benefited zooplanktivores, including American shad (an introduced species) (Northwest Power and Conservation Council 2004). Although shad do not appear to be in direct competition with salmonids, their biomass alone—more than 4 million returning adults a year—represents a threat to trophic relationships in the Columbia River. Future increases in water temperatures as a result of climate change may improve conditions for shad in the Columbia River Basin and lead to their continued expansion (Independent Scientific Advisory Board 2008). Other exotic fish species such as introduced walleye and catfish also have been able to capitalize on degraded conditions in the upper reaches of the estuary and altered food web dynamics through predation and competition for food resources (Northwest Power and Conservation Council 2004).

Pinniped predation on adult spring Chinook and winter steelhead continues to increase. On the West Coast the total abundance of California sea lions is approximately 250,000; Stellar sea lions total about 31,000, and Pacific harbor seals total about 25,000 (Griffin 2006). Each spring about 1,000 Stellar sea lions, 3,000 Pacific harbor seals, and 800 California sea lions take up residence in the lower estuary (Griffin 2006). About 1,000 sea lions and harbor seals enter the freshwater portion of the estuary; of these, approximately 80 animals (primarily California sea lions) congregate at Bonneville Dam. The U.S. Army Corps of Engineers' estimates that annual adult mortality at Bonneville Dam because of pinnipeds (primarily California sea lions) ranged from 0.4 percent (2002) to 4.2 percent (2007) during the study period ending in 2010 (U.S. Army Corps of Engineers 2010).[1] Other, radio telemetry-based studies suggest that annual pinniped predation on spring Chinook and winter steelhead at Bonneville Dam may be as high as 8.5 percent and 20 percent, respectively (NMFS 2008b, Appendix G). There is a need for better estimates of the mortality caused by pinnipeds throughout the estuary and plume. Unsubstantiated estimates suggest a mortality rate of 10 percent of the entire adult spring Chinook and steelhead runs in a given year.

Non-native plant species have altered habitat and food webs in the Columbia River estuary. The rate of intentional and unintentional introductions has been increasing over the past 100

[1] Estimated consumption of adult salmonids ranged from a low of 1,010 in 2002 to a high of 6,081 in 2010; the percent of run consumed varied among reporting years in part because of changes in run size.

years, mostly as a result of horticultural practices and the increase in travel and commerce in the Columbia River. Four of those species—purple loosestrife, Eurasian water milfoil, parrot feather, and Brazilian elodea—are of particular concern. Each of these species, in its own way, alters habitat and food webs in the estuary. Purple loosestrife, for example, adapts easily to environmental changes and expands its ranges quickly. The primary ecological effect of purple loosestrife is that it disrupts wetland ecosystems by displacing native plants. Eventually, animals that rely on native flora for food, nesting, or cover also are displaced (Northwest Power and Conservation Council 2004).

Limiting factors this threat contributes to: Native birds, native fish, native pinnipeds, introduced invertebrates, exotic fish, and exotic plants.

Threat: Ship Ballast Practices

Ship ballast practices have been responsible for the introduction of at least 21 exotic species in the Columbia River estuary (Sytsma et al. 2004). When ships release ballast water, non-indigenous species can enter receiving waters. Most of the non-indigenous species in the estuary have originated from Asia (Sytsma et al. 2004). Populations of non-native copepods have established themselves in Reaches A and B (Youngs Bay, Cathlamet Bay, and Grays Bay), and the New Zealand mudsnail has colonized other estuary reaches. The Asian bivalve *Corbicula fluminea* has expanded its range in the estuary, with densities of 10,000 per m^2 being recorded in Cathlamet Bay; however, densities of 100 to 3,000 m^2 are more common (Northwest Power and Conservation Council 2004). These and other non-indigenous invaders disrupt food webs and out-compete juvenile salmonids' native food sources.

An emerging source of concern regarding ship ballast practices is the potential entrainment of juvenile salmonids when large ships take on ballast water as they leave ports unloaded. This issue is being evaluated in relevant Endangered Species Act (ESA) Section 7 consultations (Tortorici 2008).

Limiting factors this threat contributes to: Introduced invertebrates.

Water Quality-Related Threats

The release of toxic contaminants, nutrient loading, and reduced dissolved oxygen have altered the quality of salmonid habitats in the Columbia River estuary. Currently the estuary receives toxic contaminants or nutrients from more than 100 point sources and numerous non-point sources, such as surface and stormwater runoff from urban and agricultural areas (Fuhrer et al. 1996 as referenced in Fresh et al. 2005). In most areas, nonpoint sources such as agricultural, urban, industrial, and timber harvest practices contribute greater nutrient loads than point sources do (Wise et al. 2007). The Snake, Yakima, Deschutes, and Willamette rivers contribute most of the nutrient loads discharged to the Columbia River. Nutrient yields (loads normalized for basin size) are generally greater in basins west of the Cascade Range and are correlated with precipitation and point-source loads (Wise et al. 2007).

Threat: Agricultural Practices

The health of an aquatic ecosystem is substantially affected by agricultural, urban, and industrial practices and wastewater discharge (National Research Council 2004). Specific threats include increased nutrients (nitrogen and phosphorus), sediment, and organic and trace metals (National Research Council 2004). For example, Wise et al. (2007) found a significant correlation between total nitrogen yields in basins west of the Cascades and fertilizer and manure loads. Increased nutrient loads from anthropogenic sources can lead to increased phytoplankton concentrations, decreased water clarity, and depressed dissolved oxygen levels, especially in areas with longer residence times and warmer water temperatures. DDT, other banned pesticides that have persisted in the environment, and pesticides in current use are entering the estuary from agricultural runoff, some of which originates outside the lower Columbia River basin. The middle and upper Columbia are primary sources of DDT and other organochlorine pesticides in the estuary, as are tributaries such as the Yakima and Willamette rivers (Clark et al. 1998, Williamson et al. 1998, Hinck et al. 2006, Johnson and Norton 2005, McCarthy and Gale 2001 as cited in Lower Columbia River Estuary Partnership 2007). A 2007 study confirmed the presence of the pesticides atrazine, simazine, metolachlor, EPTC, DCPA, and diuron at sites throughout the estuary, often in combination (Lower Columbia River Estuary Partnership 2007). The timing of detections suggests that precipitation events play an important role in transporting pesticides to the Willamette River, which is a primary contributor of both agricultural and urban/industrial contaminants to the Columbia River estuary.

The U.S. Geological Survey's National Stream Quality Accounting Network (NASQAN) program also reports detection of a wide range of commonly used pesticides at sampling sites near Bonneville Dam and at the confluence of the Willamette and Columbia rivers (Fresh et al. 2005). Detected pesticides include simazine, atrazine, chlorpyrifos, metolachlor, diazinon, and carbaryl. Arsenic and trace metals such as copper, iron, and manganese also have been detected. Although trace metals occur naturally, they also are introduced through human activities, such as the use of lead arsenate as an insecticide for apples (Fresh et al. 2005). Water-soluble contaminants, trace metals, and chlorinated compounds have been detected in the estuary (Fresh et al. 2005), and DDT, PCBs, dioxins, and metals have been detected at elevated levels in tissue from fish in the estuary (Northwest Power and Conservation Council 2004).

Limiting factors this threat contributes to: Non-bioaccumulative toxicity, bioaccumulation toxicity, and increased microdetrital inputs.

Threat: Urban and Industrial Practices

The Columbia River downstream of Bonneville Dam is the most urbanized stretch in the entire basin. The area has more than 100 point sources that are known to discharge directly into the Columbia River estuary; these include chemical plants, pulp and paper mills, hydroelectric facilities, municipal wastewater treatment plants, and seafood processors (Fuhrer et al. 1996 as cited in Lower Columbia River Estuary Partnership 2007). Potential nonpoint sources include hazardous waste sites, landfills, marinas and moorages, and overland surface runoff that transports nutrients, sediment, PAHs, metals, and pesticides from streets, yards, and industries.

The largest sources of effluent in this area are the Portland and Vancouver sewage treatment plants (Fresh et al. 2005), with Portland's wastewater treatment facility being the largest point-source discharger in the Columbia Basin (Wise et al. 2007). The annual nutrient loads from this facility equal approximately 2 to 3 percent of the annual in-stream nutrient loads at the Beaver Army Terminal water quality sampling site, downstream of Longview, Washington (Wise et al 2007). Contaminants also are transported to the estuary from areas above Bonneville Dam, such as the Deschutes, Yakima, and Snake rivers. These rivers, together with the Willamette, contribute most of the nutrient loads discharged to the Columbia River (Wise et al. 2007).

An intensive study of sediments in Portland Harbor (the stretch of the Willamette River from Sauvie Island to Swan Island) has uncovered pesticides, PCBs, and other toxic chemicals. In general, studies have shown that PCB and PAH concentrations in salmon and their prey in the estuary are comparable to those in organisms in other moderately to highly urbanized areas (Fresh et al. 2005, Lower Columbia River Estuary Partnership 2007, Johnson et al. 2007b). Industrial contaminants such as PAHs have been detected in sediments from the lower Willamette River in Portland at levels that exceed state or Federal sediment quality guidelines. The U.S. Environmental Protection Agency identified PCB and DDT hot spots within the estuary, including near Longview, West Sand Island, the Astoria Bridge, and Vancouver (Fresh et al. 2005). Studies in the 1990s found that sediment contamination was highest near urban and industrial areas, with concentrations in excess of levels of concern for DDE (a breakdown product of DDT), PCBs, dioxins and furans, and PAHs (Tetra Tech 1996). Current studies find higher levels of flame retardants (PBDEs), PCBs, and DDT on bed sediment collected near Portland than in sediment collected from other sites in the estuary (Jones et al. 2008).

In addition, emerging contaminants associated with urban development are beginning to be detected in the Columbia River estuary. These include PBDE flame retardants, which have been found in juvenile salmon tissue, their stomach contents, the water column, and on suspended sediment at sites throughout the estuary (Lower Columbia River Estuary Partnership 2007). Caffeine, human and veterinary antibiotics, synthetic musk, and the plasticizer bisphenol A have also been detected in the water of the estuary (Lower Columbia River Estuary Partnership 2007). Although the effects of these compounds are not yet well understood, some of them are suspected hormone disruptors, and juvenile salmon collected from the estuary show evidence of exposure to estrogenic compounds (Lower Columbia River Estuary Partnership 2007). This could be the result of emerging contaminants or more familiar toxic contaminants in the estuary, such as certain pesticides.

Limiting factors this threat contributes to: Non-bioaccumulative toxicity, bioaccumulation toxicity, and increased microdetrital inputs.

Other Threats

Threat: Riparian Practices

Riparian practices along the estuary mainstem and in tributaries throughout the Columbia River basin have contributed to increases in water temperature in the estuary by changing hydrology and removing riparian habitats (National Research Council 2004) that—among other ecological functions—provide insects and macrodetrital inputs to the food web.

Problematic practices include shoreline modifications, timber harvest, certain agricultural activities within riparian zones, and residential, commercial, and industrial land uses. These activities increase water temperatures, alter hydrology and macrodetrital inputs, and in some cases modify shoreline habitats used by salmonids, especially ocean types (Lower Columbia Fish Recovery Board 2004).

Limiting factors this threat contributes to: Sediment/nutrient-related estuary habitat changes, reduced macrodetrital inputs, water temperature, and exotic plants.

Threat: Ship Wakes

Ships traveling through the Columbia River estuary produce waves and an uprush which, under certain circumstances, causes juvenile salmonids and other fish to become stranded on shore (Bauersfeld 1977). Although Bauersfeld concluded that ship wake stranding was a significant cause of mortality in ocean-type Chinook salmon and other species, other studies have not confirmed the magnitude of this threat. As a part of the U.S. Army Corps of Engineers' channel deepening project, a study is under way that may help characterize the magnitude of ship wake stranding. The purpose of the study is to document ship wake stranding before and after channel deepening. The first half of the study, published in February 2006, documented stranding events at three test sites. The second part of the study will begin after dredging is completed (Pearson et al. 2006). These results should be useful as partial basis for Light Detection and Ranging (LIDAR) analysis and extrapolation of test site mortality throughout the estuary for similar habitat types. Early in 2008, the Port of Vancouver enlisted Entrix, Inc., to perform a spatial analysis of beach susceptibility for the stranding of juvenile salmonids by ship wakes (Pearson 2008). The study examined wave characteristics and the geomorphology of the lower river but did not examine nearshore fish density. The purpose of the study was to estimate the number of miles of shoreline that exhibit traits expected to potentially cause stranding. The study concluded that approximately 33 miles of shoreline between the mouth of the river and the city of Vancouver have shoreline characteristics consistent with stranding (Pearson 2008).

Limiting factors this threat contributes to: Stranding.

Prioritization of Threats

This estuary recovery module establishes priorities for threats by linking them to pertinent limiting factors and estimating their relative contribution to those limiting factors. The threats identified above are well supported in a wide variety of literature sources, including Fresh et al. (2005), Bottom et al. (2005), the "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" (Northwest Power and Conservation Council 2004), and a variety of more topic-specific primary literature sources.[2] The prioritization of threats, though, is not nearly as well supported, partly because of the limited understanding of how threats contribute to limiting factors and to what degree salmon and steelhead are affected by a given limiting factor. While it is attractive to assume that additional study will fully answer these questions, the biological response to environmental conditions will always be difficult to model because of the tremendous complexities of the physical, biological, and

[2] As with the limiting factors, most of the threats identified in this chapter are not supported by data at the reach or sub-reach scale.

ecological interplay that occurs in the environment. On the other hand, new interest in the estuary and its role in the recovery of listed species in the Columbia River has generated better understanding, and it is likely that uncertainty surrounding threats and limiting factors will continue to lessen.

Table 4-1 demonstrates the relationship between limiting factors and threats by showing which threats are causing which limiting factors and estimating the contribution of each threat to each limiting factor. The presumed relative contribution of a threat to each limiting factor is indicated by the primary, secondary, or tertiary designation. The contribution of each threat to its associated limiting factor(s) is multiplied by the relative importance of that limiting factor to salmonids to yield the threat index score. This score expresses the relative priority of the threat in question. (The relative importance of limiting factors is taken from Table 3-2.)

PC Trask & Associates, Inc., developed the initial threat contribution scores for Table 4-1 by reviewing the extent to which the three main literature sources—and other sources—described relationships between limiting factors and threats or evaluated the contribution of multiple threats to a single limiting factor. Although literature sources were useful in making connections between threats and limiting factors, in many cases the literature did not separate limiting factors from threats or did not attempt to identify and rank the full scope of threats that might be contributing to a particular limiting factor. In nearly all cases, authors discussed cause-and-effect relationships in qualitative language. In some cases, authors described quantitative relationships, as in the relationship between flow regulation and sediment transport. Only a handful of sources estimated priorities for threats.

To supplement information gleaned from the literature, the author talked with regional experts (see Acknowledgements) to identify potential threat contributions not described in the literature. The author also refined the initial scores based on review and input by NMFS Northwest Fisheries Science Center, NMFS Northwest Regional office, Lower Columbia River Estuary Partnership, and Lower Columbia Fish Recovery Board staff. The author, in consultation with staff from the Lower Columbia River Estuary Partnership and NMFS, also made minor adjustments to the scores in response to comments received during the public review period.

TABLE 4-1
Linkages Between Limiting Factors and Threats to Ocean- and Stream-Type Salmonids

Limiting Factor	Threat	Limiting Factor Priority & Numerical Score[a]	Contribution of Threat to Limiting Factor, & Numerical Score[b]	Threat Index[c]
Flow-related estuary habitat changes	Climate cycles and global climate change	Top (5)	Secondary (2)	10
	Water withdrawal	Top (5)	Secondary (2)	10
	Flow regulation	Top (5)	Primary (3)	15
Flow-related changes in access to off-channel habitat	Climate cycles and global climate change	Top (5)	Secondary (2)	10
	Water withdrawal	Top (5)	Secondary (2)	10
	Flow regulation	Top (5)	Primary (3)	15
Flow-related plume changes	Climate cycles and global climate change	Top (5)	Secondary (2)	10
	Water withdrawal	Top (5)	Secondary (2)	10
	Flow regulation	Top (5)	Primary (3)	15

Limiting Factor	Threat	Limiting Factor Priority & Numerical Score[a]	Contribution of Threat to Limiting Factor, & Numerical Score[b]	Threat Index[c]
	Impaired transport of coarse sediment	Top (5)	Secondary (2)	10
	Entrapment of fine sediment in reservoirs	Top (5)	Tertiary (1)	5
Water temperature	Climate cycles and global climate change	Top (5)	Secondary (2)	10
	Reservoir-related temperature changes	Top (5)	Secondary (2)	10
	Riparian practices	Top (5)	Secondary (2)	10
Reduced macrodetrital inputs	Climate cycles and global climate change	Top (5)	Secondary (2)	10
	Water withdrawal	Top (5)	Secondary (2)	10
	Riparian practices	Top (5)	Secondary (2)	10
	Flow regulation	Top (5)	Primary (3)	15
	Dikes and filling	Top (5)	Primary (3)	15
Sediment/nutrient-related estuary habitat changes	Impaired transport of coarse sediment	High (4)	Primary (3)	12
	Entrapment of fine sediment in reservoirs	High (4)	Secondary (2)	8
	Dredging	High (4)	Secondary (2)	8
	Pilings and pile dike structures	High (4)	Primary (3)	12
	Dikes and filling	High (4)	Primary (3)	12
	Over-water structures	High (4)	Tertiary (1)	4
	Riparian practices	High (4)	Tertiary (1)	4
Bankfull elevation changes	Dikes and filling	High (4)	Primary (3)	12
Native birds	Entrapment of fine sediment in reservoirs	High (4)	Tertiary (1)	4
	Dredging	High (4)	Secondary (2)	8
	Altered predator/prey relationships	High (4)	Primary (3)	12
Native pinnipeds	Altered predator/prey relationships	High (4)	Primary (3)	12
Non-bioaccumulative toxicity	Agricultural practices	High (4)	Primary (3)	12
	Urban and industrial practices	High (4)	Primary (3)	12
Native fish	Entrapment of fine sediment in reservoirs	Medium (3)	Tertiary (1)	3
	Altered predator/prey relationships	Medium (3)	Primary (3)	9
Bioaccumulation toxicity	Agricultural practices	Medium (3)	Primary (3)	9
	Urban and industrial practices	Medium (3)	Primary (3)	9
Sediment/nutrient-related plume changes	Dredging	Low (2)	Primary (3)	6
	Pilings and pile dike structures	Low (2)	Secondary (2)	4
	Dikes and filling	Low (2)	Secondary (2)	4
Stranding	Ship wakes	Low (2)	Primary (3)	6
Increased microdetrital inputs	Agricultural Practices	Low (2)	Secondary (2)	4
	Urban and industrial practices	Low (2)	Secondary (2)	4
	Increased phytoplankton production	Low (2)	Primary (3)	6
	Flow regulation	Low (2)	Tertiary (1)	2

Limiting Factor	Threat	Limiting Factor Priority & Numerical Score[a]	Contribution of Threat to Limiting Factor, & Numerical Score[b]	Threat Index[c]
Exotic fish	Entrapment of fine sediment in reservoirs	Lowest (1)	Tertiary (1)	1
	Over-water structures	Lowest (1)	Secondary (2)	2
	Pilings and pile dike structures	Lowest (1)	Secondary (2)	2
	Altered predator/prey relationships	Lowest (1)	Primary (3)	3
Introduced invertebrates	Altered predator/prey relationships	Lowest (1)	Tertiary (1)	1
	Ship ballast practices	Lowest (1)	Primary (3)	3
Exotic plants	Dikes and filling	Lowest (1)	Primary (3)	3
	Riparian practices	Lowest (1)	Secondary (2)	2
	Altered predator/prey relationships	Lowest (1)	Primary (3)	3

[a] From Table 3-2.

[b] Indicates how important the threat is in perpetuating the limiting factor:

3 = Threat is a primary cause of the limiting factor. Addressing this threat would significantly improve salmonid performance.

2 = Threat is a secondary cause of the limiting factor. Addressing this threat would improve performance.

1 = Threat is a tertiary cause of the limiting factor. Addressing this threat would benefit performance, but by itself would result in only minor improvement.

[c] Product of the numerical scores for the limiting factor priority and the threat's contribution to the limiting factor. A high threat index score means that the threat is a major contributor to one or more significant limiting factors. A low threat index score means the threat is a small contributor to a minor limiting factor.

Table 4-2 organizes threats by their threat index score, in descending order. However, the state of the science is such that the differentiation of threat priorities in Tables 4-1 and 4-2 should be viewed as reasonable guidance and a set of working hypotheses to be tested and refined through research and evaluation. Given uncertainties about estuarine ecosystems and how they function, some threats that are ranked relatively low in Table 4-2 may eventually prove to have large impacts to the estuary. For example, it is difficult to dispute the importance of flow regulation compared to ship ballast practices. But it is possible that the effects of exotic invertebrates introduced to the estuary through ship ballast practices will significantly degrade the overall health of the estuary ecosystem over time and that this threat will move up in the priority ranking. As another consideration, Tables 4-1 and 4-2 reflect the prioritization of threats across the entire estuary; within each reach, threats could be prioritized differently. A reach-scale analysis of limiting factors and threats was beyond the scope of this document and, in some cases, beyond the limits of currently available science. But such an analysis would be useful as additional scientific information becomes available.

TABLE 4-2
Prioritization of Threats to Ocean- and Stream-Type Salmonids

Threat	Threat Index*	Threat Priority
Flow regulation	15	
Dikes and filling	15	
Altered predator/prey relationships	12	
Urban and industrial practices	12	HIGH
Agricultural practices	12	
Impaired transport of coarse sediment	12	
Pilings and pile dike structures	12	
Reservoir-related temperature changes	10	
Riparian practices	10	
Climate cycles and global climate change	10	
Water withdrawal	10	
Dredging	8	
Entrapment of fine sediment in reservoirs	8	
Ship wakes	6	
Increased phytoplankton production	6	LOW
Over-water structures	4	
Ship ballast practices	3	

* From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

Summary

Chapter 4 provides information on the underlying causes of the factors that influence the viability of ocean- and stream-type ESUs during their residency and migration in the estuary. Analysis of threats is challenging because a single threat often contributes to multiple limiting factors and may originate miles upstream from the estuary. In Chapter 4, threats were identified, described, linked to limiting factors, and prioritized. Chapter 5 turns to management actions, identifying actions that will address threats and thus help reduce risks to the 13 ESA-listed ESUs using the Columbia River estuary.

CHAPTER 5

Management Actions

Chapters 3 and 4 of this recovery plan module identify factors that currently limit salmonids' biological performance in the estuary and the threats that contribute to those limiting factors. Chapter 5 presents 23 management actions that, together, address the range of threats salmonids in the estuary face, from altered habitat-forming processes to physical structures in the estuary, changes in the food web, and poor water quality. If implemented, the actions presented in this chapter would reduce the impacts of threats to salmonids during their migration and residency in the estuary and plume.

In addition to identifying the management actions, Chapter 5 evaluates them in terms of constraints to implementation, potential improvement in salmonid survival, and cost. More specifically, the chapter discusses each management action's potential benefits and implementation constraints, hypothesizes how benefits could translate into increased survival of salmonids, breaks each action into component projects, and estimates the cost of each project, and thus of each action. Also included is a list of actions that would address threats to salmonids in the estuary but that would need to be implemented outside the estuary, either in estuary tributaries or in upstream areas of the Columbia River basin.

As in other chapters of this recovery plan module, the analysis in Chapter 5 does not fully capture the subtleties of the ecological interactions that influence salmonid survival. Despite continuing research, many aspects of the salmonid life cycle are poorly understood, in part because of the sheer complexity of the ecosystems that salmonids transition into and out of during their lives. The actual relationships among threats and management actions are far more intricate than what is described here. Additionally, given the limits in scientific understanding, there is a degree of uncertainty at each step of the analysis in this chapter. Yet the categories, ratings, and associations presented here are useful tools for discussing complex ecological relationships and comparing possible outcomes of different management actions.

Identification of Management Actions

For the purposes of this recovery plan module, a management action is any action that has the potential to reduce the impact of human-caused or naturally occurring threats to salmonids while they migrate or rear in the estuary and plume. PC Trask & Associates, Inc., identified management actions using available literature and input from area experts (see Acknowledgements). Key documents used to identify management actions are the "Mainstem Lower Columbia River and Columbia River Estuary Subbasin Plan" (Northwest Power and Conservation Council 2004) and its supplement; *Role of the Estuary in the Recovery of Columbia River Salmon and Steelhead (*Fresh et al. 2005); *Salmon at River*'s *End* (Bottom et al. 2005); and the *2004 FCRPS Biological Opinion on Remand* (National Marine Fisheries Service 2004). Table 5-1 lists threats to salmonids in the estuary and plume and management actions that would address those threats; this information is organized by topic and does not reflect the priority of either threats or management actions.

TABLE 5-1
Management Actions to Address Threats

	Threat	Management Action
Flow-related threats	Climate cycles and global climate change[2]	**CRE[1]-1:** Protect intact riparian areas in the estuary and restore riparian areas that are degraded.[2] **CRE-2:** Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.[2] **CRE-3:** Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.[2]
	Water withdrawal	***CRE-3:*** *Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries*
	Flow regulation	**CRE-4**: Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume. ***CRE-3:*** *Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.*
Sediment-related threats	Entrapment of fine sediment in reservoirs	**CRE-5:** Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.
	Impaired transport of coarse sediment	**CRE-6:** Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially. **CRE-8:** Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health. ***CRE-4:*** *Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.*
	Dredging	**CRE-7:** Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.
Structural threats	Pilings and pile dike structures	***CRE-8:*** *Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health.*
	Dikes and filling	**CRE-9:** Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat. **CRE-10:** Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.
	Reservoir-related temperature changes	***CRE-2:*** *Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.*
	Over-water structures	**CRE-11:** Reduce the square footage of over-water structures in the estuary.

	Threat	Management Action
Food web-related threats	Increased phytoplankton production	***CRE-10:*** *Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.*
	Altered predator/prey relationships	**CRE-13:** Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids. **CRE-14:** Identify and implement actions to reduce salmonid predation by pinnipeds. **CRE-15:** Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants. **CRE-16:** Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island. **CRE-17:** Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations. **CRE-18:** Reduce the abundance of shad in the estuary. ***CRE-8:*** *Remove or modify pilings and pile dikes with low economic value when removal or modification would benefit juvenile salmonids and improve ecosystem health.*
	Ship ballast practices	**CRE-19:** Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations ***CRE-7:*** *Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.*
Water quality-related threats	Agricultural practices	**CRE-20:** Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.[3] ***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.* ***CRE-9:*** *Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.*
	Urban and industrial practices	**CRE-21:** Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants. **CRE-22:** Restore or mitigate contaminated sites. **CRE-23:** Implement stormwater best management practices in cities and towns.[3] ***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.* ***CRE-9:*** *Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.*
Other threats	Riparian practices	***CRE-1:*** *Protect intact riparian areas in the estuary and restore riparian areas that are degraded.*
	Ship wakes	**CRE-12:** Reduce the effects of vessel wake stranding in the estuary.

[1] CRE = Columbia River estuary.

[2] Study of the impacts of global climate change is an evolving field, and additional research is needed to understand the phenomenon's likely effects on estuarine habitats and processes with specificity. At this time, the Independent Scientific Advisory Board of the Northwest Power and Conservation Council expects that the regional effects of global climate change in the next century will include more precipitation falling as rain rather than snow, reduced snow pack, and late-summer/early-fall stream flows, and associated rises in stream temperature (Independent Scientific Advisory Board 2007). The climate-related management actions in Table 5-1 reflect these expected impacts. Although the management actions clearly would not change the threat of global climate change itself, they have the potential to lessen its impact on salmonids in the estuary. Even if climate cycles and global climate change have effects different from those assumed in this document, the management actions that Table 5-1 associates with climate would provide benefits to salmonids by addressing other threats, such as water withdrawal, urban and industrial practices, and reservoir heating. All three of the management actions associated with climate in Table 5-1 are associated with other threats listed in Table 5-1.

[3] Unless otherwise noted, the term *best management practices* is used in this document to indicate general methods or techniques found to be most effective in achieving an objective. NMFS envisions that in implementation, specific best management practices would be developed or recommended.

Note: Italics indicate an action's second occurrence in the table, in connection with a different threat.

Given the complexity of the riverine, estuarine, and marine ecosystems that salmon use during their lives, the actual relationships among threats and management actions are more complicated than Table 5-1 suggests. For example, several of the management actions in Table 5-1 are associated with more than one threat (italics indicate an action's second occurrence in the table). This illustrates the complex interplay of ecological processes in the estuary, particularly processes related to flow, sediment, the food web, and water quality, all of which influence salmon survival. Later in this chapter actions are described and analyzed discretely. Some actions are interrelated, both in the problems they attempt to solve and their probable effects. As an example, CRE-2 through CRE-5 (reducing the effects of reservoir heating, protecting/enhancing instream flows influenced by withdrawals and other water management actions in tributaries, adjusting flow timing and magnitude, and addressing entrapment of fine sediments in reservoir) all deal with reservoir and hydrosystem operations. If implemented together, these actions could act in concert to significantly improve water temperature and sediment delivery in the estuary, potentially providing greater benefits through synergistic action than if they were implemented singly. The potential for synergistic effects of management actions is discussed in more detail in Chapter 7.

The estuary recovery module also identifies specific monitoring, research, and evaluation activities appropriate to the 23 management actions. These activities will provide crucial information on the effectiveness of actions that are implemented in the estuary, associated changes in the ecology of the estuary, and scientific uncertainties that affect implementation of the actions. Monitoring, research, and evaluation activities are presented in Chapter 6. Some of these activities are part of the *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program* (Johnson et al. 2008), while others are specific to the management actions in this recovery plan module.

Other Recommended Management Actions

In many ways, conditions in the estuary are the sum of ecological stressors that exist throughout the Columbia River basin. Although some threats to salmonids in the estuary originate exclusively in the estuary itself (Caspian tern predation is one example), others are the result of activities in estuary tributaries or in upstream areas; examples of such threats are riparian practices and upstream water withdrawals that reduce stream flow in the estuary. Still other threats, such as land use practices that contribute contaminants to the river, originate in all three areas—estuary, estuary tributaries, and upstream. Because of the geographic scope of these threats, fully addressing them will require effort not just in the estuary but throughout the basin.

When it comes to management actions, though, the geographic scope of this estuary recovery plan module is limited. For the most part the module focuses on management actions that can be implemented within the estuary itself and that will address threats that either originate exclusively within the estuary itself or have a significant in-estuary component. The assumption is that threats originating from outside the estuary are affecting local conditions in tributary and upstream areas and that actions to address these threats will be included in recovery plans being developed for upstream salmonid populations.

Even so, the analysis in Chapters 3 and 4 of this recovery plan module and a review of contemporary literature yielded six management actions that would directly affect threats to salmonids in the estuary yet would need to be implemented almost exclusively outside of the estuary or are otherwise beyond the scope of this document:

- Implement hatchery actions as appropriate throughout the Columbia River basin to reduce the threat of density-dependent mortality as a direct result of ecological interactions (disease, predation, or competition for food or space) between hatchery and wild salmonid juveniles using reduced and/or impaired lower river habitats. The magnitude of the ecological interactions as a function of the cumulative effects of large hatchery releases on natural-origin salmonids, both spatially and temporally, is currently an important scientific uncertainty.
- Upgrade up-river irrigation structures to reduce evaporation and conveyance losses and improve estuary instream flows.
- Implement public and private best management and water system conservation practices to maximize the quantity and quality of instream flows entering the estuary.
- Incorporate water availability analysis in land use planning activities to ensure efficient use of water, improve tributary flows, and reduce stream temperatures.
- Protect and restore riparian areas in tributaries to provide shade and future wood sources.
- Reduce inputs of toxic contaminants originating from upstream tributary and mainstem sources.

Because these six actions are outside the geographic scope of the estuary recovery plan module, they are not analyzed in this chapter. Nevertheless, implementation of these six out-of-estuary actions is important to improving the survival of salmonids in the estuary, so it is recommended that the actions be included in recovery plans being developed for upstream areas of the Columbia River basin.

One factor that is beyond the geographic scope of the estuary recovery plan module but is addressed in the module in a limited manner is hydrosystem operations, which affect water temperature, sediment transport, and various other habitat-forming processes and conditions in the estuary. Although actual operation of the hydrosystem occurs outside the estuary, the system's effects are considered in the module because they are such significant determinants of habitat conditions for juvenile salmonids in the estuary. Also, unlike the recommended out-of-estuary actions listed above, hydrosystem operations that affect estuarine habitat are unlikely to be addressed in recovery plans being developed for upstream areas of the Columbia River basin. For these reasons, the estuary recovery plan module includes two management actions (CRE-2 and CRE-4) that focus specifically on hydrosystem operations.

The recommendation of out-of-estuary actions to improve survival in the estuary is another reflection of the interconnectedness of the various ecosystems salmonids use during their life cycles, the power of the river as a connector, and how the effects of problematic upstream activities are manifested—and sometimes magnified—in the estuary.

Evaluation of Management Actions: Constraints to Implementation

Constraints to implementation are a key factor in evaluating management actions and their likely impacts on salmonids. No management action can benefit salmonids if it cannot be implemented, and in many cases the degree of benefit corresponds to the degree of implementation. For this reason, the 23 management actions identified above are evaluated in terms of the constraints to their implementation, which yields information about the actions' likely outcomes and starts to provide a basis for comparing the probable effectiveness of different actions.

PC Trask & Associates, Inc., performed an initial rating of management action constraints by qualitatively estimating the degree of difficulty in implementing each action, taking into account social, political, and technical factors, including the probable cost of implementation. Staff at the Lower Columbia River Estuary Partnership, NMFS Northwest Fisheries Science Center, NMFS Northwest Regional Office, and Lower Columbia Fish Recovery Board provided input into this process. PC Trask & Associates, Inc., and NMFS also revised some constraint scores in response to the *Federal Register* public comment process. Because the scientific literature generally falls short of prescribing discrete actions to address threats and is even less robust when it comes to evaluating constraints to implementation, the reader should view specific ratings as a qualitative estimate only, but one that is useful in comparing relative implementation constraints across the 23 management actions.

For each management action, Table 5-2 summarizes the primary threat and limiting factors that the action addresses and expresses the significance of those threats and limiting factors in terms of a threat index. (The threat index indicates whether the threat is a major contributor to a significant limiting factor or a minor contributor to a minor limiting factor. The index is useful in distinguishing those actions that, even if they were successful, would affect a relatively small number of fish from those actions that, even if they were only partially implemented or partially successful, would have more profound benefits because they would affect a larger number of fish.) Table 5-2 also provides a score for the potential benefit to salmonids in the estuary if implementation of the action were completely unconstrained, plus a brief rationale for the score.

Assigning a score for potential benefit with unconstrained implementation is just the first step in evaluating management actions. In fact, decisions about management actions will be made within a complex social and political context that includes a wide variety of interests, and it is likely that many of the actions will not be able to be implemented fully because of various technical, financial, political, or social obstacles. To address this issue, Table 5-2 assigns an implementation constraints score to each management action and briefly explains how implementation of the action could be constrained by various factors. It then gives a score that represents the potential benefits of the action if implementation of the action is constrained. By design, the estuary recovery module takes a relatively optimistic view about what is possible in terms of reducing the constraints to implementation of management actions. This means that even the score in Table 5-2 for constrained implementation of an action may represent a higher degree of implementation than is likely to actually occur. However, some constraints may be reduced over time, such as through technology advances or changes in economic sectors; as a result, some actions may have greater potential for implementation than is represented in this recovery plan module.

The table concludes with a score for potential benefit of each action assuming that implementation of the action is constrained. This score is an attempt to identify more realistically what the results of an action would be given the social, political, and financial climate in which management actions will be decided on, but it also assumes that considerable effort is made to reduce constraints to implementation. Also, the difference in Table 5-2 between potential benefit with unconstrained implementation of an action and potential benefit with constrained implementation is helpful in identifying where it might be worthwhile to expend effort to reduce constraints because the benefits would be great. This topic is discussed more fully in Chapter 7.

The threat index and scoring in Table 5-2 are for the estuary as a whole, instead of by reach, because in most cases the assessment information needed to do a reach-scale analysis currently is lacking. However, the severity of individual threats and limiting factors varies from reach to reach in the estuary, as do the potential benefits of the management actions. It is assumed that implementation of the management actions will involve dialogue and additional evaluation at the reach scale to aid in prioritizing actions and focusing them in the geographical areas where they would be most beneficial.

TABLE 5-2
Constraints to Implementation of Management Actions

Management Action CRE-1:

Protect intact riparian areas in the estuary and restore riparian areas that are degraded.

Primary threat this action would address		**Riparian Practices.** Riparian areas provide key ecological functions that affect water temperature, the availability of insects, and macrodetrital inputs to the ecosystem. Riparian areas in the lower Columbia River have been degraded by a number of factors, including shoreline modifications, diking and dike maintenance practices, and activities related to the disposal of dredged material.
Associated limiting factors		Water temperature, reduced macrodetrital inputs, and exotic plants.
Threat index[1]	10	This threat is a secondary contributor to two top-priority limiting factors (water temperature and reduced macrodetrital inputs) and a tertiary contributor to one additional limiting factor.
Potential benefits with unconstrained implementation of action [2]	4	Protecting intact riparian areas and restoring degraded riparian areas in priority reaches would provide significant benefits to salmonids by reducing water temperatures and increasing macrodetrital inputs to the system.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	3	Levels of protection vary across the lower Columbia region. In some cases, riparian areas in cities and counties are protected through regulatory mechanisms such as growth management or shoreline rules. Regulatory tools such as buffer zones along streams can be effective but require broad public support over time. Restoration projects are expensive and can take decades to provide their full benefit to tributaries directly entering the estuary.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-2:

Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.

Primary threat this action would address		**Reservoir-related temperature changes.** Low-velocity flows and broad surface area exposure in reservoirs increase the temperature of flows in the estuary. Salmonids are cool-water fish that need stream temperatures of 20º C or lower for normal metabolism, growth, disease resistance, and timing of important life functions such as smoltification and adult migration. Salmonids in the estuary are experiencing water temperatures at the upper limit of their tolerance for longer periods and more frequently than they did historically.
Associated limiting factors		Water temperature.
Threat index[1]	10	This threat is a secondary contributor to a top-priority limiting factor.
Potential benefits with unconstrained implementation of action [2]	3	Given that at many times during the year water temperatures in the estuary are at or above the upper limits of salmonids' thermal tolerance, any lowering of water temperature could provide significant survival benefits. Water temperatures of below 20º C throughout the year would aid salmonids in carrying out essential physiological processes and life functions.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	5	Elevated temperatures that result from reservoir heating are difficult to reduce. Temperatures may be influenced by the volume and speed of flows through the hydrosystem and the source of those flows (some impoundments have cooler water than others do). International treaties, conflicting fish management objectives systemwide, the need for flood control, power management, and other factors constrain management of the hydrosystem to allow cooler flows to enter the estuary.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-3:

Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.

Primary threats this action would address		**Water withdrawal and impaired transport of coarse sediment.** Instream flows in the estuary are important for salmonids because they maintain habitat-forming processes and conditions in the estuary and plume. Transport of sand and gravel from upstream and estuary sources during high flows helps establish and maintain salmonid habitats, contributes to turbidity that shelters salmonids from predation, and influences food sources in the plume. Some instream flows have been established in Columbia River basin tributaries, but others are needed, especially with human population growth in the basin. This action focuses on water withdrawals in tributaries and the mainstem and other tributary flow issues, including tributary hydropower. It complements CRE-4, which focuses on mainstem hydrosystem flow-related issues, such as hydrosystem regulation, to establish incremental flow improvements in the estuary within the context of power generation and flood control.
Associated limiting factors		Flow-related estuary habitat changes, flow-related changes in access to off-channel habitat, flow-related plume changes, and reduced macrodetrital inputs.
Threat index[1]	12	This threat is a secondary contributor to four top-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	2	This action contributes incremental instream flow improvements that protect/enhance the flow regime in the estuary and plume and support associated habitat-forming processes.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings); stream-type salmonids in the plume.
Implementation constraints[3]	5	Implementation of this action would require the involvement of multiple stakeholders, including irrigation, commercial, industrial, hydrosystem, tribal, Federal, state, and local interests, plus significant public involvement. Establishing protected instream flows is challenging because of competing interests and often takes years.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-4:

Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.

Primary threats this action would address		**Flow regulation and impaired transport of coarse sediment.** The magnitude, frequency, and timing of flows are an important determinant of habitat opportunity for salmonids in the estuary. Salmonids have adapted to historical flows and depend on them to complete their life cycles. The transport of sand and gravel from upstream and estuary sources helps maintain salmonid habitats, contributes to turbidity that shelters salmonids from predation, and influences food sources in the plume. Spring freshets are important habitat-shaping events for the estuary and plume. Improved flow regimes would help ecological processes (and salmonids) by making nutrients and other food sources, such as insects, available in the food web.
Associated limiting factors		Flow-related estuary habitat changes, flow-related changes in access to off-channel habitat, flow-related plume changes, reduced macrodetrital inputs in the estuary, and sediment/nutrient-related estuary habitat changes.
Threat index[1]	15	This threat is a primary contributor to several top-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	5	Return to a more natural flow regime would have significant ecosystem benefits and would affect all facets of salmonid life histories expressed in the estuary and plume. Adjustments to the timing, magnitude, and frequency of hydrosystem flows entering the estuary would be likely to have synergistic effects that would increase the benefit of many of the other actions.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies; stream-type juveniles rearing in the plume.
Implementation constraints[3]	5	Constraints on hydrosystem operations prevent the return to a natural flow regime in the estuary. Implementation of this action would be limited by international treaties, the need for flood control, fish management objectives systemwide, and power production. However, even slight modifications in the flow regime have the potential to provide significant ecosystem benefits.
Potential benefits with constrained implementation of action	3	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-5:

Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.

Primary threat this action would address		**Entrapment of fine sediment in reservoirs.** Fine sediments originating from upstream sources are trapped in low-velocity impoundments in the Columbia River, and their movement into the estuary and plume has been reduced. This alters processes that form shallow-water habitats, affects food sources, and reduces turbidity that otherwise would shelter salmonids from predation.
Associated limiting factors		Flow-related plume changes and sediment/nutrient-related estuary habitat changes.
Threat index[1]	8	This threat is a secondary contributor to several high-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	2	Fine sediment transport processes are important determinants of estuary and plume habitats. Effective mitigation of this threat would reduce predation of salmonids in the main channel and plume and strengthen habitat-forming processes.
Affected salmonids		Ocean- and stream-type salmonids.
Implementation constraints[3]	5	There are no apparent technical solutions to this threat at this time. Mitigation is recommended, but research is needed to identify the magnitude of the threat and potential solutions or mitigation measures.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = significant potential for implementation.
5 = Current constraints to implementation are significant.

Management Action CRE-6:

Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.

Primary threat this action would address		**Impaired transport of coarse sediment.** The transport of sand and gravel from upstream and estuary sources is a primary force that influences the creation, maintenance, and distribution of salmonid habitats in the estuary. While there are many potential beneficial uses of dredged materials—including enhanced nourishment of the littoral cell, land creation, property stabilization, and out-of-stream uses—there is also an important ecological need to retain coarse sediments in the estuary for habitat creation and maintenance.
Associated limiting factors		Sediment/nutrient-related estuary habitat changes and flow-related plume changes.
Threat index[1]	12	Although impaired transport of coarse sediment is a primary contributor to a top-priority limiting factor (flow-related plume changes), this management action is likely to have its greatest effect in addressing sediment/nutrient-related estuary habitat changes, a high-priority limiting factor; thus it has a threat index of 12.
Potential benefits with unconstrained implementation of action [2]	2	The beneficial use of sand resulting from dredge activities could play an important role in restoring habitat capacity and habitat opportunity in the estuary and plume. The beneficial use of dredged materials to provide sand nourishment could reduce the effects of ship wake stranding, improve habitat for *Americorphium* (a food source for salmonids), and be beneficial in the development of intertidal swamps and marshes and other salmonid habitat features. Sand entering the littoral cell could also have important ecological benefits.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings). This particularly applies to ocean-type juveniles because of their significant use of shallow-water habitats and the nearshore environment.
Implementation constraints[3]	3	Beneficial uses of dredged materials, such as through littoral cell sand nourishment and direct beach nourishment, are currently receiving significant attention, The most obvious constraint to implementation is identifying funding sources to pay for activities beyond the minimum required by law.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-7:

Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.

Primary threat this action would address		**Dredging**. Annual dredge operations maintain a navigational channel that concentrates flows, alters tidal influences, reduces circulation patterns around the estuary, and releases toxic contaminants from substrates. Dredging activities can result in deposited contaminants being disturbed and redistributed throughout the estuary. Dredging activities also result in the entrainment of juvenile salmonids and benthic organisms through the physical removal of sand via pipeline or clamshell dredging. Ship ballast intake may also result in the entrainment of juveniles as ships take on ballast water when exiting port facilities.
Associated limiting factors		Sediment/nutrient-related estuary habitat changes, native birds, and sediment/nutrient-related plume changes.
Threat index[1]	8	As it relates to this action, dredging is a secondary contributor to a high-priority limiting factor (sediment/nutrient-related estuary habitat changes) and thus has a threat index of 8.
Potential benefits with unconstrained implementation of action [2]	2	Continued dredge operations represent a physical change to the Columbia River estuary. However, reducing or mitigating the effects of dredging would improve habitat-forming processes that would benefit salmonids. Reduction of entrainment through new technologies or management practices for both dredging and ship ballast intake would reduce mortality of juveniles.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	2	Dredging activities have been occurring since the 1870s to provide sufficient draft for ships entering the Columbia River and will continue into the foreseeable future. Ongoing maintenance is needed to keep the channel to specifications for ships, and additional dredging will be conducted in the estuary as part of the channel deepening process. Maintaining the navigation channel requires dredging and disposal of large volumes of material (4 to 5 million cubic yards) each year. Changing dredging equipment, ballast water intake screens, and practices to reduce entrainment and habitat effects would be expensive.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.

1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.

1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-8:

Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.

Primary threat this action would address		**Pilings and pile dike structures**. Extensive use of pilings and pile dikes has altered sediment accretion and erosion processes and reduced flow circulation through shallow-water habitats in the estuary. Pile structures also have created favorable conditions for predators of salmonids and can reduce physical access to low-velocity juvenile salmonid habitats. In some cases, treated pilings may release toxic contaminants, including PAHs, and it can be beneficial to remove these structures. In other cases, pile structures may protect riparian areas from erosion and wave energy, collect large wood to form complex habitat, and stimulate sediment accretion in the creation of habitat. In these cases, maintenance or modification of existing structures may be beneficial.
Associated limiting factors		Sediment/nutrient-related estuary habitat changes, sediment/nutrient-related plume changes, exotic fish, native birds, and bioaccumulation toxicity.
Threat index[1]	12	This threat is a primary contributor to a high-priority limiting factor (altered predator/prey relationships), a secondary contributor to a high-priority limiting factor (sediment/nutrient-related estuary habitat changes) and two low-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	4	Removing many instream structures would improve circulation in shallow-water habitats and eliminate some salmonid predator habitats.
Affected salmonids		Ocean-type salmonids; stream-type salmonids (yearlings) leaving the heavier flows to forage in shallow waters downstream of pilings and pile dikes; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings);
Implementation constraints[3]	2	Only some of the thousands of pilings, pile dikes, and similar structures in the Columbia River estuary are necessary to maintain the shipping channel, protect property, or serve their intended economic use. Removal of superfluous structures generally is restricted only by cost and would be unlikely to affect property rights or the shipping industry. In cases where pile dikes that do aide in navigation are removed, constraints to implementation would include the cost for additional dredging to maintain the channel.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-9:

Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.

Primary threat this action would address		**Dikes and filling.** High-quality off-channel habitat provides crucial feeding, rearing, and refuge opportunities for juvenile salmonids and supplies macrodetrital inputs to the estuarine food web. Reduced floodplain inundation has limited juvenile salmonids' access to historical wetland and swamp habitat, much of which has been converted to other land uses. Protecting remaining intact and accessible off-channel habitats and restoring accessible but degraded off-channel areas are critical to maintaining key habitats and food sources for juvenile salmonids.
Associated limiting factors		Reduced macrodetrital inputs, sediment/nutrient-related estuary habitat changes, bankfull elevation changes, sediment/nutrient-related plume changes, and exotic plants.
Threat index[1]	15	This threat is a primary contributor to both top-priority and high-priority limiting factors.
Potential benefits with unconstrained implementation of action[2]	5	Protecting high-quality off-channel areas would help maintain important wetland habitats and supply macrodetrital inputs to the food web and insect food sources for juvenile salmonids—a main component of their diet. Restoring or enhancing accessible but degraded off-channel areas in the estuary represents a largely untapped strategy that could provide similar benefits. Benefits from this strategy likely would be realized more quickly than from the passive restoration associated with CRE-10.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	3	Regulatory programs often do not effectively protect floodplains from conversion to other uses. The acquisition of land for habitat protection remains controversial in the estuary. Rural county governments see land disappearing off tax rolls and also listen to citizen disapproval of public ownership of land. Land acquisition is expensive and depends on the willingness of landowners to sell. Restoring accessible off-channel habitat also depends on willing landowners .The fact that many habitats already have been converted to other land uses limits opportunities to protect high-quality off-channel habitat.
Potential benefits with constrained implementation of action	3	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-10:

Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.

Primary threat this action would address		**Dikes and filling.** Many juvenile salmonids rely on off-channel habitats for feeding and refuge opportunities. Historically, insects and macrodetritus from these habitats were important inputs to the estuarine food web. Dikes, levees, tide gates, and filling have limited the amount and accessibility of key off-channel habitats by reducing floodplain inundation and allowing conversion of land to agricultural, residential, and industrial uses. This action would allow juvenile salmonids access to habitats and food sources that currently are unavailable to them and support improved habitat conditions over time.
Associated limiting factors		Reduced macrodetrital inputs, sediment/nutrient-related estuary habitat changes, bankfull elevation changes, sediment/nutrient-related plume changes, and exotic plants.
Threat index[1]	15	This threat is a primary contributor to both top-priority and high-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	5	Establishing or improving access to off-channel areas via dike breaching and similar activities would reclaim habitat that is important to salmonids. Over time, improved hydrology would support reestablishment of wetland vegetation and salmonid food sources in off-channel areas, through passive restoration. In most cases, project benefits would accrue over relatively long periods of time.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	3	Opportunities to establish or improve access to off-channel habitats are limited because many such habitats already have been filled with dredged materials. Breaching, lowering, or relocating dikes and levees or removing tide gates often requires the cooperation of multiple landowners and may fundamentally alter land uses. The associated habitat restoration is expensive.
Potential benefits with constrained implementation of action	4	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-11:

Reduce the square footage of over-water structures in the estuary.

Primary threat this action would address		**Over-water structures.** Over-water structures may provide habitats for predators and affect instream and shoreline plant communities. However, the total surface area of over-water structures in the estuary has not been quantified and the structures' case-by-case functions have not been analyzed.
Associated limiting factors		Sediment/nutrient-related estuary habitat changes and exotic fish.
Threat index[1]	4	This threat is a tertiary contributor to a high-priority limiting factor (habitat changes) and a secondary contributor to one of the lowest priority limiting factors (exotic fish).
Potential benefits with unconstrained implementation of action [2]	3	Given the uncertainty about how much of a threat over-water structures actually pose to salmonids, the potential improvement in survival must be considered low pending additional research and analysis.
Affected salmonids		Ocean-type salmonids (because of their preference for the shallow-water habitats where most structures are located); stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	3	It is assumed that some over-water structures are more important than others and that removing superfluous or less useful structures would not have deleterious effects on adjacent land uses. Removal of over-water structures that are in currently use would likely require compensation. In some cases, structures such as log rafts could be relocated.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-12:

Reduce the effects of vessel wake stranding in the estuary.

Primary threat this action would address		**Ship wakes.** Wakes from deep-draft vessels traveling through the estuary wash subyearling salmonids onto shore, leaving them stranded. Factors that affect stranding include beach slope and time of day as well as vessel draft, speed, and hull design.
Associated limiting factors		Stranding.
Threat index[1]	6	This threat is a primary contributor to a low-priority limiting factor.
Potential benefits with unconstrained implementation of action [2]	2	The extent of mortality caused by ship wake stranding is unknown. Studies in 1977 and 1994 (Bauersfeld 1977, Hinton and Emmett 1994) reached different conclusions, using different approaches. A soon-to-be-released study by the University of Washington and U.S. Army Corps of Engineers may provide further clarification of the issue.
Affected salmonids		Ocean-type salmonids (because of their longer estuarine residency times, their relatively small size, and the habitats they prefer); stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	3	Options for reducing the effects of vessel wake stranding are limited, primarily because of the lost revenues that would result from slower ship travel. Ship traffic through the estuary will continue, ship hull design is unlikely to change, and the speed of ships traveling the estuary may be difficult to alter. Modification of some habitats may be necessary to reduce this threat and would likely be expensive.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-13:

Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.

Primary threat this action would address		**Altered predator/prey relationships.** Pikeminnows have always been a significant source of mortality for juvenile salmonids in the Columbia River, but changes in physical habitat, such as the addition of in-water structures, have created more favorable conditions for predation by pikeminnow. Introduced species such as smallmouth bass, walleye, and channel catfish also prey on juvenile salmonids, primarily in the freshwater reaches.
Associated limiting factors		Native fish and exotic fish.
Threat index[1]	12	This threat contributes to many limiting factors, although the management action addresses only the native and exotic fish limiting factors, which have threat indexes of 12 and 3, respectively.
Potential benefits with unconstrained implementation of action [2]	4	Ecosystem alterations in the estuary as a result of pikeminnow, smallmouth bass, walleye, and channel catfish are uncertain. Scientists speculate that pikeminnow may be preying on both ocean- and stream-type juveniles. Stream-type juveniles may be affected significantly more than previously thought because evidence suggests that they forage in shallow areas downstream of piling structures.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	2	Because of their abundance, pikeminnow appear to be a far greater threat to juvenile salmonids than bass, walleye, and channel catfish, at least at this time. Implementation activities to reduce pikeminnow predation are constrained by the challenge of reducing their preferred slack-water habitats. Bounty programs can be effective at removing older pikeminnow, which represent the largest threat to salmonids. Although the introduction of exotic fish to the estuary may be irreversible, there are viable tools for managing smallmouth bass, walleye, and channel catfish; these include habitat management and less restricted harvest management. It is likely that warm-water fishers would actively support maintaining the abundance of these species at current—rather than reduced—levels.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-14:

Identify and implement actions to reduce salmonid predation by pinnipeds.

Primary threat this action would address		**Altered predator/prey relationships.** Pinniped predation on adult salmonids at Bonneville Dam has been estimated at between 0.4 percent (2002) and 4.2 percent (2007) of the spring Chinook and winter steelhead runs, or possibly as high as 8.5 percent and 20 percent, respectively (based on radio-telemetry studies). The extent of predation needs further study and documentation.
Associated limiting factors		Native pinnipeds.
Threat index[1]	12	This threat contributes to many limiting factors, although the management action relates only to native pinnipeds.
Potential benefits with unconstrained implementation of action [2]	3	Actions to reduce predation by pinnipeds would have moderate impacts on salmonid survival, depending on how many adults are actually being consumed by pinnipeds—a question that remains uncertain.
Affected salmonids		Ocean- and stream-type salmonids.
Implementation constraints[3]	4	Methods for reducing salmonid predation by pinnipeds are limited because pinnipeds are protected under the Marine Mammal Protection Act (MMPA). It could take years to amend the act to allow additional pinniped management tools. Non-lethal methods have been only minimally successful, although it is possible that additional testing would identify effective non-lethal methods. In 2008, NMFS granted Washington, Oregon, and Idaho authority to use and evaluate lethal methods of control under Section 120 of the MMPA.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-15:

Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.

Primary threat this action would address		**Altered predator/prey relationships.** Exotic plants in the estuary often out-compete native plants and change the structure of plant communities. The resulting habitat frequently does not provide the same food or shelter that other species, including salmonids, have adapted to over time.
Associated limiting factors		Exotic plants.
Threat index[1]	3	This threat contributes to many limiting factors, although the management action relates only to exotic plants, one of the lowest priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	2	Preventing and controlling invasive plants would help maintain the estuarine food web and habitats that juvenile salmonids rely on.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	4	Controlling existing infestations of certain species is functionally impossible once the species are established. Although landowners are the most important agents in preventing and controlling exotic plant infestations, landowner education is a significant task that requires a large effort.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-16:

Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.

Primary threat this action would address		**Altered predator/prey relationships.** Caspian tern predation represents a significant source of mortality for stream-type juveniles migrating to saltwater. Stream-type salmonids are particularly vulnerable because of the timing of their out-migration (during tern nesting season) and their preference for deep-channel habitats near tern nesting sites.
Associated limiting factors		Native birds.
Threat index[1]	12	This threat contributes to many limiting factors, although the management action relates only to Caspian terns.
Potential benefits with unconstrained implementation of action[2]	5	Reducing tern predation could have significant effects on the survival of stream-type salmonids, as terns have been documented to consume as much as 3 percent of stream-type juveniles migrating through the estuary.
Affected salmonids		Stream-type salmonids; ocean-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	2	Management efforts have helped reduce mortality by relocating terns to nearby habitats. Long-term solutions will require habitat improvements elsewhere for Caspian terns.
Potential benefits with constrained implementation of action	3	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-17:

Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.

Primary threat this action would address		**Altered predator/prey relationships.** Predation by double-crested cormorants represents a significant source of mortality for stream-type juveniles migrating to saltwater.
Associated limiting factors		Native birds.
Threat index[1]	12	This threat contributes to many limiting factors, although the management action relates only to double-crested cormorants.
Potential benefits with unconstrained implementation of action[2]	4	Studies indicate that double-crested cormorants prey on salmonid juveniles in the estuary at a rate equal to or greater than the rate by Caspian terns. Cormorants are estimated to have consumed an average of 7 million juvenile salmonids annually over the years 2001 to 2009.
Affected salmonids		Ocean- and stream-type juvenile salmonids are preyed upon by double-crested cormorants with some fluctuation from year to year. In 2009 double-crested cormorants consumed approximately 11 million juvenile salmonids.
Implementation constraints[3]	4	Double-crested cormorants are more difficult to relocate than Caspian terns. Techniques such as the use of decoys and audio playback have not been as effective compared to terns. Perch habitats are plentiful enough in the estuary that removal of pile dikes and other structures may not be an effective tool.
Potential benefits with constrained implementation of action	2	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-18:

Reduce the abundance of shad in the estuary.

Primary threat this action would address		**Altered predator/prey relationships.** Shad returns to the Columbia River number approximately 4 million annually. Shad's effects on the estuary ecosystem and salmonids are poorly understood. However, shad are an introduced species and their biomass alone represents a threat to trophic relationships in the Columbia River.
Associated limiting factors		Exotic fish.
Threat index[1]	3	This threat contributes to many limiting factors, although the management action relates only to shad.
Potential benefits with unconstrained implementation of action [2]	2	The impacts of shad in the estuary are unclear. However, it is likely that reducing shad numbers would have some benefits for salmonids.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	5	Shad are thought to have permanently altered the estuary ecosystem, and their complete removal from the estuary is neither practical nor feasible. Effective management tools to limit shad productivity in the Columbia River basin currently are not available. Research is needed in the near term to determine the significance of this threat and identify potential management actions to manage the abundance of shad.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-19:

Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.

Primary threat this action would address		**Ship ballast practices.** Ship ballast water is responsible for the introduction of non-native aquatic invertebrates in the estuary. The effects of these introductions are poorly understood, but it is likely that exotic invertebrates disrupt food webs and out-compete juvenile salmonids' native food sources.
Associated limiting factors		Introduced invertebrates.
Threat index[1]	3	This threat is a primary contributor to one of the lowest priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	2	Reducing the impacts of non-native aquatic invertebrates would help maintain traditional salmonid food sources and the trophic relationships that salmon have adapted to.
Affected salmonids		Ocean-type salmonids; stream-type salmonids displaying less dominant life history strategies (e.g., early and late fingerlings and subyearlings).
Implementation constraints[3]	4	Improvements in ship ballast practices have already been implemented by the industry as a result of new regulations, and stricter regulations are currently being debated at the Federal level. However, there are inherent challenges in managing ballast water that contains organisms from other ecosystems. Also, once non-native aquatic invertebrates have been introduced, they represent a permanent alteration of the ecosystem and opportunities to reduce their effects may be few. Current understanding of how the estuary ecosystem is affected by introductions of exotic invertebrates is very limited.
Potential benefits with constrained implementation of action	1	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-20:

Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.[1]

Primary threat this action would address		**Agricultural practices.** Fertilizers include different forms of nutrients that are important for plant growth. When fertilizers make their way to the estuary through overland runoff, they contribute nutrients to the estuary that increase phytoplankton production, alter the food web, and in some instances depress dissolved oxygen levels. Water-soluble contaminants such as simazine, atrazine, chlorpyrifos, metolachlor, diazinon, and carbaryl enter the estuary as a result of tributary and upstream agricultural practices. DDT and PCBs have been detected at elevated levels in the estuary. These and other agricultural contaminants can cause salmonid mortality through bioaccumulation or non-bioaccumulative toxicity.
Associated limiting factors		Non-bioaccumulative toxicity, bioaccumulation toxicity, and increased microdetrital inputs.
Threat index [2]	12	This threat is a primary contributor to a high-priority limiting factor (non-bioaccumulative toxicity) and a medium-priority limiting factor.
Potential benefits with unconstrained implementation of action [3]	3	Reducing the level of pesticides and herbicides in the estuary would improve survival by reducing ocean-type salmonids' acute and chronic exposure to toxic contaminants and stream-type salmonids' acute exposure.
Affected salmonids		Ocean- and stream-type salmonids.
Implementation constraints[4]	4	Impacts from pesticides and fertilizers have lessened dramatically since the 1950s as a result of new application technologies, new products, and better understanding and regulation of these toxins. More extensive compliance with existing regulations and usage guidelines, along with development of additional best management practices, could further reduce the impacts of pesticides and fertilizers. The integration of new practices can be expensive and time-consuming.
Potential benefits with constrained implementation of action	1	

[1] The term best management practices is used here to indicate general methods or techniques found to be most effective in achieving an objective. NMFS envisions that in implementation, specific best management practices would be developed or recommended.

[2] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[3] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[4] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-21:

Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.

Primary threat this action would address		**Urban and industrial practices.** The estuary has been affected by historical and current releases of toxic contaminants, including industrial and commercial pollutants such as PCBs and PAHs. These substances have been found near Portland, Vancouver, Longview, and Astoria. Studies have demonstrated significant juvenile mortality in the estuary as a result of toxic contaminants. In addition, urban and industrial effluent and stormwater runoff are principal sources of nutrients that can support increased phytoplankton levels.
Associated limiting factors		Non-bioaccumulative toxicity, bioaccumulation toxicity, and increased microdetrital inputs.
Threat index[1]	12	This threat is a primary contributor to high- and medium-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	4	Reducing sources of pollutants would lower water temperature, nutrient loading, and the amount of toxic contaminants in the estuary. This would improve both habitat capacity in the estuary and the fitness level of salmonids.
Affected salmonids		Ocean- and stream-type salmonids (particularly ocean types because of their longer residency in the estuary).
Implementation constraints[3]	4	While some discharges of industrial and commercial pollutants are permitted, others are not. Efforts to reduce industrial and commercial pollutants are already under way, and there is potential to reduce point-source emissions. Efforts to reduce sources of pollutants are expensive and time-consuming and often have a negative economic effect on operations.
Potential benefits with constrained implementation of action	3	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-22:

Restore or mitigate contaminated sites.

Primary threat this action would address		**Urban and industrial practices.** The estuary has been affected by historical and current releases of toxic contaminants, including industrial and commercial pollutants such as PCBs and PAHs. These substances have been found near Portland, Vancouver, Longview, and Astoria. Studies have demonstrated significant juvenile mortality in the estuary as a result of toxic contaminants. The action is intended to address the need to monitor the entire estuary for contaminants; however, actual restoration activities are feasible only in specific reaches.
Associated limiting factors		Non-bioaccumulative toxicity and bioaccumulation toxicity.
Threat index[1]	12	This threat is a primary contributor to high- and medium-priority limiting factors.
Potential benefits with unconstrained implementation of action [2]	5	Reducing toxic contaminants in the estuary would improve both habitat capacity and the fitness level of salmonids.
Affected salmonids		Ocean- and stream-type salmonids (particularly ocean types because of their longer residency in the estuary).
Implementation constraints[3]	3	Monitoring activities are already occurring; however, actual restoration of contaminated sites is expensive and technically challenging in many cases. In cases where restoration is not feasible, the effects of contaminated sites should be mitigated.
Potential benefits with constrained implementation of action	3	

[1] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[2] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[3] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Management Action CRE-23:

Implement stormwater best management practices in cities and towns.[1]

Primary threat this action would address		**Urban and industrial practices.** Municipal stormwater runoff can convey nutrients and toxic contaminants to the estuary, reduce groundwater recharge, and increase the “flashiness” of stream flows. Although cities and towns in the Columbia River basin generally have programs to reduce the impacts of stormwater runoff, stormwater best management practices have not been universally accepted or implemented throughout the basin.
Associated limiting factors		Non-bioaccumulative toxicity, bioaccumulation toxicity, and increased microdetrital inputs.
Threat index[2]	9	This threat is a secondary contributor to a medium-priority limiting factor as it relates to this management action.
Potential benefits with unconstrained implementation of action [3]	2	Identifying and implementing stormwater best management practices throughout the Columbia River basin would improve conditions and provide a net benefit to salmonids in the estuary through a more normal flow regime, reduced exposure to contaminants, and lower water temperatures.
Affected salmonids		Ocean- and stream-type salmonids (particularly ocean types because of their longer residency in the estuary).
Implementation constraints[4]	2	Some cities lack the resources or will to implement or enforce stormwater best management practices. The benefits of improved stormwater practices generally are associated only with new development and do not offset the full impact of the impervious surfaces in those developments, or the existing impervious surfaces in areas that have already been developed.
Potential benefits with constrained implementation of action	1	

[1] The term best management practices is used here to indicate general methods or techniques found to be most effective in achieving an objective. NMFS envisions that in implementation, specific best management practices would be developed or recommended.

[2] From Table 4-1. Indicates the significance of the associated limiting factor and the threat's contribution to that limiting factor. High numbers indicate threats that have a major contribution to high-priority limiting factors; lower numbers indicate threats that have a minor contribution to low-priority limiting factors. Numbers indicate the highest score per threat category and do not account for multiple limiting factor contributions.

[3] Estimate of the expected benefits to salmonids (ocean- and stream-types combined) if the action were fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[4] Indicates the feasibility of implementing the action.
1 = Current constraints to implementation are minimal.
5 = Current constraints to implementation are significant.

Table 5-2 estimates the potential of each management action to benefit salmonids under two different implementation scenarios. Assuming that implementation of most actions is significantly constrained, which management actions would be likely to result in the greatest survival improvements?

In partial answer to this question, Table 5-3 summarizes the potential benefits of each action under both unconstrained and constrained implementation scenarios. It is tempting to sort the actions in Table 5-3 by potential benefit with constrained implementation and view the sorted list as a prioritized list of management actions, with the actions at the top being those predicted to have the greatest benefits. Although Table 5-3 does provide insight into the relative benefits of the various management actions, it is perhaps most useful as a means of contrasting the benefits that might be achieved with unconstrained implementation of an action with the benefits that might be achieved under a more likely scenario of constrained implementation.

To provide greater insight into the relative benefits of each management action, PC Trask & Associates, Inc., developed a second analysis based on survival improvement targets. This analysis, which is presented in the next section of the document, is more refined and specific than the analysis in Table 5-3. For instance, it focuses more on how the potential benefits of the 23 management actions would compare to each other and on the survival benefits that might be gained from each action. It also evaluates the benefits of each action to both ocean- and stream-type salmonids.

TABLE 5-3
Summary of Constraints to Implementation of Management Actions

Number	Action Description	Benefit with Unconstrained Implementation of Action[1]	Benefit with Constrained Implementation of Action[2]
CRE-01	Protect intact riparian areas in the estuary and restore riparian areas that are degraded.	4	2
CRE-02	Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	3	2
CRE-03	Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.	2	1
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.	5	3
CRE-05	Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.	2	1
CRE-06	Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	2	1

Number	Action Description	Benefit with Unconstrained Implementation of Action[1]	Benefit with Constrained Implementation of Action[2]
CRE-07	Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.	2	1
CRE-08	Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	4	2
CRE-09	Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.	5	3
CRE-10	Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.	5	4
CRE-11	Reduce the square footage of over-water structures in the estuary.	3	1
CRE-12	Reduce the effects of vessel wake stranding in the estuary.	2	1
CRE-13	Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.	4	2
CRE-14	Identify and implement actions to reduce salmonid predation by pinnipeds.	3	2
CRE-15	Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.	2	1
CRE-16	Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	5	3
CRE-17	Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.	4	2
CRE-18	Reduce the abundance of shad in the estuary.	2	1
CRE-19	Prevent new introductions of invertebrates and reduce the effects of existing infestations.	2	1
CRE-20	Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.	3	1
CRE-21	Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	4	3
CRE-22	Restore or mitigate contaminated sites.	5	3
CRE-23	Implement stormwater best management practices in cities and towns.	2	1

[1]Estimate of potential benefit if action is fully implemented, with no constraints.
1 = very low benefits.
5 = very high benefits.

[2]Estimate of potential benefit assuming that implementation is constrained.
1 = very low benefits.
5 = very high benefits.

Evaluation of Management Actions: Survival Improvement Targets

The Columbia River estuary and plume are only two of many ecosystems that salmonids travel in their complex and lengthy journey from headwaters to ocean and back again. Mortality occurs at every stage of this journey. Each year, scientists from the NMFS Northwest Fisheries Science Center estimate the number of juvenile salmonids that enter the estuary from upstream of Bonneville Dam and from estuary tributaries. For 2006, scientists from NMFS estimated that about 168 million juvenile salmonids (both wild and hatchery) would enter the estuary (Ferguson 2006b). Some years later, the surviving fish return to the estuary in varying numbers, with the average return in the last 10 years being approximately 1.7 million fish; roughly 65 to 75 percent of those fish are of hatchery origin.[1] This means that less than 1 percent of the juveniles that enter the estuary are returning as adults.

Estimating Juvenile Mortality in the Estuary and Plume

How much juvenile mortality is occurring in the estuary and plume? The answer to this question is fundamental to developing an understanding of the role the estuary will play in the recovery of salmonid populations basinwide. The answer also is critical in evaluating the benefits and costs of potential management actions because it helps establish the level of effort needed to offset threats to salmonids in the estuary. Unfortunately, determining how much juvenile mortality is occurring in the estuary and plume is challenging for scientists. Counting juveniles in the Columbia River estuary and plume is problematic because available tracking technologies are limited, and it is difficult to monitor juveniles—which tend to move in and out of saltwater—in large, high-energy sites such as the mouth of the Columbia River.

However, some efforts have been made to separate mortality that occurs in the estuary and plume from mortality that occurs in the ocean. One such effort has been the underlying assumptions in the Ecosystem Diagnosis and Treatment (EDT) model, which is used extensively throughout the Columbia River basin. For juveniles entering the estuary from tributaries to the lower Columbia River, EDT assumes mortality rates in the estuary and plume of between 18 and 58 percent, depending on the salmonid species and the amount of time juveniles spend in the estuary (Lower Columbia Fish Recovery Board 2004). In a study of juvenile mortality in the estuary, Schreck et al. (2006) estimated spring/summer Chinook mortality at between 11 and 17 percent, largely from avian predation.

In addition, research is under way by NMFS, the U.S. Army Corps of Engineers, and Battelle Laboratories to estimate the survival rate of juvenile salmonids in the lower Columbia River. This research involves new technologies for miniaturizing acoustic tags to a size capable of tracking yearling and subyearling juveniles. Current technology developed for the project allows for the tracking of subyearlings of sizes down to approximately 90 mm. Results for the first year (2005) indicated an approximate range of survival of 65 to 75 percent for subyearlings and yearlings during their residency in the estuary (Ferguson 2006a). It is probable that actual survival rates are lower than these preliminary estimates suggest

[1] This is an informal estimate; determining the ratio of hatchery-origin fish with more certainty would require stock-by-stock run calculations averaged over many years.

because the research did not address mortality among juveniles smaller than 90 mm or mortality occurring in the plume and nearshore. The studies above have not been conclusive, and separating estuarine and ocean mortality for juvenile salmonids in the Columbia River remains significant challenge.

Some specific estimates of salmonid mortality are known in the estuary; they include estimates for double-crested cormorants and Caspian terns. For other threats to salmonids, such as toxic contamination, ship wake stranding, and pinniped predation, information on mortality in the estuary is incomplete or relatively new in the literature. Still other threats, especially those related to the food web, are poorly understood and have no mortality estimates associated with them, although in some cases the change in conditions from the historical template to the present has been well documented.

Establishing Survival Improvement Targets

An important goal of this estuary recovery plan module is to estimate the potential benefits—in terms of increased survival of salmonids in the estuary—that could result from the implementation of different management actions. To accomplish this goal, PC Trask & Associates, Inc., used available information about limiting factors, threats, and constraints to the implementation of management actions to assign benefits that could possibly result from different actions.

If scientific understanding of the relationships between ecological conditions and biological responses in estuarine systems were robust, it would be attractive to assign specific mortality rates to each of the factors limiting salmonids' biological performance in the Columbia River estuary. Then one could follow a deterministic logic path that associates mortality rates with specific threats, relates the mortality rates to management actions, and ultimately arrives at an estimate of the survival improvement that would be likely to result from each action. This is not possible at this time, and it will likely not be possible until there have been significant advances in scientific understanding of the complex estuarine environment.

To compensate for the lack of detailed information on mortality in the estuary, PC Trask & Associates, Inc., established targets for improved survival of wild ESA-listed salmonids rearing and migrating in the estuary and plume, assuming that the implementation of management actions is constrained to the degree indicated in Table 5-2. PC Trask & Associates, Inc., then allocated these survival targets to individual management actions. These targets are intended to serve as a planning tool useful in characterizing the potential results of actions and describing the level of effort needed to recover salmonids.

The primary purpose of the survival improvement targets is to help compare the potential benefits of different management actions, particularly actions that partially address major limiting factors versus actions that fully address minor limiting factors. In addition, the survival improvement targets provide insight into the specific survival benefits of each action and the differential benefits of each action to stream- and ocean-type salmonids. Numerically, the survival improvement targets in this chapter were based on an estimate of the number of naturally produced ESA-listed ocean- and stream-type juvenile salmonids entering the estuary. The total number of naturally produced ESA-listed juvenile salmonids estimated to enter the estuary in 2006 was approximately 39 million (Ferguson 2006b).[2] Of these, approximately 25 million were estimated to be ocean type and 14 million were estimated to be stream type.

To establish survival improvement targets, PC Trask & Associates, Inc., developed some assumptions about the overall mortality of juvenile salmonids during estuary and plume residency. Ocean-type juveniles were assumed to have an overall mortality rate of 50 percent during their estuary residency; this includes the 35 percent mortality suggested by the unpublished micro-acoustic tagging research (Ferguson 2006a) plus an additional 15 percent to account for juveniles too small to be tracked. Stream-type juveniles were assumed to have an overall mortality rate of 40 percent during estuary and plume residency. This rate was based on the 25 percent mortality found in the micro-acoustic tagging research (Ferguson 2006a) plus an additional 15 percent to account for mortality occurring in the plume, which was not part of study. These assumptions about estuary mortality are based on best professional judgment by PC Trask & Associates, Inc., after a review of pertinent literature and discussions with subject matter experts, including scientists at the NMFS Northwest Fisheries Science Center.

Table 5-4 shows the number of wild, ESA-listed ocean- and stream-type juveniles thought to be entering the lower Columbia estuary and plume, their estimated mortality and survival rates based on the assumptions above, and the number of juveniles estimated to survive their journey through the estuary and plume—again, based on the assumptions above.

TABLE 5-4
Estimated Mortality Rates, Survival Rates, and Survival Improvement Targets for Wild, ESA-Listed Juveniles

Type	Juveniles Entering Estuary*	Assumed Mortality Rate	Assumed Survival Rate	Estimated Number of Juveniles Exiting Estuary and Plume*	Survival Improvement Target (20 percent)**
Ocean Type	25 million	50%	50%	12.5 million	2.5 million***
Stream Type	14 million	40%	60%	8.4 million	1.68 million***

* = Wild, ESA-listed juveniles.

** = Twenty percent of the estimated number of juveniles exiting the estuary and plume; this target represents additional fish surviving their estuary and plume residency.

*** These numbers are used to characterize the potential, relative benefits of implementing various management actions and do not represent actual numbers of additional fish expected to survive.

Table 5-4 also presents survival improvement targets for ocean- and stream-type salmonids in the estuary and plume. For planning purposes only, this estuary recovery plan module selects 20 percent as a target for improvement in the survival rate of wild, ESA-listed ocean- and stream-type juveniles in the estuary and plume. Twenty percent represents a hypothetical level of improvement that might be realized through the implementation of the management actions, assuming that considerable effort is expended to help offset constraints to implementation, such that threats and limiting factors are reduced. For ocean types, increasing survival by 20 percent would result in a total of 15 million juveniles exiting

[2] Current scientific information on the effects of limiting factors and actions does not differentiate between hatchery- and natural-origin salmon and steelhead, or between salmon and steelhead that are listed under the ESA and those that are not. Because ESA recovery is determined by the status of natural-origin fish, the intent of the module is to improve the estuarine survival of naturally produced, ESA-listed salmon and steelhead. Naturally produced fish are the focus of the analysis of survival improvement targets because they are the focus of the module.

the estuary and plume—2.5 million more juveniles than the current estimate of 12.5 million. For stream types, a 20 percent improvement would equal 10.08 million—1.68 million additional juveniles beyond the current 8.4 million that are estimated to exit the estuary and plume. Thus the survival improvement targets for ocean- and stream-type salmonids are 2.5 million and 1.68 million, respectively, as shown in Table 5-4. Targets for both types were set at 20 percent to avoid the appearance of a false level of precision in establishing them. Ocean-type juveniles were assumed to incur more mortality in the estuary and nearshore compared to stream types. Stream types were assumed to incur less mortality in the estuary than ocean types but significantly more mortality in the plume.

PC Trask & Associates, Inc., selected the 20 percent survival improvement number for ocean- and stream-type juvenile salmonids based on a qualitative analysis of the level of improvement that reasonably and plausibly might be expected if the 23 management actions were implemented. In establishing the 20 percent target, PC Trask & Associates, Inc., reviewed existing management plans, other literature sources, and the constraints analysis in Table 5-2. However, setting 20 percent as the target for improvement, rather than 15 or 30 percent, is inherently subjective and relies in part on the following assumptions:

- That estuary mortality for juveniles (currently between 40 and 50 percent, depending on population) can be reduced by initiating restoration projects and reducing uncertainties through research and monitoring
- That mortality rates associated with certain threats, such as Caspian terns and cormorants, are well understood and will be lessened through actions specified in management plans that are reasonably likely to be implemented
- That all of the actions identified in this chapter are implemented to a reasonable degree and historical and current constraints to action implementation are thoroughly challenged

Actual improvements in survival will depend on which management actions are implemented, how fully they are implemented, and their efficacy—factors that at this point are open to interpretation and can be qualitatively estimated only. Although the 20 percent targets for ocean- and stream-type salmonids are intended to be reasonable and plausible given the information available to date, open technical, political, and social discussion could refine the targets until science can substantiate them.

The survival improvement targets in Table 5-4 were developed using ocean- and stream-type life history strategies to characterize the 13 ESUs in the Columbia River basin. As a result, the survival improvement targets do not account for important variations found at the ESU, population, and subpopulation scales. For example, not all ocean-type ESUs in the Columbia River basin exhibit the same run timing, size at estuary entry, or use of particular habitats (Fresh et. al 2005). In fact, this variability in estuarine use by the ESUs is fundamental to the member/vagrant theory proposed by the NMFS Northwest Fisheries Science Center and a central premise of the estuary recovery plan module (see Chapter 2 for more information on the member/vagrant theory). Although genetic and spatial diversity are not explicitly accounted for in survival improvement targets, the suite of management actions identified in the estuary recovery plan module is intended to collectively address all life history strategies historically expressed in the estuary and plume. This further emphasizes that the survival improvement targets are best viewed as a planning tool only. In reality, there will be significant variability among ESUs, populations, and subpopulations in how much additional survival might result from improvements in estuary and plume habitat.

Assigning Survival Improvement Targets to Recovery Actions

The usefulness of the 20 percent target lies not in the 20 percent number itself, but in the distribution of the targets (2.5 million ocean-type juveniles and 1.68 million stream-type juveniles) across the various management actions, as a way of characterizing the relative benefits of the various management actions.[3] Table 5-5 shows this allocation of survival improvement targets to the 22 management actions for juvenile salmonids.[4] In cases where there is good scientific literature that supports the allocation of survival targets, as with terns and cormorants, PC Trask & Associates, Inc., used that information as a basis for the analysis in Table 5-5. In other cases, such as reservoir-related temperature changes, PC Trask & Associates, Inc., estimated survival improvements based on literature discussion of related limiting factors and threats. The reader should view the resulting survival improvement targets as the product of a planning exercise, not a representation of deterministically based estimates. (Appendix B presents more information on how PC Trask & Associates, Inc., allocated survival improvement targets to the different actions.)

Although the survival improvement targets in Table 5-5 are estimates only, they complement the analysis summarized in Table 5-3.[5] In addition, they provide a useful way to show the potential magnitude of juvenile survival at the action scale relative to other actions. The survival improvement targets illustrate how a small increment of implementation of a far-reaching action could offer significantly more potential for recovery than full implementation of an action that is more limited in scope. Comparison of Tables 5-3 and 5-5 and the cost estimates that are developed in the next section form the basis for prioritization of actions in Chapter 7, "Perspectives on Implementation."

A special case in assigning survival improvement targets to actions are those actions (CRE–01 and CRE–09) that use land protection as a means of achieving the target. In theory, protection projects contribute only to maintenance of baseline conditions and not to recovery. However, the estuary recovery plan module does assign a portion of the survival improvement targets to protection projects. The reasoning here is that without protection of baseline environmental conditions, significantly more effort would be required in restoration projects to offset the continued loss of functioning habitat that would result from increases in the human population and corresponding conversion of habitats to economically beneficial land uses. Thus, assigning survival improvement targets to

[3] Although for the purposes of this analysis 20 percent is considered a hypothetical number, it is a plausible number. The 20 percent figure is based on overall estimates of juvenile mortality in the estuary, known mortality that can be attributed to specific threats, and professional judgment regarding the efficacy of the different management actions and the likelihood that constraints to their implementation can be overcome.

[4] Although the survival improvement targets are expressed in terms of numbers of natural-origin ESA-listed fish, this is simply to illustrate the potential benefits of actions, not to analyze differential benefits to natural-origin listed fish versus unlisted or hatchery-origin fish; what is important is the allocation of relative benefits among the management actions.

[5] Table 5-2 contrasts the difference between constrained and unconstrained implementation of an individual action, while Table 5-5 compares potential benefits across the entire set of actions. Given the two tables' different purposes, there is not a mechanistic relationship between them. However, there is a rough correlation between the potential benefits of constrained implementation in Table 5-2 and where an action falls in the relative rankings presented in Table 5-5.

protection projects reflects the value of avoiding the additional effort that would be required to restore functioning habitats lost because they were not protected.

Uses of the Survival Improvement Targets

The purpose of the survival improvement targets in Table 5-5 is to address a particular planning challenge in the estuary module: how to compare the potential benefits of management actions that are disparate in their scope and feasibility, especially when scientific information about the causes of salmonid mortality in the estuary is incomplete. In the absence of comprehensive scientific data, the targets provide a useful framework for evaluating the relative merits of different actions. However, survival improvement targets do not represent actual numbers of fish.

For example, it would be inappropriate to use the survival improvement targets to estimate total juvenile mortality in the estuary, attribute a level of mortality to a specific limiting factor or threat, or calculate "per-fish" costs of actions. Because the survival improvement targets are not scientifically derived, they have limited use for life-cycle modeling. On the other hand, the targets could serve as a starting point for life-cycle modeling in the absence of rigorous data.

It also would be unwise to predict specific outcomes of an action or suite of actions based solely on the survival improvement targets. Although it would be appropriate to use the targets to guide expenditures and the selection of individual projects that are consistent with the module's management actions, monitoring should accompany any implementation of those projects—to evaluate their effectiveness, test the assumptions underlying the targets, and provide a basis for refining them.

Because the survival improvement targets are a tool for comparing the relative benefits of actions, they are particularly useful in weighing the trade-offs involved in implementing some actions but not others, or implementing actions only partially. For example, in theory, if a certain action were implemented partially or not at all, the potential 20 percent gain in the number of wild, ESA-listed juveniles leaving the estuary and plume could not be achieved unless other actions were implemented to a greater extent than envisioned in the module, to compensate. Survival improvement targets provide a way of evaluating various scenarios for implementation. This is critical because the implementation of every action already is constrained (often significantly) and, in most cases, the opportunities to remove constraints and implement actions more fully are limited.

TABLE 5-5
Survival Improvement Targets Allocated to Management Actions[1]

Number	Action Description	Survival Improvement Target[1] with Constrained Implementation (numbers of wild, ESA-listed fish)			
		Ocean Type[1]	% of Total Improvement Target	Stream Type[1]	% of Total Improvement Target
CRE-01	Protect intact riparian areas in the estuary and restore riparian areas that are degraded.	150,000	6%	100,000	6%
CRE-02	Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	90,000	4%	20,000	1%
CRE-03	Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.	25,000	1%	20,000	1%
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.	225,000	9%	125,000	7%
CRE-05	Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.	5,000	<1%	5,000	<1%
CRE-06	Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	50,000	2%	15,000	<1%
CRE-07	Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities in the estuary.	8,000	<1%	10,000	<1%
CRE-08	Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	150,000	6%	100,000	6%
CRE-09	Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.	400,000	16%	150,000	9%
CRE-10	Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.	450,000	18%	100,000	6%
CRE-11	Reduce the square footage of over-water structures in the estuary.	25,000	1%	3,000	<1%
CRE-12	Reduce the effects of vessel wake stranding in the estuary.	55,000	2%	2,000	<1%

Number	Action Description	Survival Improvement Target[1] with Constrained Implementation (numbers of wild, ESA-listed fish)			
		Ocean Type[1]	% of Total Improvement Target	Stream Type[1]	% of Total Improvement Target
CRE-13	Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.	140,000	6%	122,000	7%
CRE-14	Identify and implement actions to reduce salmonid predation by pinnipeds.	N/A[2]	N/A	1,034[2]	N/A
CRE-15	Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.	20,000	<1%	15,000	<1%
CRE-16	Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	2,000	<1%	350,000	21%
CRE-17	Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.	2,000	<1%	250,000	15%
CRE-18	Reduce the abundance of shad in the estuary.	5,000	<1%	5,000	<1%
CRE-19	Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.	8,000	<1%	2,000	<1%
CRE-20	Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.	50,000	2%	42,000	3%
CRE-21	Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	275,000	11%	72,000	4%
CRE-22	Restore or mitigate contaminated sites.	300,000	12%	142,000	8%
CRE-23	Implement stormwater best management practices in cities and towns.	65,000	3%	30,000	2%
	Total	2.5 million		1.68 million	

[1] Appendix B presents more information on how survival improvement targets were developed.

[2] The survival improvement targets are assigned for juvenile salmonids only. Although CRE-14 relates specifically to adult salmonids, the survival numbers for CRE-14 are not included in the 20 percent survival improvement targets for juvenile salmonids. The stream-type survival number is based upon an estimated 17 percent reduction in adult fish mortality applied to 2010 run-size information reported in U.S. Army Corps of Engineers (2010). Some mortality may be occurring as a result of pinniped predation on ocean-type juvenile salmon and steelhead. The extent to which this is occurring has not been established.

Evaluation of Management Actions: Costs and Schedule

Implementing recovery actions in the estuary will require a long-term commitment by many entities. In Tables 5-2 and 5-5, two approaches were used to portray the potential survival improvements associated with implementing actions. In Table 5-6, each action is broken down into one or more projects that can be considered elements of that action.

For some management actions, the first project involves conducting a study or assembling existing technical information. There are several reasons for this. In some cases, existing information about how to reduce the associated threat to salmonids is limited, and additional study is needed to identify and pilot-test possible actions to determine which ones would be most effective. This is particularly important when funds for implementing management actions are limited. Additionally, conducting a study or assembling technical information involves stakeholders who may have local knowledge about the threat or will be responsible for implementing projects. Lastly, studies and information gathering provide an opportunity to understand the constraints of management actions, to reexamine assumptions about what is and is not possible, and to explore the lengths to which, as a society, we are willing to go to implement actions that will contribute to the recovery of salmon and steelhead in the Columbia River basin. The intent of including studies and information gathering in the management actions, when appropriate, is not to postpone taking on-the-ground action but to ensure that any actions that are taken are truly effective, that stakeholders are involved in the process, and that important dialogue occurs about the value of reducing constraints and implementing management actions as fully as possible, even in situations where implementation is highly constrained.

The recovery plan module does not present a detailed list of projects waiting to be completed in the estuary. This is because in many cases, additional work is needed to develop complex, large-scale projects that will provide maximum benefit, or to work with landowners and other stakeholders to gain their support, or to understand the most effective avenue for implementation.

Table 5-6 provides cost estimates for each of the 23 actions in the estuary recovery plan module and a timeframe for their implementation. Each project in Table 5-6 has a corresponding unit and cost, and the project costs are summed to produce a total cost for each action. The costs identified in this section do not represent a detailed economic analysis; in fact, they are not economic costs in that they have not been discounted across time. Instead, the cost estimates are in constant dollars over a 25-year period. A 25-year implementation period was selected for several reasons. Many of the actions identified in the estuary module include project types that have never been implemented in the estuary, and it will take time to establish or modify programs to implement these projects; some will require new research and monitoring to guide their effective implementation. In addition, a 25-year implementation period will allow time to identify funding sources and build the landowner buy-in and project sponsor capacity needed to implement the 23 actions.

In most cases the costs listed in Table 5-6 are direct, incremental costs, meaning that they are (1) out-of-pocket costs that a public or private interest would pay to initiate and complete a management action, and (2) costs in addition to the baseline costs for existing programs and activities, which may or may not be focused on salmon recovery. This approach is consistent with NMFS Northwest Regional Office guidance on cost estimates for ESA recovery plans. In some cases, distinctions between baseline and incremental costs are clear. For instance, reducing the abundance of shad (CRE-18) is an action that includes only incremental costs because it is a new action that has yet to be implemented in the estuary. Other actions, such as breaching, lowering, or relocating dikes (CRE-10), have been implemented in the estuary at a relatively modest scale. For such actions, the estuary recovery plan module cost estimate is still entirely incremental in that it identifies an additional level of effort needed to achieve the survival improvement targets identified later in this chapter.

Several of the 23 actions do contain some baseline costs, because in some cases these baseline costs represent a small fraction of the overall implementation cost of the action and it was deemed infeasible to separate out the incremental costs. In these cases, this fact is noted in Table 5-6 under the key assumptions for the individual management action. For example, Caspian tern management (CRE-16) is supported by an existing management plan, and some efforts are already under way to implement the action. The other two examples are managing pikeminnow and other piscivorous fish (CRE-13) and implementing stormwater best management practices (CRE-23). In these examples, programs are in place, but major portions of the estuary recovery plan module action have not been implemented to date. In addition, for one action—adjusting the timing, magnitude, and frequency of hydrosystem flows (CRE-4)—the primary costs are the costs of foregone power generation. Generally, recovery action cost estimates do not include such opportunity costs. We have included an estimate of such costs in this case because otherwise this action would have skewed the cost-effectiveness assessment in Chapter 7 (see Table 7-5) in a way that would preclude constructive dialogue about adjusting flows.

The cost estimates in Table 5-6 were developed by PC Trask & Associates, Inc., and reviewed by the Lower Columbia Fish Recovery Board, the Lower Columbia River Estuary Partnership, and NMFS. In addition, an economist at the NMFS Northwest Fisheries Science Center reviewed Chapter 5 and provided comments (although not a detailed evaluation of the costs). Lower Columbia River Estuary Partnership staff contributed substantively to cost estimates for actions for which the Estuary Partnership has some history of implementation. For example, the Estuary Partnership has funded multiple dike breaches (CRE-10), riparian protection projects (CRE-1), and off-channel protection/restoration projects (CRE-9). In other cases, where possible, experts knowledgeable about implementing similar actions were consulted. For example, staff from the NMFS Northwest Regional Office were consulted to estimate costs for managing pinnipeds (CRE-14).

In still other cases, a coarse estimate was established based on the component projects and assumptions about the feasibility of their implementation. These were generally cases in which the extent of on-the-ground actions could not be determined until certain scientific or technical questions have been answered more definitively through studies or information gathering (see, e.g., CRE-2, CRE-7, CRE-12, CRE-18). In these cases, costs of any assessment work were estimated, and then a coarse-scale, placeholder cost estimate was developed based on assumptions about the magnitude and nature of subsequent projects needed to implement the management action. It is expected that such cost estimates will be refined as more specific projects are defined.

Thus the cost estimates in Table 5-6 attempt to establish a realistic cost for recovery, but the precision with which costs can be estimated at this time is limited, and there is considerable uncertainty in all the cost estimates. In Chapter 6, some additional costs are identified for research, monitoring, and evaluation activities (see Table 6-7).

The estuary recovery plan module addresses habitat conditions for all Columbia River basin ESUs during a single stage of their life cycle, but many additional management actions—including actions in the tributaries—will be needed to achieve recovery of any particular ESU. Because the management actions in the module are only a subset of all the actions needed for recovery of an ESU, the costs in Table 5-6 do not reflect the total costs to achieve recovery. Total costs for recovery are more appropriately represented in the recovery plans for each ESU, as these plans deal with multiple life stages for a specific ESU.

Each action in Table 5-6 includes a proposed schedule for implementation. The schedule is designed to place projects in a logical order and spread costs over a long period of time when possible. Costs are estimated over a 25-year span, with some projects being implemented once over a relatively short period and others continuing over the entire 25 years.

Other elements contained in Table 5-6 include the association of actions to specific geographical reaches, key assumptions about actions, a list of potential implementers,[6] notes that help explain how costs were developed, and a brief summary of some of the existing programs that address limiting factors identified in this recovery plan module. The summaries of existing programs are not exhaustive and are intended to emphasize that opportunities exist to build on existing programs to improve salmon and steelhead survival in the estuary. The relationship of actions to the eight geographic reaches and the plume helps to define the breadth of the action and may also indicate which jurisdictions may implement actions in the future. Key assumptions relate primarily to implementation and provide insight into the level of effort reflected in the action costs. Notes are specific information that helps clarify a particular unit or cost.

[6] The list of potential implementers is intended only to indicate entities that *may* have a role in implementation and to serve as a guide to begin discussion of implementation roles. It does not imply any budgetary, regulatory, or other responsibility for implementation.

TABLE 5-6
Estimated Cost and Schedule

Management Action CRE-1:

Protect intact riparian areas in the estuary and restore riparian areas that are degraded.

Project	Unit	Cost	Schedule
1. Educate landowners about the ecosystem benefits of intact riparian areas and the costs of degraded riparian areas.[1]	20 years @ $50,000/year	$1 million	2008 - 2028
2. Encourage and provide incentives for local, state, and Federal regulatory entities to maintain, improve (where needed), and enforce consistent riparian area protections throughout the lower Columbia region.[2]	10 years @ $500,000/year	$5 million	2008 - 2018
3. Actively purchase riparian areas from willing landowners in urban and rural settings when the riparian areas cannot be effectively protected through regulation or voluntary or incentive programs and (1) are intact, or (2) are degraded but have good restoration potential.	Rural: 3,500 acres at $5,000/acre[3] Urban: 100 acres at $75,000/acre	$25 million	2007 - 2031
4. Restore and maintain ecological benefits in riparian areas; this includes managing vegetation on dikes and levees to enhance ecological function and adding shoreline/instream complexity for juvenile salmonid refugia.	28 miles @ $250,000/mile	$ 7 million	2006 - 2031

Total costs: $38 million

Geographical priority: Reaches A-H and the Lower Willamette reach.

Key assumptions: (1) New homes, businesses, and industry will increase with population growth in the basin. (2) Some intact riparian areas are not adequately protected. (3) Protecting intact riparian areas would be cheaper than restoring degraded areas. (4) Some degraded riparian areas could be restored and gain ecological function, with associated downstream benefits. (5) Comprehensive protection and restoration of riparian habitats would occur concurrently with population growth, which will continue at a high rate.

Existing efforts: Protection of riparian areas relies heavily on local governments; the content and implementation of their land use plans specifically for shoreline and floodplain protection will be key to this action. Multiple Federal and state resource agencies provide funding for land acquisition and restoration, and multiple entities such as land trusts and watershed councils actively acquire and restore lands in the lower river. The Division of State Lands in Oregon and the Department of Natural Resources in Washington own and/or regulate submerged and submersible lands. The Natural Resource Conversation Service and conservation districts provide technical assistance to private landowners. Where water quality issues (such as toxic or conventional contaminants) are involved, agencies such as Washington's Department of Ecology and Oregon's Department of Environmental Quality may provide additional support.

Potential implementers:

- U.S. Army COE
- BPA
- WA Dept. of Fish & Wildlife
- OR Dept. of Fish & Wildlife
- Cities\Counties
- Port districts
- Conservation districts
- Columbia Land Trust
- The Wetlands Conservancy
- The Nature Conservancy
- Ducks Unlimited
- Natl. Fish & Wildlife Foundation
- Tribes
- OR Watershed Enhance. Bd.
- Salmon Recovery Fund. Bd.
- Lower Col. River Est. Partnership
- National Marine Fisheries Service
- Col. River Estuary Study Taskforce
- Utility districts
- Watershed councils

Notes:

[1] Projects CRE-1.1 and CRE-9.1 both call for outreach efforts. Outreach efforts for these two actions will be combined in a single outreach program whose costs will be shared.

[2] Projects CRE-1.2 and CRE-9.2 both call for incentives for local, state, and Federal entities to maintain, improve, and enforce regulatory protections. Given their similarities, activities for CRE-1.2 and CRE-9.2 could be coordinated or combined into one effort.

[3] Acreage amounts are 25-year targets that depend on willing sellers and funding.

Management Action CRE-2:

Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.

Project	Unit	Cost	Schedule
1. Conduct a reservoir heating study to determine the extent of the issue and identify hydrosystem operational changes (including design) that would reduce effects and/or mitigate downstream temperature issues.	1 study	$2.5 million	2007 - 2013
2. Implement hydrosystem operational changes to reduce temperature effects; if no change is possible, mitigate effects through restoration of tributary riparian areas.	25 years @ $700,000/year[1]	$17.5 million	2010 - 2032

Total costs: $20 million

Geographical priority: Reaches A-H and the plume.

Key assumption: (1) Either there is potential to alter management practices in the hydrosystem to reduce flow temperatures or a commensurate level of mitigation in tributaries would reduce temperatures in the estuary. (2) If temperatures continue to increase above 19° C, the estuary could become completely lethal for salmonids and other native species.

Existing efforts: The U.S. Environmental Protection Agency (EPA) is concerned about water temperature issues in the Columbia and Snake River system and their impacts on ecosystem health, particularly in light of global climate change. Oregon and Washington have listed the Columbia River as impaired for temperature under the Clean Water Act Section 303(d). In 2003, EPA issued a Preliminary Draft Total Maximum Daily Load (TMDL) for the mainstem Columbia River, but the TMDL has not been finalized. EPA plans to work with the states of Oregon and Washington to revisit the TMDL and decide how to address mainstem Columbia River temperature issues.

Potential implementers:

- Bonneville Power Administration
- U.S. Army Corps of Engineers
- Utility districts
- Oregon Department of Environmental Quality
- Washington State Department of Ecology

Notes:
[1] Assumes that some level of improvement is possible but that the level of possible improvement is likely to be minor because of complexities of the hydrosystem; assumes that mitigation will be needed to offset temperature increases.

Management Action CRE-3:

Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.

Project	Unit	Cost	Schedule
1. Explore technical options and develop policy recommendations on instream flows.	5 years @ $1 million/year	$5 million	2007 - 2015
2. Implement instream flow regulations in accordance with the policy recommendations in Project No. 1.	5 years @ $1 million/year	$5 million	2015 - 2023

Total costs: $10 million

Geographical priority: Reaches A–H and the plume.

Key assumptions: (1) Demand for water for human use will grow as the human population in the basin increases. (2) Additional instream flows in the Columbia River mainstem and tributaries could be established through the efforts of affected parties basinwide. (3) Establishing an instream flow regime would protect flows entering the estuary in the future. (4) An instream flow regime would help develop additional water conservation efforts and guide land use development in concert with water availability. (5) Protecting and/or enhancing estuary instream flows would require coordination with the Columbia River hydrosystem to achieve lasting results.

Existing efforts: Resource agencies can request instream flows to support fish and wildlife, water quality, and recreational needs in tributaries entering the estuary. In Oregon, the Department of Environmental Quality, Department of Fish and Wildlife, and Department of Parks & Recreation are authorized to request instream water rights to support their statutory obligations. The Oregon Water Resources Department and Commission review these requests and establish instream water rights. In Washington, the Department of Ecology established instream flows in all of the major Washington tributaries entering the estuary. Tributary flows also are often addressed in the relicensing processes for hydropower facilities regulated by the Federal Energy Regulatory Commission. Over the past decade, many tributary hydropower facilities (e.g., the Cowlitz River Project and the Lewis River Hydroelectric Projects) have been relicensed. Establishing an instream flow regime for the estuary would involve many Federal and state agencies and would require an organizational framework that currently does not exist.

Potential implementers:
- States (Washington, Oregon, Idaho, Montana)
- Cities and counties
- Irrigators
- Tributary hydropower utilities
- U.S. Army Corps of Engineers
- Bonneville Power Administration
- U.S. Bureau of Reclamation

Management Action CRE-4:

Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.

Project	Unit	Cost	Schedule
1. Conduct a flood study to determine the risks and feasibility of returning to more normative flows in the estuary.	2 years @ $500,000/year	$1 million	2009 - 2010
2. Conduct a study to determine the habitat effects of increasing the magnitude and frequency of hydrosystem flows (i.e., how much access of river to off-channel habitats would increase).	3 years @ $500,000/year	$1.5 million	2009 - 2011
3. Conduct additional studies to determine the extent of other constraints, including international treaties, systemwide fish management objectives, and power management.	4 years @ $500,000/year	$2 million	2010 - 2014
4. Make policy recommendations to action agencies on flow, taking into consideration beneficial estuary flows, flood management, power generation, irrigation, water supply, fish management, and other interests.	25 years @ $100,000/year	$2.5 million	2010 - 2035
5. Implement modified estuary flow regime annually in concert with other interests, including hydroelectric, flood control, and water withdrawals.	25 years @ $1.5 million/year[1]	$37.5 million	2011 - 2036

Total costs: $44.5 million

Geographical priority: All reaches (A-H) and the plume.

Key assumptions: (1) Even incremental changes in the magnitude and frequency of hydrosystem flows would improve salmonid habitat opportunity and food inputs, which would have benefits throughout the ecosystem. (2) Studies of flood risk and the effect of flow changes on estuarine habitat would provide data useful in modifying hydrosystem operations to benefit salmonids. (3) Studies of constraints to implementation would identify some obstacles that could be overcome. (4) Small to moderate changes in the magnitude, frequency, and timing of flows would improve sediment transport-related habitat opportunity in the estuary. (5) Increased spring freshets would yield greater sediment transport-related benefits than would other flow modifications.

Existing efforts: Large-scale efforts to adjust flows entering the estuary and return hydrology to more historical conditions have not yet begun because of the level of uncertainty regarding potential scenarios for adjusting the timing and volume of flow and the associated habitat benefits. Significant efforts have been undertaken by Bonneville Power Administration, the U.S. Army Corps of Engineers, and the U.S. Bureau of Reclamation to manage the hydrosystem for passage of juvenile salmonids. In addition, flows entering the estuary currently are managed to minimum seasonal flows to protect chum redds in the mainstem below Bonneville Dam.

Potential implementers:

- Bonneville Power Administration
- U.S. Army Corps of Engineers
- U.S. Bureau of Reclamation

Notes:

[1] Assumes $1.5 million per year cost of decreased hydrosystem generation revenues associated with minor and incremental adjustments to flows; also assumes that the flood risk associated with beneficial estuary flows does not increase significantly. The $1.5 million per year cost is included primarily as an indicator that there would be some foregone revenues even with minor changes in the flow regime. Specific costs will be evaluated during implementation as specific scenarios for modifying flows are developed and considered.

Management Action CRE-5:

Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.

Project	Unit	Cost	Schedule
1. Identify the effects of reservoir sediment entrapment on economic and ecological processes; this includes effects on ship channels, turning basins, port access, jetty activities, and habitat availability.	1 study	$2 million	2008 - 2011
2. Develop a regionwide sediment plan for the estuary to address salmonid habitat-forming processes.	10 years @ $100,000/year	$1 million	2006 – 2031
3. Implement projects recommended in the plan to mitigate the effects of sediment entrapment.	5 projects @ $1 million/project	$5 million	2010 - 2020

Total costs: $8 million

Geographical priority: Reaches A-H and the plume.

Key assumptions: (1) Sediment entrapment in reservoirs will continue. (2) Sediment entrapment has negative effects, both ecologically and economically. (3) The extent of these effects warrants exploration and implementation of potential mitigation measures. (4) Studying potential mitigation measures would identify some actions that would be effective and could be implemented. (5) Synergistic ecological effects may be realized as a result of implementing CRE-5 and CRE-6, which could increase sediment inputs into the estuary (CRE-5) and optimize beneficial uses of dredged materials (CRE-6).

Existing efforts: The Lower Columbia Solutions Group, a bi-state organization made up of local, state, and Federal governmental and non-governmental stakeholders, was formed by the governors of Washington and Oregon to address activities related to the disposal of dredged materials in the estuary. Developing a sediment budget is one of the activities of the Lower Columbia Solutions Group; it is likely that this sediment management budget will include the effects of reservoir sediment entrapment.

Potential implementers:

- U.S. Army Corps of Engineers
- Bonneville Power Administration

Management Action CRE-6:

Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.

Project	Unit	Cost	Schedule
1. Develop a regionwide sediment plan for the estuary and littoral cell.	See CRE-5.	See CRE-5.	See CRE-5.
2. Identify and implement dredged material beneficial use demonstration projects, including the notching and scrape-down of previously disposed materials and placement of new materials for habitat enhancement and/or creation.	100 acres @ $10,000/ acres	$1 million	2006 - 2012
3. Dispose of dredged materials using techniques identified through the demonstration projects and regionwide planning.	500 acres @ $10,000/acre[1]	$5 million	2008 - 2033

Total costs: $6 million

Geographical priority: Reaches A, B, C, and G, the Lower Willamette reach, and the plume and nearshore.

Key assumptions: (1) Dredging activities will continue or increase over time. (2) Opportunities to beneficially use dredged materials for habitat can be identified. (3) Beneficial use of dredged material would have a positive effect on sediment transport and habitat-forming processes in the estuary, plume, and littoral cell.

Existing efforts: Several agencies and organizations are actively engaged in the evaluation of dredged material for ecosystem-based beneficial uses. The Lower Columbia Solutions Group currently is focused on reducing the disposal of dredged materials in open waters off the mouth of the Columbia River in favor of supplementing the nearshore littoral cell with sediments. The Portland District of the U.S. Army Corps of Engineers is exploring tidal wetland development in the estuary based on an assessment of wetlands that have formed accidentally where dredged materials were placed historically. The Port of Portland also is exploring the use of dredged materials for potential development of subtidal habitats.

Potential implementers:

- U.S. Army Corps of Engineers
- Port districts
- Cities
- Lower Columbia River Solutions Group
- Oregon Department of Environmental Quality
- Oregon Department of State Lands
- Oregon Department of Fish and Wildlife
- Oregon Department of Land Conservation and Development
- Washington Department of Ecology
- Washington Department of Fish and Wildlife

Notes:

[1]Unit cost is funding to pay for activities beyond the minimum required by law, to achieve regional-scale ecosystem benefits.

Management Action CRE-7:

Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.

Project	Unit	Cost	Schedule
1. Identify and evaluate dredge operation techniques designed to reduce entrainment and other habitat effects.	1 project	$500,000	2008 - 2010
2. Initiate demonstration projects designed to test and evaluate dredge operations.	5 projects @ $200,000/project	$1 million	2009 - 2012
3. Implement best management techniques.	10 years @ $250,000/year[1]	$2.5 million	2011 – 2036
4. Study the effects of entrainment of juvenile salmonids from ship ballast water intake.	1 study @ $250,000	$250,000	2009 – 2011
5. Implement a demonstration project to evaluate the feasibility of reducing entrainment of juvenile salmonids from ship ballast intake.	1 project @ $250,000	250,000	2012 -- 2015

Total costs: $4.5 million

Geographical priority: Reaches A, B, C, D, E, F, G, and the Lower Willamette reach.

Key assumptions: (1) Improved best management practices can be identified that would help reduce the impact of dredging. (2) Mitigation activities would help offset changes to the estuary caused by dredging.

Existing efforts: The U.S. Army Corps of Engineers and ports in the lower Columbia River have studied the effects of entrainment on aquatic species and have implemented actions to reduce negative effects. Screening and other ship ballast activities to decrease entrainment of juvenile salmonids have been implemented.

Potential implementers:

- U.S. Army Corps of Engineers
- Port districts
- Private entities, such as ports and sand and gravel dredgers
- Counties and cities

Notes:

[1]This is an estimate of the incremental cost above permitted dredge activities. Cost may vary significantly depending on site-specific conditions.

Management Action CRE-8:

Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.

Project	Unit	Cost	Schedule
1. Inventory, assess, and evaluate in-channel pile dikes for their economic value and their negative and positive impacts on the estuary ecosystem; develop working hypotheses for removal or modification.	1 plan	$250,000	2007 - 2009
2. Implement demonstration projects designed to test working hypotheses and guide future program priorities.	4 pile dike removal projects @ $125,000/project	$500,000	2009 - 2010
3. Remove or modify priority pilings and pile dikes.	25 years @ $1 million/year	$25 million	2008 - 2033
4. Monitor the physical and biological effects of pile dike removal and/or modification.	10 years @ $150,000/year	$1.5 million	2010 - 2020

Total costs: $27.25 million

Geographical priority: Reaches A – H and the Lower Willamette reach.

Key assumption: (1) Many pilings, pile dikes, and similar structures could be removed or modified without compromising the shipping channel or protection of property. (2) Over time, the removal or modification of superfluous pile dikes would improve conditions for salmonids and the ecosystem.

Existing efforts: This action was incorporated into the 2008 Federal Columbia River Power System Hydropower Biological Opinion (BiOp) Remand as Reasonable and Prudent Alternative 38: Piling and Dike Removal Program. A project team composed of the Lower Columbia River Estuary Partnership, Bonneville Power Administration, and the U.S. Army Corps of Engineers is working to develop a strategic plan to remove, modify, or retain pile structures within the mainstem lower river. (Modification could include adding large wood to make complex habitat, for example.) The program currently is funded at a level of $1 million per year and is expected to be funded through 2018 if the program proves successful in providing benefits to salmonids.

Potential implementers:

- U.S. Army Corps of Engineers
- Bonneville Power Administration
- Washington Department of Natural Resources
- Washington Department of Fish and Wildlife
- Oregon Department of Fish and Wildlife
- Oregon Department of Lands
- Lower Columbia River Estuary Partnership
- Counties and cities
- Tribes

Management Action CRE-9:

Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.

Project	Unit	Cost	Schedule
1. Educate landowners about the ecosystem benefits of protecting and stewarding intact off-channel areas and the costs of restoring degraded areas.[1]	(See CRE-1.1)	$500,000	2008 - 2028
2. Encourage and provide resources for local, state, and Federal regulatory entities to maintain, improve (where needed), and consistently enforce habitat protections throughout the lower Columbia region.[2]	10 years @ $500,000 million/year	$5 million	2008 - 2018
3. Actively purchase off-channel habitats in urban and rural settings that (1) cannot be effectively protected through regulation, (2) are degraded but have good restoration potential, or (3) are highly degraded but could benefit from long-term restoration solutions.[3]	Rural: 5,000 acres at $3,000/acre Urban:150 acres at $100,000/acre	$30 million	2007 – 2031
4. Restore degraded off-channel habitats with high intrinsic potential for increasing habitat quality.	Rural: 6,000 acres at $5,000/acre Urban: 500 acres at $5,000/acre	32.5 million	2007 - 2031

Total costs: $68 million

Geographical priority: Reaches A, B, C, and G and the Lower Willamette reach.

Key assumptions: (1) Protection opportunities can be increased over the next decade through public awareness, educational, regulatory, and acquisition programs. (2) Protection of off-channel habitats is less expensive than restoration. (3) High-quality off-channel habitats offer benefits to salmonids that cannot be provided in other ways. (4) Protection will be needed to offset increasing threats resulting from human population increases in the estuary and basin. (5) Restoring off-channel habitat function in the estuary is critical to ecosystem processes. (6) Restoring off-channel habitats enhances juvenile salmonid growth by increasing access to food sources and provides refugia from high flows and predation.

Existing efforts: Protection of off-channel habitats relies heavily on local governments; the content and implementation of their land use plans specifically for shoreline and floodplain protection will be key to this action. Multiple Federal and state resource agencies provide funding for land acquisition and restoration, and multiple entities such as land trusts and watershed councils actively acquire and restore lands in the lower river. The Division of State Lands in Oregon and the Department of Natural Resources in Washington own and/or regulate submerged and submersible lands. The Natural Resource Conversation Service and conservation districts provide technical assistance to private landowners. Where water quality issues (such as toxic or conventional contaminants) are involved, agencies such as Washington's Department of Ecology and Oregon's Department of Environmental Quality may provide additional support. The Lower Columbia River Estuary Partnership's Habitat Restoration Program largely is directed toward this action, CRE-1, and CRE-10. Organizations such as the Columbia Land Trust and the Columbia River Estuary Study Taskforce are actively involved in off-channel restoration activities.

Potential implementers:

- U.S. Army COE
- BPA
- Columbia Land Trust
- The Wetlands Conservancy
- Ducks Unlimited
- Col. River Est. Study Taskforce
- The Nature Conservancy
- Lower Col. River Est. Partnership
- Watershed councils
- OR Watershed Enhancement Bd.
- OR Dept. of Fish and Wildlife
- WA Dept. of Ecology
- Port districts
- Cities
- Conservation districts
- Other special districts
- Tribes

Notes:

[1] Projects CRE-1.1 and CRE-9.1 both call for outreach efforts. Outreach efforts for these two actions will be combined in a single outreach program whose costs will be shared.

[2] Projects CRE-1.2 and CRE-9.2 both call for incentives for local, state, and Federal entities to maintain, improve, and enforce regulatory protections. Given their similarities, activities for 1.2 and 9.2 could possibly be coordinated or combined into a single effort.

[3] Assumes purchases are made over a 25-year period with willing sellers.

Management Action CRE-10:

Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.

Project	Unit	Cost	Schedule
1. Breach, lower the elevation of, or relocate dikes and levees; create and/or restore tidal marshes, shallow-water habitats, and tide channels.	5,000 acres[1] @ $10,000/acre	$50 million	2006 - 2031
2. Remove tide gates to improve the hydrology between wetlands and the channel and to provide juveniles with physical access to off-channel habitat; use a habitat connectivity index to prioritize projects.	2,000 acres[1] @ $10,000/acre	$20 million	2006 - 2031
3. Upgrade tide gates or perched culverts where (1) no other options exist, (2) upgraded structures can provide appropriate access for juveniles, and (3) ecosystem function would be improved over current conditions.	1,000 acres[1] @ $5,000/acre	$5 million	2006 - 2031

Total costs: $75 million

Geographical priority: Reaches A, B, C, E, F, and G and the Lower Willamette reach.

Key assumptions: (1) Additional opportunities to restore off-channel habitats can be developed through long-term outreach and improved landowner relationships. (2) Restoration of sites, including elevation restoration, would yield broad-scale ecosystem benefits over time. (3) A habitat connectivity index would help target efforts toward the projects that would provide the greatest benefits. (4) Restoration of highly degraded sites may be necessary to yield long-term benefits.

Existing efforts: Multiple Federal and state resource agencies provide funding for restoration activities, including improving hydrologic conditions and access for juvenile salmonids. In the estuary, the U.S. Army Corps of Engineers, Columbia River Estuary Taskforce, and Columbia Land Trust have significant experience breaching dikes or retrofitting tide gates. Other entities, including watershed councils, conservation districts, and private firms, also have experience but sometimes lack sufficient technical and infrastructure capacity. Extensive community outreach and long-term relationship building will be needed to implement this action. The Lower Columbia River Estuary Partnership's Habitat Restoration Program largely is directed toward this action, CRE-1, and CRE-9.

Potential implementers:

- U.S. Army Corps of Engineers
- Bonneville Power Administration
- U.S. Fish and Wildlife Service
- Oregon Watershed Enhancement Board
- Oregon Department of Fish and Wildlife
- Columbia Land Trust
- Columbia River Estuary Study Taskforce
- Salmon Recovery Funding Board
- Conservation districts
- Other districts
- Cities
- Counties
- Lower Columbia River Estuary Partnership
- Lower Columbia Fish Recovery Board
- Watershed councils
- Tribes

Notes:

[1]Acreage equals amount of affected area. Costs include those associated with protecting other land uses from renovated hydrology (i.e., moving dikes and levees).

Management Action CRE 11:

Reduce the square footage of over-water structures in the estuary.

Project	Unit	Cost	Schedule
1. Inventory over-water structures and develop a GIS layer with detailed metadata files.	2 projects @ $150,000/project	$300,000	2007 - 2009
2. Initiate a planning process to evaluate existing and new over-water structures for their economic, ecological, and recreational value.	2 phases[1] @ $100,000/phase	$200,000	2009 - 2013
3. Remove or modify over-water structures to provide beneficial habitats.	10 projects @ $500,000/project[2]	$5 million	2012 - 2037
4. Establish criteria for new permit applications to consider the cumulative impacts of over-water structures.	1 project	$300,000	2008 - 2010

Total costs: $5.8 million

Geographical priority: Reaches D and G and the Lower Willamette reach.

Key assumptions: (1) Over-water structures pose some threat to salmonids. (2) A fair number of over-water structures are no longer in use or have relatively minor value to owners. (3) An inventory of over-water structures would aid in assessing individual structures' economic, ecological, and recreational value.

Existing efforts: Over-water structures are regulated by specific sections of the Federal Clean Water Act, state statute, or both. These laws are administered by Federal agencies (U.S. Army Corps of Engineers, U.S. Environmental Protection Agency) or state agencies (Oregon Department of Environmental Quality, Oregon Division of State Lands, Oregon Department of Land Conservation and Development, Washington Department of Ecology, and Washington Department of Natural Resources). The Lower Columbia River Estuary Partnership created a shoreline condition inventory that maps all over-water structures using GIS. Currently, there are no targeted efforts to remove over-water structures in the estuary.

Potential implementers:

- U.S. Army Corps of Engineers
- Cities
- Washington Department of Natural Resources
- Oregon Department of Land Conservation and Development
- Oregon Department of State Lands

Notes:

[1]The first phase is technical and the second phase is policy.
[2]A project is defined as a set of structures that have been identified for removal; cost is level of effort.

Management Action CRE-12:

Reduce the effects of vessel wake stranding in the estuary.

Project	Unit	Cost	Schedule
1. Analyze factors contributing to ship wake stranding to determine potential approaches to reducing mortality in locations where juveniles are most vulnerable. Design and implement demonstration projects and monitor their results.	1 study @ $1 million	$1 million	2007 - 2010
2. Implement projects identified in Project No. 1 that are likely to result in the reduction of ship wake stranding events.	12 projects @ $1 million/project[1]	$12 million	2011 - 2026

Total costs: $13 million

Geographical priority: Reaches C, D, E, and F.

Key assumptions: (1) Vessel wake stranding is a significant issue for ocean- and stream-type salmonids employing the fry life history strategy in the estuary.

Existing efforts: The U.S. Army Corps of Engineers initiated a two-phase study on vessel wake stranding associated with the channel deepening project. Phase 1 was completed in 2006 as part of the channel deepening project. Results could be used to design follow-up studies analyzing factors that contribute to ship wake stranding. In addition, in 2008 the Port of Vancouver completed a study designed to estimate the total acres of estuary shoreline (downstream of the port) that may contribute to ship wake stranding.

Potential implementers:

- U.S. Army Corps of Engineers
- Columbia River pilots
- Ports
- US Coast Guard
- River and bar pilots

Notes:

[1] This is a level-of-effort cost approach that will require information generated in Projects No. 1 and 2.

Management Action CRE-13:

Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.

Project	Unit	Cost	Schedule
1. Monitor the abundance levels of pikeminnow, smallmouth bass, walleye, and channel catfish.	5 monitoring events @ $100,000/event (every 5 years)	$500,000	2006 - 2031
2. Implement actions as necessary to prevent population growth (i.e., modify habitat)[1]; increase the northern pikeminnow bounty program in the estuary.	25 years @ $500,000/year	$12.5 million	2006 - 2031

Total costs: $13 million

Geographical priority: Reaches D, E, F, G, and H and the Lower Willamette reach.

Key assumption: Management techniques would maintain populations at levels that would maintain or reduce predation impacts to salmonids. A pikeminnow management plan exists and is being implemented. Costs associated with this action are partly covered as a baseline cost. Costs associated with managing other piscivorous fish, including smallmouth bass, walleye, and channel catfish, are entirely incremental costs.

Existing efforts: Bonneville Power Administration funds the Northern Pikeminnow Sport Reward Fishery Program whereby anglers receive $4 to $8 for every qualifying northern pikeminnow 9 inches or longer returned to a registration station. Since 1990, more than 3.1 million northern pikeminnow have been removed from the Snake and Columbia rivers as a result of this program. The annual budget for the Northern Pikeminnow Management Program has varied from $2.0 to $6.4 million, with an average of about $3.0 million basinwide.

Potential implementers:

- U.S. Army Corps of Engineers
- Washington Department of Fish and Wildlife
- Oregon Department of Fish and Wildlife
- Bonneville Power Administration
- National Marine Fisheries Service

Notes:

[1] It is unknown whether projects will be needed to manage warm-water fish. In some cases, there may be warm-water habits close to juvenile habitat, in which case site-specific action would be required.

Management Action CRE-14:

Identify and implement actions to reduce salmonid predation by pinnipeds.

Project	Unit	Cost	Schedule
1. Expand Federal and state activities at Bonneville Dam to test non-lethal and potentially lethal methods of reducing pinniped populations throughout the estuary. This includes efforts to manage pinnipeds through the Marine Mammal Protection Act.	5 years @ $500,000/year	$2.5 million	2007 - 2011
2. Implement actions likely to reduce pinniped predation on adult salmonids.	25 years @ $500,000/year[1]	$12.5 million	2007 - 2032

Total costs: $15 million

Geographical priority: Reaches A-H (especially H).

Key assumptions: (1) Mortality from pinnipeds throughout the lower Columbia River may be a larger source of salmonid mortality than previously understood. (2) Further study would clarify the impact of pinniped predation on salmonids; studies by the U.S. Army Corps of Engineers at Bonneville Dam represent a good start on this task. (3) Mortality from pinniped predation could be reduced through non-lethal and lethal methods. (4) The Marine Mammal Protection Act could be modified over time to allow more tools for managing pinnipeds in the estuary. In 2008, NMFS granted authority under Section 120 of the Marine Mammal Protection Act to the states of Oregon, Washington, and Idaho to intentionally take, by lethal methods, individually identifiable California sea lions that prey on Pacific salmon and steelhead at Bonneville Dam (Federal Register 2008).

Existing efforts: The National Marine Fisheries Service, Oregon and Washington, the U.S. Army Corps of Engineers, and Bonneville Power Administration have initiated efforts to manage pinnipeds, primarily at Bonneville Dam. As of 2010, efforts included both lethal and non-lethal methods sanctioned under Section 120 of the Marine Mammal Protection Act.

Potential implementers:

- U.S. Army Corps of Engineers
- Bonneville Power Administration
- National Marine Fisheries Service
- Columbia River Inter-Tribal Fish Commission
- Oregon Department of Fish and Wildlife
- Washington Department of Fish and Wildlife

Notes:

[1] Units are years; given the constraints to this action, it is likely that ongoing efforts to prevent predation will continue over the next 25 years.

Management Action CRE-15:

Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.

Project	Unit	Cost	Schedule
1. Increase public awareness of exotic plant species and proper stewardship techniques.[1]	10 years @ $100,000/year	$1 million	2008 – 2018
2. Inventory exotic plant species infestations and develop a GIS layer with detailed metadata files.	5 phases @ $200,000/phase	$1 million	2007 – 2012
3. Implement projects to address infestations on public and private lands.	10,000 acres @ $1,000/acre	$10 million	2008 – 2028
4. Monitor infestation sites.	20 years @ $25,000/year	$500,000	2010 - 2030

Total costs: $12.5 million

Geographical priority: Reaches A-H and the Lower Willamette reach).

Key assumptions: (1) Aquatic invasive plants have a negative effect on the estuary ecosystem and affect juvenile salmonids by altering habitat and causing food webs to deteriorate. (2) Additional information is needed on the location, extent, and type of infestations and their effects on the estuary ecosystem. (3) Because introductions of invasive plants can permanently alter the estuary ecosystem, prevention activities are crucial. (4) Education, outreach, and monitoring would help prevent further introductions of invasive plants.

Existing efforts: The fish and wildlife departments of Oregon and Washington have management responsibilities for fish and wildlife, including the control of non-indigenous species. The Washington Department of Fish and Wildlife has developed an Aquatic Non-indigenous Species Management Plan. The Pacific States Marine Fisheries Commission promotes interstate communication and facilitates the coordination of aquatic non-indigenous species activities on the West Coast. The Oregon and Washington Sea Grant programs combined to form the Northwest Marine Invasive Species Team to raise the level of awareness about the threats of invasive species. The Invasive Alien Species Executive Order at the Federal level created the Invasive Species Council and directed development of an Invasive Species Management Plan. Multiple Federal and state resource agencies provide funding for restoration projects that remove exotic invasive plants, and entities such as land trusts and watershed councils actively eradicate exotic native plants and plant native species in the lower river. Noxious weed control entities exist in Oregon and Washington to help educate landowners and control invasive plants.

Potential implementers:

- U.S. Army Corps of Engineers
- Bonneville Power Administration
- US Fish and Wildlife Service
- State agencies
- Conservation districts
- Noxious weed districts
- Counties
- Cities
- Tribes
- Watershed councils
- Lower Columbia River Estuary Partnership
- The Nature Conservancy
- Landowners

Notes:

[1]This project is recommended for upstream mainstem and tributaries, but the costs presented here are for activities in the estuary only. Many exotic plants have established themselves upstream and represent a constant downstream threat to the estuary.

Management Action CRE-16:

Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.

Project	Unit	Cost	Schedule
1. Enhance or create tern nesting habitat at alternative sites in Washington, Oregon, and California.	3 sites @ $1 million/site	$3 million	2008 - 2012
2. Reduce tern nesting habitat on East Sand Island from 6 acres to 1 to 1.5 acres.	1 project @ $4.5 million/project	$4.5 million	2007 - 2010
3. Monitor the regional tern population.	25 years @ $100,000/year	$2.5 million	2010 - 2035

Total costs: $10 million

Geographical priority: Reaches A and B.

Key assumption: Ongoing and new management actions directed to Caspian tern nesting habitat would continue to reduce salmonid mortality from tern predation. A management plan exists and is being implemented. Costs associated with this action are partially covered as a baseline cost.

Existing efforts: The U.S. Army Corps of Engineers has recently constructed alternative habitat for Caspian terns outside of the estuary. The Corps also funds studies assessing Caspian tern population levels and predation rates on juvenile salmonids. These studies track terns along the West Coast to determine whether management actions in the lower river result in redistribution of terns elsewhere along the West Coast. A predatory bird Web site (www.birdresearchnw.org) keeps the public and others informed on the status of management plans and research.

Potential implementers:

- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- Oregon Department of Fish and Wildlife
- Washington Department of Fish and Wildlife

Management Action CRE-17:

Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.

Project	Unit	Cost	Schedule
1. Identify, assess, and evaluate methods of reducing double-crested cormorant abundance numbers.	1 multiphase study	$1 million	2007 - 2011
2. Implement demonstration projects resulting from Project No. 1 (i.e., decoys and audio playback methods).	5 pilot projects @ $500,000/project	$2.5 million	2010 - 2015
3. Implement projects resulting in reduced predation by cormorants.[1]	10 years @ $700,000/year	$7 million	2013 - 2023

Total costs: $10.5 million

Geographical priority: Reaches A and B.

Existing efforts: The U.S. Army Corps of Engineers funds studies assessing cormorant population levels and predation rates on juvenile salmonids. These studies track cormorants along the West Coast to determine whether management actions in the lower river result in redistribution elsewhere along the West Coast. A predatory bird Web site (www.birdresearchnw.org) keeps the public and others informed on the status of management plans and research.

Potential implementers:

- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- Oregon Department of Fish and Wildlife
- Washington Department of Fish and Wildlife

Notes:

[1]This is a level-of-effort cost estimate; efforts to manage cormorants in the estuary are significantly lagging Caspian tern management efforts and will likely be more difficult to implement.

Management Action CRE-18:

Reduce the abundance of shad in the estuary.

Project	Unit	Cost	Schedule
1. Organize existing technical information about shad and identify data gaps and potential control methods.	2 phases @ $250,000/phases	$500,000	2007 - 2011
2. Implement demonstration projects to evaluate effective shad management methods.	4 projects @ $500,000/project	$2 million	2008 - 2015
3. Implement shad population management techniques.[1]	10 years @ $250,000/year	$2.5 million	2010 - 2015
4. Monitor and evaluate shad management techniques.	10 years @ $50,000/year	$500,000	2011 - 2021

Total costs: $5.5 million

Geographical priority: Reaches A-H and the Lower Willamette reach.

Key assumptions: (1) Shad have negative affects on salmonids in the estuary. (2) Additional research would shed light on how shad affect salmonids and suggest new management techniques. (3) New management techniques would be unlikely to cause significant change.

Existing efforts: The U.S. Geological Survey, with funding from Bonneville Power Administration, is studying the presence of American shad in the Columbia River throughout the year, assessing shad diet trends, and PIT tagging up to 1,000 adult pre-spawn shad in the estuary to examine their time of arrival at dams using PIT tag detection technologies in fishways.

Potential implementers:

- U.S. Army Corps of Engineers
- U.S. Geological Survey
- Oregon Department of Fish and Wildlife
- Washington Department of Fish and Wildlife

Notes:

[1]This is a level-of-effort cost estimate; currently there are no plans to manage shad abundance levels in the Columbia River.

Management Action CRE-19:

Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.

Project	Unit	Cost	Schedule
1. Assemble existing technical information on introduced aquatic invertebrates in the estuary and develop a plan for managing existing infestations and preventing new infestations.	2 phases @ $250,000/phase	$500,000	2007 - 2010
2. Implement recommendations from the plan for managing existing infestations and preventing new infestations (Project No. 1, above).[1]	5 projects @ $500,000/project	$2.5 million	2008 – 2013

Total costs: $3 million

Geographical priority: Reaches A-H and the Lower Willamette reach.

Key assumptions: (1) Ship ballast practices could be improved to help prevent further degradation of the estuary ecosystem. (2) Additional research would help scientists understand the effects of exotic invertebrates on the ecosystem. (3) Because the effects of exotic invertebrates on the ecosystem usually cannot be reversed, it is important to prevent introductions when possible.

Existing efforts: Following the direction of the 2007 Oregon Legislature, the Shipping Transport of Aquatic Invasive Species Task Force was convened in 2008 to examine how Oregon can better handle aquatic invasive species coming into the state via shipping activities. The task force compiled a report outlining various aspects of preventing the introduction of aquatic invasive species from shipping-related pathways. The report also recommended steps that the Oregon Department of Environmental Quality, working with other agencies and the shipping industry, can take to bolster efforts to halt the arrival and spread of aquatic invasive species that degrade existing ecosystems and displace native species.

Likewise, the Aquatic Nuisance Species Unit of the Washington Department of Fish and Wildlife (WDFW) has implemented the Washington State ballast water program since 2000. This program receives state funds for program management, vessel report tracking, and vessel inspection efforts. Two vessel inspectors stationed in Puget Sound and the SW/Columbia River regions target high-risk vessels for boarding and ballast sampling. Washington established discharge standards that, as of 2009, had not yet been implemented.

In 2008, the Environmental Protection Agency issued a Vessel General Permit (VGP) as part of the National Pollutant Discharge Elimination System under the Federal Water Pollution Control Act. This permit is intended to regulate discharges resulting from the normal operation of all non-recreational vessels 79 feet or longer. In addition, the ballast water discharge provisions apply to any non-recreational vessel of less than 79 feet and commercial fishing vessels of any size discharging ballast water, and require adoption of best management practices for discharges. Currently, the VGP regulations adopt U.S. Coast Guard ballast water exchange requirements and coastal exchange requirements for domestic voyages along the West Coast but do not include ballast water treatment technology. Under the Clean Water Action Section 401 certification requirements, states can adopt more stringent conditions than the VGP in their certifications if so needed to meet requirements of either the Clean Water Act or state law.

Potential implementers:

- Port districts
- Oregon Department of Fish and Wildlife
- Washington Department of Fish and Wildlife
- U.S. Fish and Wildlife Service
- Oregon Department of Agriculture
- Washington State Department of Agriculture
- Portland State University
- Oregon State Marine Board
- Washington State Parks and Recreation Commission
- Oregon Department of Environmental Quality

Notes:

[1]This is a level-of-effort cost estimate.

Management Action CRE-20:

Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.

Project	Unit	Cost	Schedule
1. Educate landowners, businesses, and other users about practices to reduce usage and the effects of pesticides and fertilizers.[1]	10 years @ $50,000/year	$500,000	2008 - 2018
2. Implement pesticide, fertilizer, and nutrient best management practices to reduce contaminants entering the estuary.	10 years @ $1.15 million/year[2]	$11.5 million	2008 – 2018
3. Evaluate the adequacy of best management practices and update as needed.	2 reviews @ $250,000	$500,000	2012 and 2017

Total costs: $12.5 million

Geographical priority: Reaches A-H and the Lower Willamette reach.

Key assumptions: (1) Some users of pesticides and fertilizers are not adequately informed about best management practices for these toxic contaminants. (2) Additional benefits to salmonids could be realized through continued efforts by farmers, chemical manufacturers, and regulatory programs to reduce impacts from fertilizers and pesticides. (3) Benefits to salmonids would increase over a relatively long period of time as agricultural practices improve. Several of the projects identified in this action are being implemented and therefore could be considered baseline costs. The costs in this action are considered additive to baseline costs because of the significant effort needed to reduce nutrients and toxic contaminants entering the estuary.

Existing efforts: Both Washington and Oregon produce and encourage implementation of best management practices (BMP) manuals to address non-point sources of pollution. In both states, load allocations and reduction strategies are identified through the total maximum daily load (TMDL) process. The Oregon Department of Environmental Quality is now conducting “pesticide stewardship partnerships” in five Oregon watersheds that eventually flow into the Columbia or Willamette rivers. These partnership programs work through outreach with the agricultural community to implement BMPs that will reduce pesticides in rivers and streams. The U.S. Department of Agriculture, through Senate Bill 1010 authorities, is developing plans to ensure BMPs on agricultural lands. The U.S. Environmental Protection Agency convened the Columbia River Basin Toxics Reduction Working Group in 2005 to coordinate monitoring, cleanup, and reporting efforts basinwide. In September 2010, the working group produced the Columbia River Basin Toxics Reduction Action Plan.

Potential implementers:

- Washington Department of Agriculture
- Oregon Department of Agriculture
- Cities
- Conservation districts
- U.S. Environmental Protection Agency
- Washington Department of Ecology
- Oregon Department of Environmental Quality
- Lower Columbia River Estuary Partnership
- Natural Resources Conservation Service

Notes:

[1] Projects CRE-20.1 and CRE 21.1 both call for outreach efforts. Outreach efforts for these two projects will be combined into a single outreach program whose costs will be shared.

[2] Unit cost includes estimates for the estuary and estuary tributaries only; the action recommends similar upstream activities.

Management Action CRE-21:

Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.

Project	Unit	Cost	Schedule
1. Educate the industrial and commercial sectors and the general public on how to reduce the introduction of pollutants into the estuary and its tributaries.[1]	10 years @ $20,000/year	$200,000	2008 - 2028
2. Identify sources, loads, and pathways of pollutants in the estuary.	8 years @ $100,000/year	$800,000	2010 - 2018
3. Provide cost-share incentives for National Pollution Discharge Elimination System (NPDES) permit holders to upgrade effluent above their permit requirements.	10 years @ $1.5 million/year	$15 million	2010 – 2020
4. Study and establish threshold treatment standards for pharmaceuticals and other unregulated substance discharges; update existing NPDES permits to reflect the new standards.	5 years @ $2 million/year	$10 million	2007 – 2012
5. Provide grants and low-cost loans to permit holders required to treat effluent to standards established in Project No. 3.	10 years @ $2 million/year	$20 million	2012 - 2017

Total costs: $46 million

Geographical priority: Reaches D and G and the Lower Willamette reach.

Key assumptions: (1) Non-permitted discharges that currently are occurring would be identified and curtailed. (2) Financial incentives or support would motivate NPDES permit holders to raise their effluent treatment levels above permit requirements. (3) Releases of industrial and commercial pollutants into the estuary would be reduced over time. Several of the projects identified in this action are being implemented and therefore could be considered baseline costs. The costs in this action are considered additive to baseline costs because of the significant effort needed to reduce inputs of pollutants.

Existing efforts: In both Oregon and Washington, pollutant load allocations and reduction strategies are identified through the total maximum daily load (TMDL) process. The Oregon Department of Environmental Quality's (DEQ) Water Quality Program is developing a list of key, persistent bioaccumulative toxic contaminants that have a documented effect on human health, wildlife, and aquatic life. The Oregon Legislature has directed DEQ to report on where persistent bioaccumulative toxic contaminants are coming from and options to reduce their discharge. In addition, legislation required Oregon's 52 largest municipal wastewater treatment plants to develop plans by 2011 to reduce priority persistent pollutants through pollution prevention and toxic reduction. Initial monitoring and reduction efforts are to focus on the Willamette River. The U.S. Environmental Protection Agency convened Columbia River Basin Toxics Reduction Working Group in 2005 to coordinate monitoring, cleanup, and reporting efforts basinwide. In September 2010, the working group produced the Columbia River Basin Toxics Reduction Action Plan. The Lower Columbia River Estuary Partnership has created a long-term monitoring strategy that calls for baseline conventional and toxic contaminant data along with data sufficient to assess trends and biological integrity.

Potential implementers:

- U.S. Environmental Protection Agency
- Washington Department of Ecology
- Oregon Department of Environmental Quality
- Cities
- Trade groups such as the Oregon Association of Clean Water Agencies that represent wastewater dischargers

Notes:

[1] Projects CRE-20.1 and CRE-21.1 both call for outreach efforts. Outreach efforts for these two actions will be combined into a single program whose costs are shared.

Management Action CRE-22:

Restore or mitigate contaminated sites.

Project	Unit	Cost	Schedule
1. Develop criteria and a process for evaluating contaminated sites to establish their restoration potential.	1 phase @ $500,000/phase	$500,000	2007 - 2017
2. Develop an integrated multi-state funding strategy to address contamination cleanup in the estuary from non-identifiable upstream sources.	Out-of-Estuary[1]	n/a	2007 - 2012
3. Restore those contaminated sites that will yield the greatest ecological and economic benefits.	20 years @ $3 million/year	$60 million	2007 - 2027

Total costs: $60.5 million

Geographical priority: Reaches A-H and the Lower Willamette reach.

Key assumptions: (1) Monitoring will continue to provide vital data needed to understand the toxic contaminant problem and identify potential solutions. (2) Monitoring will identify hot spots of contamination. (3) Contamination sites will be identified for which responsible parties cannot be determined. (4) Additional analysis would identify contamination sites whose restoration would yield significant ecological and economic benefits. (5) Restoration of contaminated sites would benefit salmonids and the ecosystem over time. (6) The action will include improving the condition of habitats that have been impaired by the contaminants, not just removing pollutants. (7) Clean up will be to levels that support survival and recovery in both the short-term and long-term. Several of the projects identified in this action are being implemented and therefore could be considered baseline costs. The costs in this action are considered additive to baseline costs because of the significant effort needed to address contamination cleanup.

Existing efforts: The U.S. Environmental Protection Agency regulates cleanup of contaminated sites under Superfund and other programs, which include monitoring of these sites. The U.S. Environmental Protection Agency convened the Columbia River Basin Toxics Reduction Working Group in 2005 to coordinate monitoring, cleanup, and reporting efforts basinwide. In September 2010, the working group produced the Columbia River Basin Toxics Reduction Action Plan. The Lower Columbia River Estuary Partnership has created a long-term monitoring strategy that calls for baseline conventional and toxic contaminant data along with data sufficient to assess trends and biological integrity. The Estuary Partnership, U.S. Geological Survey, and NMFS completed a 3-year study that compiled and analyzed monthly toxic and conventional pollutant data at five sites, primarily for PAHs, PCBs, estrogenic compounds, flame retardants, current-use pesticides, nutrients, and trace elements, Toxics monitoring of juvenile salmon also was conducted at six sites (for PCBs, PAHs, organochlorine pesticides, and flame retardants) (Lower Columbia River Estuary Partnership 2007). In addition, the Estuary Partnership and NMFS developed three models that describe the role that toxics play in a salmon's life history: a conceptual model of the interactions between contaminants and endangered salmonid species, a contaminant transport and uptake model, and an ecological risk model to provide a quantitative measure of the impact of contaminant exposure on salmonid populations in the Columbia River basin (Spromberg and Johnson 2008, Leary et al. 2005, and Leary et al. 2006).

Potential implementers:

- Lower Col. River Est. Partnership
- Col. River Est. Study Taskforce
- Cities
- Conservation districts
- OR Dept. of Env. Quality
- WA State Dept. of Ecology
- Port districts
- U.S. Geological Survey
- Federal regulatory agencies such as the National. Marine Fisheries Service and U.S. Geological Survey

Notes:

[1] Cost is considered to be outside the purview of estuary-specific projects.

Management Action CRE-23:

Implement stormwater best management practices in cities and towns.

Project	Unit	Cost	Schedule
1. Monitor stormwater outputs to measure treatment compliance with existing local and state regulations throughout the basin; develop a network of monitoring sites and establish a data repository that includes data collected by permittees.	10 years @ $200,000/year	$2 million	2007 - 2015
2. Establish a fund source for regulatory agencies and local governments to use when insufficient resources are available to (1) access best available science, (2) develop standards beyond requirements, or (3) adequately enforce regulations.	3 years @ $2 million/year	$6 million	2009 – 2011
3. Evaluate the adequacy of best management practices and update as needed.	3 evaluations @ $500,000	$1.5 million	2010 – 2025
4. Provide incentives for low-impact development practices.	20 years @ $500,000/year	$10 million	2010 - 2030

Total costs: $19.5 million

Geographical priority: Reaches D and G and the Lower Willamette reach.

Key assumptions: (1) Population growth in the Columbia River basin will continue to influence the hydrology and water quality in the estuary. (2) Stormwater practices could be improved by monitoring and enforcing compliance with existing regulations, making best scientific information available, and developing higher standards. (3) The resulting improvements in hydrology and contaminant exposure in the estuary would occur slowly over time. (4) This action is protective in nature; costs are not associated with retrofitting existing stormwater facilities. Several of the projects identified in this action are being implemented and therefore could be considered baseline costs. The costs in this action are considered additive to baseline costs because of the significant effort needed to address stormwater-related water quality issues.

Existing efforts: Both the Washington Department of Ecology and Oregon Department of Environmental Quality produce best management practices manuals to address certain non-point sources. Local governments develop and update land use plans that include stormwater practices and that guide future development. The Lower Columbia River Estuary Partnership has worked with three schools on Schoolyard Stormwater Projects and engaged corporate partners to design and construct stormwater facilities.

Potential implementers:

- Cities and counties
- Washington Department of Ecology
- Oregon Department of Environmental Quality
- U.S. Environmental Protection Agency
- Lower Columbia River Estuary Partnership

Notes:

This action is recommended for upstream mainstem and tributaries, but the costs presented here are for activities in the estuary only.

Table 5-7 is a summary of costs for the 23 management actions. The total estimated budget for constrained implementation of the actions as described in Table 5-6 approaches is $528.05 million over 25 years. This number contrasts with the $1.1 billion estimated to help restore salmon in Puget Sound tributaries over a 10-year period. Other major ecosystem restoration efforts across the United States, including San Francisco Bay, Chesapeake Bay, the Everglades, and the Louisiana Coast, are estimated to cost several billion dollars apiece.

TABLE 5-7
Summary of Costs of Management Actions

Number	Action Description	Cost for Constrained Implementation	%*
CRE-01	Protect intact riparian areas in the estuary and restore riparian areas that are degraded.	$38 million	7%
CRE-02	Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	$20 million	4%
CRE-03	Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.	$10 million	2%
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.	$44.5 million	8%
CRE-05	Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.	$8 million	2%
CRE-06	Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	$6 million	1%
CRE-07	Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.	$4.5 million	1%
CRE-08	Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	$27.25 million	5%
CRE-09	Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.	$68 million	13%
CRE-10	Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.	$75 million	14%
CRE-11	Reduce the square footage of over-water structures in the estuary.	$5.8 million	1%
CRE-12	Reduce the effects of vessel wake stranding in the estuary.	$13 million	2%

Number	Action Description	Cost for Constrained Implementation	%*
CRE-13	Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.	$13 million	2%
CRE-14	Identify and implement actions to reduce salmonid predation by pinnipeds.	$15 million	3%
CRE-15	Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.	$12.5 million	2%
CRE-16	Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	$10 million	2%
CRE-17	Implement projects to reduce double-breasted cormorant habitats and encourage dispersal to other locations.	$10.5 million	2%
CRE-18	Reduce the abundance of shad in the estuary.	$5.5 million	1%
CRE-19	Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.	$3 million	1%
CRE-20	Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.	$12.5 million	2%
CRE-21	Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	$46 million	9%
CRE-22	Restore or mitigate contaminated sites.	$60.5 million	11%
CRE-23	Implement stormwater best management practices in cities and towns.	$19.5 million	4%
	Total	$528.05 million	

*Column shows the relative percentage of each action to the total cost. Percentages do not add up to 100 percent because of rounding.

Summary

The estuary and plume ecosystems are especially vulnerable to threats because these ecosystems are affected by factors across a wide geographic range—from upstream to the estuary itself, and even well out in the Pacific Ocean. A set of actions has been identified to help reduce threats to salmonids in the estuary and plume. Other recovery venues must also address upstream threats to effectively improve degraded habitats in the estuary. This estuary recovery plan module uses survival improvement targets to help estimate the level of effort required and the costs of that effort.

CHAPTER 6

Research, Monitoring, and Evaluation[1]

Research, monitoring, and evaluation (RME) is a critical element of recovery planning for ESA-listed species (Crawford and Rumsey 2010). RME provides essential information for planners, implementers, and managers of recovery programs on the effectiveness of their programs, whether individual actions are improving the performance[2] of listed salmonids, and how limiting factors and threats are affecting salmonids. This chapter describes RME needed to assess juvenile salmonid performance in the estuary and to evaluate the effectiveness of the 23 management actions described in Chapter 5. It also describes existing monitoring plans, programs, and projects that relate to estuary module RME needs and identifies gaps and potential projects to fill those gaps.

Monitoring plans for ESA-listed Columbia Basin salmonids have been or will be drafted for all domain recovery plans in the basin. These monitoring plans address the most basic question in recovery planning: Is the status of the listed population or ESU improving? Estuary RME will address other key questions, such as whether the performance of juvenile salmonids passing through and using the estuary is improving or worsening, and whether the limiting factors that affect the status of a population or ESU within the estuary are changing. Accordingly, estuary RME will complement monitoring for recovery plans for all domains in the Columbia River basin. Additional questions addressed by estuary RME are as follows:

- Are the actions identified in the estuary recovery plan module being implemented correctly, in sufficient scope, and according to schedule?
- What are the effects of estuary management actions on juvenile salmonids and their habitat?
- Are additional actions needed?
- Are there additional or new threats and limiting factors within the estuary beyond those considered in the estuary recovery plan module?
- How will the monitoring data be managed, analyzed, interpreted, and disseminated?
- How will monitoring data be incorporated into management decisions to best allow an adaptive management approach?

Monitoring for this estuary recovery plan module needs to build on ongoing efforts. In particular, *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary*

[1] Catherine Corbett of the Lower Columbia River Estuary Partnership and Gary Johnson of Pacific Northwest National Laboratories provided the principal input to this chapter.

[2] Salmonid performance refers to life history diversity, foraging success, spatial structure, and growth (Bottom et al. 2005).

Program (ERME) (Johnson et al. 2008) is an appropriate monitoring plan on which to base the estuary recovery plan module RME. The ERME monitoring plan is important because it formed the basis for estuary RME in the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (National Marine Fisheries Service 2008a and 2008b), and was carried over into the 2010 FCRPS Supplemental Biological Opinion (National Marine Fisheries Service 2010). In addition, versions of the ERME monitoring plan have been reviewed by the Independent Scientific Review Panel of the Northwest Power and Conservation Council (Independent Scientific Review Panel 2006a and 2006b), along with state and tribal fisheries management agencies. Finally, the ERME monitoring plan was initially developed and refined by an inter-agency estuary/ocean subgroup for Federal RME that included members from the Bonneville Power Administration, the U.S. Army Corps of Engineers, the Lower Columbia River Estuary Partnership, NMFS, and the Pacific Northwest National Laboratory. This chapter borrows greatly from the Johnson et al. (2008) ERME plan.

In addition to the *Research, Monitoring, and Evaluation Program for the Federal Columbia River Estuary* (Johnson et al. 2008), nine other monitoring plans and guidance documents are applicable to a framework for estuary recovery plan module RME (see Table 6-1). The earliest planning document for estuary RME—*Lower Columbia River Estuary Plan, Aquatic Ecosystem Monitoring Strategy for the Lower Columbia River and Information Management Strategy* (Lower Columbia River Estuary Partnership 1998)—outlined a general monitoring strategy that addressed coordination and oversight, data management and quality assurance, conventional and toxic contaminants, habitat, exotic species, and primary production. This document continues to be germane today. More recently, NMFS produced a document for recovery plans called *Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead Listed under the Federal Endangered Species Act* (Crawford and Rumsey 2010). This chapter is consistent with the guidance provided in that document, especially regarding the monitoring framework and adaptive management approach.

RME Framework

The main elements of estuary RME are status and trends monitoring, action effectiveness research, critical uncertainties research, and implementation and compliance monitoring. These elements inform an adaptive management approach that includes synthesis, reporting, and evaluation of monitoring data and use of results to modify management actions and monitoring programs. The main elements of the estuary RME are described below.

Status and Trends Monitoring

The overall objective of status and trends monitoring in the estuary is to determine the status of ESA-listed salmonids, determine environmental conditions that are ecologically significant to listed species, and track how the status changes over time. The results of status and trends monitoring should provide information on ambient environmental conditions and insight into the cumulative effects of existing and new management actions and anthropogenic impacts as they occur.

TABLE 6-1
Monitoring Plans Applicable to Estuary RME

Title	Lead Agency(s)	Description	Application
Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead Listed under the Federal Endangered Species Act (Crawford and Rumsey 2010)	NMFS	This document provides general guidance for monitoring and evaluation within an adaptive management framework for recovery plans for ESA-listed salmonids in the Pacific Northwest.	Estuary recovery plan module RME used the monitoring elements and adaptive management approach espoused in this work.
Lower Columbia River Estuary Plan, Volume 2: Aquatic Ecosystem Monitoring Strategy (Lower Columbia River Estuary Partnership 1998)	Estuary Partnership	The *Monitoring Strategy* makes specific recommendations for monitoring oversight, data management, and monitoring and research on pollutants, toxics, habitat, exotic species, and primary production.	Many of the recommendations in this strategy pertain to the management actions in the estuary recovery plan module and, thus, were inherently applied to module RME.
Columbia River Basin Research Plan (Northwest Power and Conservation Council 2006a)	NPCC	This plan identifies key uncertainties that, if resolved, would support actions to conserve and recover fish and wildlife populations addressed in the BPA/NPCC's Fish and Wildlife Program. There are three uncertainties listed for the estuary, one of the plan's focal areas.	Research called for in this plan informs many of the management actions in the estuary recovery plan module.
Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program (Johnson et al. 2008)	BPA/ NMFS/ NPCC/USACE	This plan for RME in the tidally influenced area, from Bonneville Dam to the ocean, including the plume, has specific goals and objectives, a conceptual ecosystem model, monitored indicators, method and protocols, and an action plan. This is a working document that is periodically updated based on new knowledge and program maturation.	Estuary recovery plan module RME relied on applicable content in this plan.
Guidance for Developing Monitoring and Evaluation as a Program Element of the Fish and Wildlife Program (Northwest Power and Conservation Council 2006b)	NPCC	This report concerns monitoring and evaluation for the Fish and Wildlife Program. It develops monitoring and evaluation guidance at two levels: Council policy-makers and project implementers. The Council's Fish and Wildlife Program was last approved in 2009.	The guidance in this report, although general, is basic to monitoring and evaluation planning and was applied as appropriate in estuary recovery plan module RME.
Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (Lower Columbia Fish Recovery Board 2010)	LCFRB	The plan includes an extensive section on monitoring and research designed to evaluate biological status of listed salmon and steelhead, tributary habitat status, implementation compliance, and action effectiveness.	Applicability to estuary recovery plan module RME is limited because the material focuses on tributary watersheds of the lower Col. R. and estuary.
Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010)	ODFW	This plan includes an extensive section on monitoring and research designed to evaluate biological status of listed salmon and steelhead, status of tributary habitat and other limiting factors, implementation compliance, and action effectiveness.	Applicability to estuary recovery plan module RME is limited because the material focuses on tributary watersheds of the lower Col. R. and estuary
FCRPS 2008 Biological Opinion and 2010 Supplemental Biological Opinion (NMFS 2008 and NMFS 2010)	NMFS	The Reasonable and Prudent Alternative in the 2008 BiOp includes estuary RME actions and subactions. These were incorporated by reference into the 2010 Supplemental BiOp.	There is some overlap between the management actions in the estuary recovery plan module and the RPAs in the Biological Opinions. As appropriate, RME from the Biological Opinions was incorporated into estuary recovery plan module RME.

Title	Lead Agency(s)	Description	Application
Supplement to the Mainstem Lower Columbia River and Estuary Subbasin Plan (Lower Columbia River Estuary Partnership 2004b)	Estuary Partnership	This supplement clarifies and provides additional details about the key elements in the subbasin plan for the estuary. It does not, however, explicitly develop an RME plan.	The supplement supports estuary RME, although specific recommendations are not provided.
Upper Columbia Monitoring and Evaluation Plan (Upper Columbia Technical Recovery Team 2007)	Upper Columbia Technical Recovery Team	This working draft provides a comprehensive plan for tributary RME. Many of the monitoring concepts are consistent with those used in the estuary.	Estuary recovery plan module RME used the monitoring guidance categories in this plan.

The U.S. Environmental Protection Agency (2000) developed 15 guidelines for developing environmental indicators that provide this type of information, including the following:

- Relevance to the assessment. Monitored indicators should be responsive to an identified question and provide information useful for management decisions.
- Linkage to management action. An indicator is useful only if it can provide adequate information to support management decisions or quantify the success of past decisions.
- Temporal variability across years. Although an indicator may show inter-annual variability, the indicator should reflect true trends in environmental conditions for the assessment question. To determine variability across years, monitoring must proceed for several years at relatively stable sites. Having a long time series of data is particularly important in the estuary, where the benefits of habitat restoration could be masked by salmonid population changes that are due to variable ocean conditions.

Examples of indicators include direct measurements (such as nutrient concentrations), indices, and multimetrics (fish assemblage, for example) (U.S. Environmental Protection Agency 2000).

There are two major objectives for status and trends monitoring in the estuary: (1) assess habitat conditions and limiting factors and threats as described in the estuary recovery plan module and (2) assess juvenile salmonid performance in the estuary. Johnson et al. (2008) list the following status and trends objectives for the estuary:

1. Status and Trends Monitoring (STM): Habitat Conditions – Determine the status and trends of monitored indicators for estuary/ocean conditions that are ecologically significant to listed salmonids in the lower river, estuary, plume, and nearshore ocean.

    STM 1. Map bathymetry and topography of the estuary as needed for RME.

STM 2. Establish a hierarchical habitat classification system based on hydrogeomorphology, ground-truth it with vegetation cover monitoring data, and map existing habitats.

STM 3. Develop an index of habitat connectivity and apply it to each of the eight reaches of the study area.

STM 4. Monitor habitat conditions periodically, including water surface elevation, vegetation cover, plant community structure, substrate characteristics, dissolved oxygen, temperature, conductivity, and primary and secondary production at representative locations in the estuary and plume.

2. Status and Trends Monitoring: Juvenile Salmonid Performance – Determine the status and trends of monitored indicators for juvenile salmonid performance in the estuary and plume.

STM 5. Evaluate migration characteristics, including juvenile salmonid abundance, residence times, growth rates, diets, and prey resources at representative locations in the estuary and plume to understand habitat usage and relative ecological importance of various habitats to juvenile salmonids.

STM 6. Monitor and evaluate juvenile salmonid survival from Bonneville Dam through the estuary into the plume.

STM 7. Develop an index and monitor and evaluate life history diversity of juvenile salmonid populations at representative locations in the estuary.

STM 8. Monitor and evaluate temporal and spatial species composition, abundance, and foraging rates of juvenile salmonid predators at representative locations in the estuary and plume.

Johnson et al. (2008) also provide guidance on potential indicators that can be monitored to provide information relevant to these objectives. Additional information about status and trends monitoring objectives can be found in the *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program* (Johnson et al. 2008).

Action Effectiveness Research

The overall objective of action effectiveness research in the estuary is to provide information about the effects of management actions. Using a representative set of management actions, such as specific types of habitat restoration, researchers monitor a suite of variables to evaluate the effects of individual actions on juvenile salmon and their estuarine habitats and provide feedback on potential methods for improving techniques, locations, or other aspects of the action. Action effectiveness research usually involves project-scale monitoring of site-specific conditions to determine whether implemented actions were effective in creating the desired change and whether project- or program-specific performance goals were met. This type of monitoring also can include long-term post-project implementation monitoring to see whether the actions continue to function as they were designed or intended. In some cases the information needed for action effectiveness monitoring may be provided by status and trends monitoring, but action effectiveness research generally requires focused evaluations of more specific parameters directly associated with actions.

The intent of action effectiveness research (AER) is to use quantitative studies to demonstrate how habitat restoration actions affect factors controlling ecosystem structures and processes at site and landscape scales and produce changes in juvenile salmonid performance. The following sub-objectives are from Johnson et al. (2008):

Using a representative set of projects, monitor and evaluate the effects of habitat restoration actions in the estuary, as follows:

AER 1. Develop a limited number of reference sites for typical habitats, e.g., tidal swamp, marsh, island, and tributary delta, to use in action effectiveness evaluations.

AER 2. Evaluate the effects of selected individual habitat restoration actions at project sites relative to reference sites and evaluate post-restoration trajectories based on project-specific goals and objectives. ("Effectiveness Monitoring")

AER 3. Develop and implement a methodology to estimate the cumulative effects of habitat conservation and restoration projects in terms of cause-and-effect relationships between ecosystem controlling factors, structures, and processes affecting salmon habitats and performance. ("Validation Monitoring")

Critical Uncertainties Research

The overall objective of critical uncertainties research in the estuary is to investigate uncertainties in the state-of-the-science that are pivotal to understanding fish performance within the estuary. Uncertainties include cause-and-effect relationships among fish, limiting factors, threats, and activities meant to protect or enhance fish performance. The following three critical uncertainties were identified as particularly relevant to this module:

- Extent of density dependence mortality in the estuary and the role of large releases of hatchery fish in density dependence
- Effects of climate cycles and global warming on salmonid performance in the estuary
- The amount of increased juvenile survival in the estuary that could reasonably be expected if all 23 management actions in the module were implemented, and the proportion of that increased survival that could be attributed to each action

Critical uncertainties were also identified in Johnson et al. (2008). The following sub-objectives pertain to critical uncertainties research (CUR):

CUR 1. Continue work to define the ecological importance of the tidal freshwater, estuary, plume and nearshore ocean environments to the viability and recovery of listed salmonid populations in the Columbia Basin.

CUR 2. Continue work to define the causal mechanisms and migration/behavior characteristics affecting survival of juvenile salmon during their first weeks in the ocean.

CUR 3. Investigate the importance of the early life history of salmon populations in tidal freshwater of the lower Columbia River.

CUR 4. Investigate the effects of hatchery fish on wild (naturally produced) fish in the estuary.

CUR 5. Understand the wetting and drying of the floodplain habitats caused by complex hydrodynamic interactions of tides, mainstem and tributary flows, and the effect of the FCRPS on river conditions.

By testing assumptions related to these and other critical uncertainties, recovery program planners, implementers, and managers can refine the foundation, implementation, and effectiveness of the management actions described in Chapter 5 to incorporate the best available science as it becomes accessible.

Implementation and Compliance Monitoring

The overall objective of implementation and compliance monitoring is to determine whether projects that address management actions are being implemented correctly, in sufficient quantities, and according to schedule. This monitoring is important for evaluating whether recovery programs are meeting objectives and performance measures, such as the number of estuary habitat acres conserved or restored annually. Objectives and performance measures for implementation and compliance monitoring are specific to the programs they evaluate; thus, in this case, performance measures and the resulting implementation monitoring would need to reflect targets derived from the 23 management actions in Chapter 5. Johnson et al. (2008) identified the following implementation and compliance monitoring (ICM) objectives:

ICM 1. Determine whether restoration projects were carried out as planned, i.e., whether specified project criteria were met ("Implementation Monitoring").

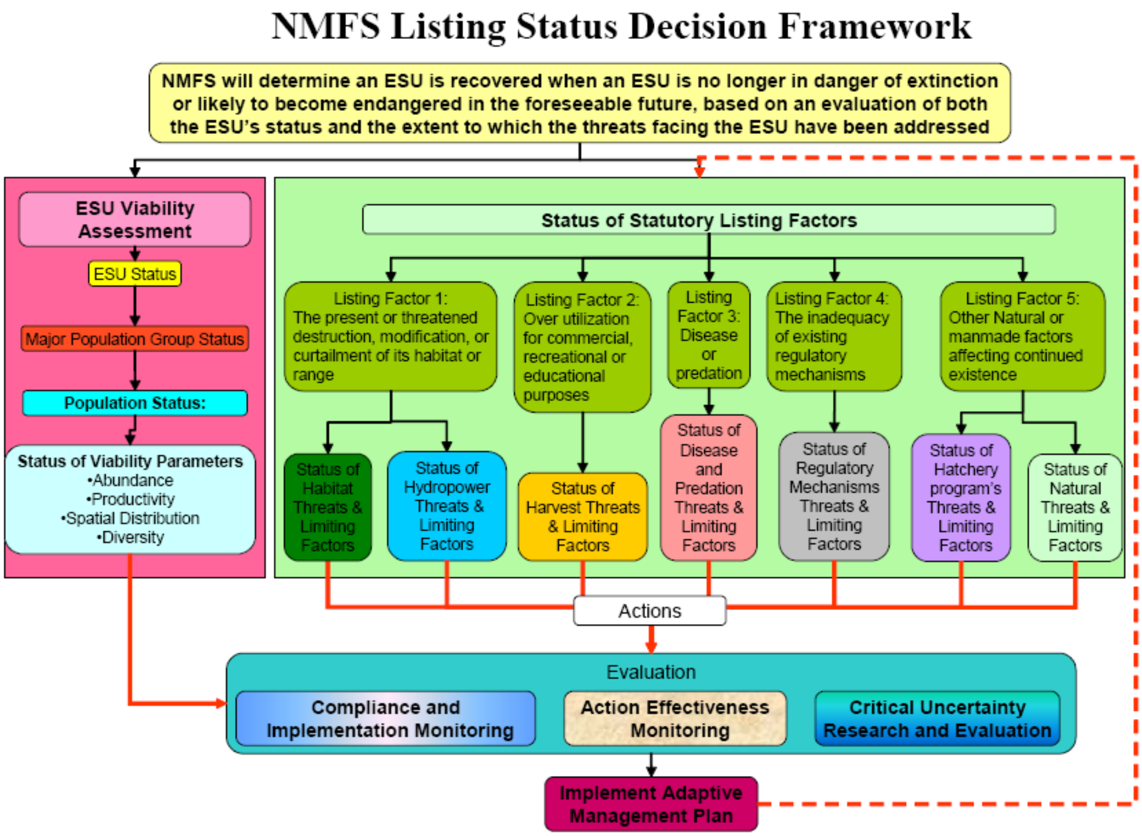
ICM 2. Total the amount of estuary habitat conserved and restored annually by habitat type.

Adaptive Management Approach

Estuary recovery plan module RME will employ an adaptive management approach. Adaptive management is the process of adjusting management actions based on new information. Management actions must be taken in an adaptive, experimental manner because ecosystems are inherently variable and highly complex (Independent Scientific Review Panel 2007). The process works by coupling decision making with the collection and evaluation of performance data and offering an explicit process through which alternative strategies to achieve the same ends can be proposed, prioritized, and implemented when necessary (Crawford and Rumsey 2010).

Figure 6-1 shows the role of RME and adaptive management in NMFS decisions regarding listing salmonids under the Endangered Species Act. The estuary recovery plan module addresses limiting factors and threats, which led to the management actions listed in Chapter 5. The RME described in this chapter will result in new information for use in evaluating the status of statutory listing factors and limiting factors and adjusting management actions as needed.

FIGURE 6-1
NMFS Listing Status Decision Framework (Crawford and Rumsey 2010)



The adaptive management approach in the estuary recovery plan module is intended to achieve effective management actions in the Columbia River estuary ecosystem. For the estuary recovery plan module, adaptive management entails the following:

- Management actions
- Research, monitoring, and evaluation actions
- Coordination and implementation
- Data and information management
- Synthesis, reporting, and evaluation
- Decisions

Estuary-scale adaptive management will benefit from adaptive management planning by individual organizations (such as the Lower Columbia River Estuary Partnership and the U.S. Army Corps of Engineers) for their habitat restoration projects and programs (see Thom et al. 2007).

Coordination

Coordination is critical in implementing RME for the Columbia River estuary, where multiple entities collect data for numerous individual projects with various objectives and potentially different monitoring protocols. Successful implementation and evaluation of estuary recovery plan module RME will require that ongoing and future RME efforts be coordinated and carried out within an adaptive management framework. An estuary RME information-sharing forum should be established that includes technical representatives of Federal, state, and local government agencies; the Lower Columbia River Estuary Partnership; and other entities involved in research, monitoring, and implementation of recovery actions. This forum would be a valuable mechanism for fulfilling the coordination need and would complement corresponding groups of policy representatives responsible for implementation.

Data and Information Management

Data and other information pertinent to estuary RME are collected by many parties for a wide variety of applications. Data analysis and management are performed at a project and sometimes agency level, but not often at the estuary-wide level. It is neither desirable nor feasible to centrally manage or analyze all data within the Columbia River estuary. However, data should be managed so that synthesis and evaluation occurs through a coordinated, communal information network that includes the following elements:[3]

- Incorporation of data produced by existing programs and information systems to avoid duplication of effort.
- Integration with other basinwide and regional RME groups, including the Pacific Northwest Aquatic Monitoring Partnership.
- Regular written project-level reporting by RME partners within a coordinated system for peer review of project plans and reports.
- Periodic estuary RME workshops to present new data, discuss findings, and exchange information on future plans.
- A system for tracking implementation of RME projects throughout the estuary.
- Establishment of a central, Web-accessible repository and library for estuary data and references.
- Guidelines for metadata standards to facilitate data exchange and application.
- Centrally facilitated program-level review for comprehensive synthesis and evaluation of pertinent information relative to the goals and objectives of this plan.
- Periodic program-level summary reports.
- Communication and information exchange with other West Coast estuary and adaptive management programs, such as the Puget Sound Partnership.
- Consistent participation and funding commitments by partners.

A data management program for the estuary should build on existing efforts, such as the Lower Columbia River Estuary Partnership's monitoring and data management activities. The Estuary Partnership's science work group (and board of directors)

[3] Adapted from Johnson et al. (2008) and Lower Columbia River Estuary Partnership (2004a).

includes technical representatives of Federal, state, and local government agencies and other entities involved in restoration, monitoring, and implementation of recovery programs. This work group complements corresponding groups of policy representatives.

Synthesis, Reporting, and Evaluation

The information from status and trends monitoring, action effectiveness research, critical uncertainties research, and implementation and compliance monitoring should be synthesized and integrated in periodic reports for decision makers and other interested parties. The intent is to “roll up” project-specific data into program-level information. Annual reporting at the project level should be a key mechanism for data dissemination; biennial reporting at the program level should be key to disseminating results of evaluations. The estuary RME information-sharing forum described above could guide the synthesis and roll-up in the biennial report. In an adaptive management process, program evaluation includes adjusting program objectives and methodologies based on new information. As Noon (2003) stated, monitoring programs “must be constantly revisited and revised as scientific knowledge is acquired.” Procedures should be established that link decision makers to estuary RME monitoring overseers and data managers. To conclude, Johnson et al. (2008) recommended the following synthesis and evaluation activities:

SE 1. Upload, compile, manage, and disseminate project-level data at the Estuary Program level.

SE 2. Synthesize the data and periodically report it to the region.

SE 3. Use the synthesized data to evaluate the Estuary Program and refine the estuary RME effort as necessary.

Existing Programs and Projects and Additional Monitoring Needs

Activities conducted as part of the ERME program (Johnson et al. 2008) and other efforts do not fully address all of the monitoring needs associated with the 23 management actions identified in the module. The following sections describe (1) existing monitoring programs and projects and their applicability to the 23 management actions identified in the module; (2) gaps between existing monitoring efforts and needed monitoring for the management actions; (3) additional monitoring activities to fill those gaps and ensure monitoring to support all of the 23 management actions; (4) recommended indicators and protocols; and (5) estimated costs of estuary module RME.

Existing Programs and Projects

Estuary recovery plan module RME will take advantage of ongoing monitoring programs and the projects implemented within them wherever possible to avoid duplication of effort. At least 21 ongoing programs include projects that address aspects of research and monitoring in the estuary (see Table 6-2). The largest RME programs are the Columbia Basin Fish and Wildlife Program, which is funded by Bonneville Power Administration via the Northwest Power and Conservation Council, and the

Anadromous Fish Evaluation Program, which is funded by the U.S. Army Corps of Engineers. These two programs address estuary RME explicitly. The other programs exist for purposes other than estuary RME, but are applicable in a limited fashion.

The research and monitoring effort in the estuary includes at least 42 projects (see Table 6-3). This project list was derived from data in Johnson et al. (2008), the Estuary Partnership's RME inventory (conducted by K. Jones), and the Pacific Northwest Aquatic Monitoring Partnership's RME Project Inventory (database provided by M. Banach, Pacific States Marine Fisheries Commission). The projects include status and trends monitoring, action effectiveness research, and critical uncertainties research.

RME Needs, Existing Project Coverage, and Recommended Projects

Table 6-4 identifies monitoring needs for each of the 23 management actions in the estuary recovery plan module (see Tables 5-2 and 5-6), lists existing projects and programs that help address the needs, and identifies gaps. Table 6-5 identifies potential new projects to fill the RME gaps identified in Table 6-4. In addition, all of the management actions will require implementation and compliance monitoring.

Monitoring Recommendations

Table 6-6 provides recommendations specific to each need identified in Table 6-4. Recommendations include sampling design, spatial and temporal scale, measured variables, measurement protocols, derived variables, analysis, possible funding entities, and potential entities for implementation and coordination. Many of the measured variables and measurement protocols were obtained from Johnson et al. (2008). Specific monitoring methods will developed on a project basis. Habitat restoration monitoring protocols for the Columbia River estuary have been developed and disseminated in Roegner et al. (2009) (Table 6-3, Project J15). Mention of possible funding entities in Table 6-6 does not imply a funding commitment of any kind.

Estimated Costs

Table 6-7 presents estimates of costs and implementation schedules for estuary recovery plan module RME. These cost estimates were developed by Gary Johnson of Pacific Northwest National Laboratories, Catherine Corbett of the Lower Columbia River Estuary Partnership, and Phil Trask of PC Trask & Associates, Inc., by researching existing programs and estimates. The costs identified in this section do not represent a detailed economic analysis; in fact, they are not economic costs, in that they have not been discounted across time. Instead, the cost estimates are in constant dollars over a 25-year period. As mentioned previously, some module actions included specific RME projects and associated cost estimates (see Table 5-6). In those cases, Table 5-6 is referenced. Other costs in Table 6-7 ($64.1 million) were estimated by evaluating the monitoring needs in Table 6-6. The total cost of the RME projects identified in the estuary recovery plan module is $85.1 million.

Summary

Monitoring, research, and evaluation elements identified in *Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead Listed under the Federal Endangered*

Species Act (Crawford and Rumsey 2010) and *Research, Monitoring, and Evaluation for the Federal Columbia River Estuary Program* (Johnson et al. 2008) provide a consistent methodology that supports the RME detailed in this chapter for the estuary recovery plan module. As management actions identified in the module are implemented, it will be important that monitoring and research data are returned to the managers of the recovery effort to determine whether the management actions in the estuary recovery plan module are achieving the desired results.

TABLE 6-2
Ongoing Monitoring Programs Applicable to Estuary RME (as of July 2009). *The program "ID" number was invented for the purpose of this module to provide linkages to Table 6-3.*

ID	Program	Lead Entity	Description	More Information
P1	National Stream Quality Accounting Network (reported in National Streamflow Information Program)	USGS (and OHSU)	Monitoring at Beaver Terminal (RM54); includes water quality and discharge measurements. Water quality components enhanced by OHSU collaboration since summer 2009.	NASQAN: http://water.usgs.gov/nasqan/ Water quality (as of summer 2009): http://columbia.loboviz.com/loboviz/ Columbia River Factsheet: http://water.usgs.gov/ nasqan/progdocs/factsheets/ clmbfact/clmbfact.html
P2	National Water-Quality Assessment Program	USGS	Routine water quality monitoring nationwide; it includes the Willamette basin, but not the estuary.	NAWQA: http://water.usgs. gov/nawqa/ Willamette page: http://or.water.usgs.gov/ projs_dir/pn366/ nawqa.html
P3	Columbia Basin Fish and Wildlife Program	BPA/ NPCC	Contains a measure addressing the question, "Is the Columbia River estuary improving or deteriorating relative to desired conditions?" BPA/NPCC implements estuary RME projects here.	http://www. nwcouncil.org/ library/2000/
P4	Columbia River Channel Improvements Project	USACE	Monitoring occurs as required for ESA concerns.	https://www.nwp. usace.army.mil/ issues/crcip/
P5	Mouth of the Columbia River Project	USACE/ Ports	Monitoring occurs as required for ESA concerns.	https://www.nwp. usace.army.mil/op/n/ projects/
P6	Anadromous Fish Evaluation Program (AFEP)	USACE	Implements the Columbia River Fish Mitigation Project designed to improve survival through the hydrosystem. The USACE does estuary research in AFEP.	https://www.nwd. usace.army.mil/ps/
P7	NOAA General Funds Program	NOAA	Provides funds for specific estuary/ocean research projects by NOAA.	Unknown
P8	Oregon Dept. of Environmental Quality/106/General Funds	ODEQ	Focus is on Willamette, including its confluence with the Columbia River.	http://www.deq.state. or.us/lab/ wqm/watershed.htm
P9	Total Dissolved Gas Monitoring Program	USACE/ USGS	Routine monitoring.	USGS: http://or.water.usgs.gov/ projs_dir/pn307.tdg/ USACE: http:// 137.161.202.92/TMT/ WQ/2001/ MonitorPlan/ tdgmgt01.pdf
P10	Washington Dept. of Ecology Ambient Monitoring Program	WDE	Usually includes at least one mainstem site, in addition to tributary water quality monitoring.	Monitoring Home: http://www.ecy.wa.gov/ programs/eap/ fw_riv/rv_main.html

ID	Program	Lead Entity	Description	More Information
P11	Water Resources Development Act – Ecosystem Restoration Programs	USACE	USACE conducts monitoring of specific restoration actions conducted under these authorities; monitoring maximum cost is 3% total project cost.	https://www.nwp. usace.army.mil/pm/lcr/
P12	Lower Columbia River Ecosystem Restoration General Investigations Feasibility Study (GI Study)	USACE	The purpose of the GI Study is to "investigate and recommend appropriate solutions to accomplish ecosystem restoration in the lower Columbia River and estuary, including wetland/riparian habitat restoration, stream and fisheries improvement, water quality, and water-related infrastructure improvements."	https://www.nwp.usace.army.mil/ pm/cr/envres.asp
P13	Portland Harbor Superfund Assessment Program	EPA	Implements cleanup at the Superfund site in Portland harbor.	EPA: http://yosemite.epa.gov/R10/ CLEANUP.NSF/sites/ ptldharbor
P14	Estuary Partnership Ecosystem, Action Effectiveness and Pile Structure Monitoring Programs	Estuary Partnership	Implements an Ecosystem Condition Status and Trends Monitoring Strategy, Restoration Actions Effectiveness Research and Pile Structure Modification action effectiveness research and critical uncertainties. Funding by BPA/NPCC, EPA, NOAA, and others.	http://www.lcrep.org
P15	NOAA Tides and Currents	NOAA	Geodetic monitoring	http://tidesandcurrents.noaa.gov/
P16	Surface Water Data Collection Program	USGS	Water quality monitoring (at Beaver Terminal combined with OHSU as of summer 2009)	http://columbia.loboviz.com/loboviz/
P17	Volunteer Water Quality Monitoring Program	Will. River Keeper	Volunteer water quality monitoring	
P18	Zebra Mussel Monitoring Program	Portland State Univ.	Monitoring of zebra mussels, an invasive species	Contact: Steven Wells
P19	National Fish and Wildlife Foundation, Columbia River Estuarine Coastal Fund	National Fish and Wildlife Foundation (NFWF)	The Columbia River Estuarine Coastal Fund was established in 2004 to receive community service payments ordered by court settlements resulting from violations of Federal pollution laws.	http://www.nfwf.org/
P20	Ship-wake program	Port of Vancouver/NOAA	Spatial analysis of beach susceptibility for stranding of juvenile salmonids by ship wakes	
P21	(Untitled)	City of Portland	Monitoring of project effectiveness, fish and wildlife, water quality, and stormwater within Portland's waterways, including the lower Willamette River. The City is in the process of revising its monitoring approach, modeling the design on EPA's Environmental Monitoring and Assessment Program.	http://www.portlandonline.com/bes/ Kaitlin.Lovell@bes.ci.portland.or.us

TABLE 6-3
Ongoing Projects Addressing Estuary RME (as of July 2009)
The project "ID" number (e.g., J4) was invented for the purpose of this module to provide linkages to Table 6-4. Project numbers (e.g., 2000-012-00) are specific to the respective program. Program numbers (e.g., P3) correspond to the program ID numbers in Table 6-2.

ID	Title	Project No.	Program	Monitoring Entity
J1	ODEQ Ambient Water Quality Monitoring	Unknown	P8	OR Dept. of Env. Quality
J2	WDOE Ambient Water Quality Monitoring	Unknown	P10	WA Dept. of Ecology
J3	USGS Discharge and Water Quality Monitoring	Unknown	P1	USGS
J4	Ives Is. Chum Salmon Monitoring	2000-012-00	P3	USFWS
J5	Lower Columbia River and Estuary Ecosystem Monitoring Project	2003-007-00	P14 + P3	Estuary Partnership/ NOAA/PNNL/UW/USGS
J6	Total Dissolved Gas Monitoring	PNAMP#409	P9	USGS
J7	Avian Predation on Juvenile Salmonids	1997-024-00	P3	OSU
J8	Tenasillahe Is. Monitoring	Unknown	P11	USFWS
J9	Canada-US Shelf Salmon Survival Study	2003-009-00	P3	DFO
J10	Life History, Habitat Connectivity, and Survival Benefits of Restoration	EST-P-09-01	P6	PNNL/UW
J11	Estimation of Salmon Survival Using Miniaturized Acoustic Tags	EST-P-02-01	P6	NMFS/ PNNL
J12	Tidal Fluvial Habitats and Juvenile Salmon – Current and Historical Linkages	EST-P-10-01	P6	NMFS
J13	Sampling PIT Tagged Juvenile Salmonids Migrating in the Estuary	BPS-W-00-11	P6	NMFS
J14	Survival and Growth of Juvenile Salmonids in the Columbia River Plume	1998-014-00	P3	NMFS
J15	Evaluation of Cumulative Ecosystem Response to Restoration	EST-P-02-04	P6	PNNL/ NMFS/ CREST
J16	Action effectiveness research on habitat restoration projects	EST-P-09-02	P6	USFWS
J17	Historic Habitat Opportunities and Food-Web Linkages of Juvenile Salmon	2003-010-00	P3	NMFS/ OHSU/ PSU/ UW
J18	Acoustic Tracking for Survival (POST)	2003-114-00	P3	Kintama
J19	Relationship Among Time of Ocean Entry, Physical, & Biological Characteristics of Estuary/Plume	EST-P-02-03	P6	NMFS
J20	Effectiveness Monitoring at Sites in Young's Bay	Unknown	P19	CREST
J21	Habitat Restoration Program – Habitat GIS, Reference Sites, Restoration Actions Effectiveness Research and Pile Structure Modification Critical Uncertainties	2003-011-00	P14 + P3	Estuary Partnership
J22	Monitoring at Smith and Bybee Lakes	Unknown	Unknown	Ducks Unlimited

ID	Title	Project No.	Program	Monitoring Entity
J23	Ramsey Lake Restoration Project Monitoring	Unknown	14	City of Portland
J24	Impact of American Shad	2007-275-00	P3	USGS
J25	Caspian Tern Management	2006-002-00	P3	OSU
J26	Tidal Freshwater Monitoring of Juvenile Salmonids	2005-001-00	P3	PNNL/ODFW/UW/NMFS
J27	Effects of Total Dissolved Gas on Chum Fry	SPE-P-07-01	P6	PNNL
J28	CORIE	Unknown	P3+	OHSU
J29	Pile Structure Removal and Modification Study	Unknown	P14	Estuary Partnership/BPA/ USACE
J30	Julia Butler Hansen Tide Gate Replacement	Unknown	P11	USFWS
J31	Comparison of Juvenile Salmonid Stranding Before and After Channel Improvements	Unknown	P4	PNNL/UW
J32	Bonneville Sea Lion Exclusion Study	ADS-02-16	P6	USCAE Fisheries Field Unit
J33	Sea Lion Deterrent System	BPA/NPCC	P3	Smith Root
J34	Caspian Tern Management Measures	AVS-P-08-01	P6	OSU
J35	Double-Crested Cormorant Management Measures	AVS-P-08-02	P6	OSU
J36	Impact of Avian Predation on Smolts	AVS-W-03-01	P6	NMFS
J37	Tides and currents	Unknown	P15	NOAA
J38	Northern Pikeminnow Surveys	1990-077-00	P3	ODFW
J39	Effectiveness Monitoring in the Lower Grays R.	PNAMP#529	P3	CREST
J40	Ives Island – Adult Chum Salmon Monitoring	PNAMP#277	P3	ODFW
J41	Volunteer Water Quality Monitoring	PNAMP#575	P17	Willamette River Keeper
J42	Zebra Mussel Monitoring	PNAMP#425	P18	PSU

TABLE 6-4
Management Actions, Associated Monitoring Needs, and Existing Coverage
Existing projects with "J" prefixes refer to projects listed in Table 6-3.

Management Action	Type	Monitoring Need	Existing Projects and Gaps
CRE-1: Protect intact riparian areas in the estuary and restore riparian areas that are degraded.	STM	Periodic mapping and areal measurement of riparian habitats and their condition using aerial photography to inform prioritization efforts	J5 and J21, although the projects do not do this at this time, but eventually could.
CRE-2: Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	STM	Water temperature monitoring in the estuary to establish baseline	J1, J2, J28
	AER	Monitoring during the hydrosystem temperature experiment	At dams, the US Army Corps of Engineers (USACE) monitors water temperature; revive hydrodynamic modeling
	UR	Reservoir heating study and downstream effects	No existing projects.
CRE-3: Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.	STM	Continuous monitoring of Col. River discharge at Beaver Terminal in the estuary	J3 USGS National Streamflow Information Program
CRE-4: Adjust the timing, magnitude and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.	STM/ AER	Continuous monitoring of Col. River discharge at Beaver Terminal in the estuary and at Bonneville dam Plume turbidity monitoring using remote sensing	J3 USGS National Streamflow Information Program; J36 NOAA Tides and Currents
	UR	Flood, habitat, and constraints study(s)	No existing projects; revive modeling, e.g., Jay and Kukulka 2003
CRE-5: Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.	UR	Effects of reservoir sediment entrapment	No existing projects; the USACE measured sediment entrapment previously.
CRE-6: Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	UR	Evaluate the long-term trajectory of beneficial use of shallow- water habitat creation sites	No existing projects; the USACE applies dredged material for beneficial uses when possible
CRE-7: Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.	UR	Dredge technique and operations study	No existing projects; the USACE studied crab entrainment previously (Pearson et al. 2006).
CRE-8: Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	STM	Periodic mapping and length and density measurements of pile structures using the Estuary Partnership's estuary GIS system	J29, J21
	AER	Monitor physical and biological effects of pile removal	J29, J21
	UR	Study fundamental physical and biological characteristics to understand where removal or modification would be advantageous	No existing projects.

Management Action	Type	Monitoring Need	Existing Projects and Gaps
CRE-9: Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.	STM	Periodic mapping and areal measurement of off-channel habitat types to inform prioritization and monitoring efforts	J5 and J21
CRE-10: Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.	STM	Periodic mapping and length measurements of dike structures using the Estuary Partnership's estuary GIS system.	J21 GIS map of dikes and tide gates
	AER	Effectiveness monitoring studies of tidal reconnections	J30 JBH study, J15 Cumulative effects, J20 Young's Bay
	UR	Ecological importance of tidal reconnections	J15 Cumulative effects J17 Habitat linkages
CRE-11: Reduce the square footage of over-water structures in the estuary.	STM	Periodic mapping and areal measurements of over-water structures using the Estuary Partnership's estuary GIS system. Track permits for construction of shoreline structures	J21 GIS map of over-water structures – needs to be expanded to areal extent, not just linear extent
	UR	Study fundamental physical and biological characteristics to understand where removal would be advantageous	No existing projects in the estuary.
CRE-12: Reduce the effects of vessel wake stranding in the estuary.	STM	Total stranding estimate for entire estuary	No existing projects.
	UR	Factors and stranding reduction study	J31 Before/after CRCIP addresses factors
CRE-13: Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.	STM	Monitor trends in predator abundance	J38
CRE-14: Identify and implement actions to reduce salmonid predation by pinnipeds.	STM	Pinniped predation monitoring	J32
	AER	Effectiveness of actions. Monitor actions under Section 120 of the Marine Mammal Protection Act	J32, J33 Section 120 monitoring
	UR	Magnitude of pinniped impact in the estuary	J32 (at BON) - expand to include magnitude of impact throughout estuary
CRE-15: Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.	STM	Inventory and map invasive plants	No existing projects; revive Sytsma et al. 2004
	AER	Effectiveness monitoring	Wahkiakum. Community Foundation Columbia Estuary Environmental Education Program (LCEEEP) identification and treatment of invasive weeds on Julia Butler Hansen Wildlife Refuge
CRE-16: Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	STM	Tern monitoring	J25, J34 Tern monitoring
	AER	Effectiveness of habitat shift	J25, J34 Tern management
CRE-17: Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.	STM	Cormorant monitoring	J35
	AER	Methods to reduce cormorant abundance	J35 Cormorant management

Management Action	Type	Monitoring Need	Existing Projects and Gaps
CRE-18: Reduce the abundance of shad in the estuary.	STM	Monitor passage of adult shad at Bonneville Dam	USACE Fish counting
	AER	Evaluate effectiveness of control methods	No existing projects.
	UR	Assess ecological effects of shad	J24 Shad impact study
CRE-19: Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.	STM	Monitor trends in abundance, distribution, and species composition of invertebrate invasives	No existing projects; revive Sytsma et al. 2004
CRE-20: Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.	STM	WQ/toxics monitoring downstream of Bonneville Dam	No existing projects.
	AER	Pre- and post-project monitoring	No existing projects.
	UR	Source tracking; fish health; sublethal and lethal thresholds	No existing projects; J5; no existing projects.
CRE-21: Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	STM	WQ/toxics monitoring	No existing projects; minimal WQ in J1, J2, J3, J5
	AER	Pre- and post-project monitoring	No existing projects.
	UR	Source tracking; fish health; sublethal and lethal threshold.	No existing projects; J5; none
CRE-22: Restore or mitigate contaminated sites.	STM	WQ/toxics monitoring	No existing projects; minimal WQ in J1, J2, J5
	AER	Pre- and post-project monitoring	No existing projects.
	UR	Source tracking; fish health; sublethal and lethal thresholds	No existing projects; J5; none
CRE-23: Implement stormwater best management practices in cities and towns.	STM	Stormwater monitoring	No existing projects; limited monitoring with NPDES permit requirements
	AER	Directed stormwater monitoring	No existing projects.
	UR	Source tracking; improve BMPs and regulations	No existing projects.

TABLE 6-5
Recommended New RME Projects or New Objectives in Existing Projects
These projects would fill gaps where "no existing projects" were noted in Table 6-4.

Action	Type	Project
CRE-2	UR	Water temperature monitoring and modeling for a reservoir heating study
CRE-4	UR	Flood, habitat, and constraints study(s) of the effects of "more normative" flows in the estuary
CRE-5	UR	Measurement of sediment entrapment in mainstem Columbia River reservoirs
CRE-6	UR	Demonstration study of beneficial use of dredged material to create shallow-water habitat
CRE-7	UR	Dredging technique and operations to minimize entrainment of juvenile salmonids
CRE-8	UR	Study fundamental physical and biological characteristics to understand where removal would be advantageous
CRE-11	UR	Assessment of impacts and benefits of removing over-water structures
CRE-12	STM	Total, estuary-wide stranding estimates by species of juvenile salmonid
CRE-15	STM	Routine monitoring of percent cover and distribution of invasive plants by species
CRE-18	AER	Effectiveness study of shad control methods
CRE-19	STM	Routine monitoring of percent cover and distribution of invasive aquatic invertebrates by species
CRE-20, 21, 22, 23	STM	Water quality, stormwater, and toxic contaminants monitoring below Bonneville Dam
CRE-20, 21, 22, 23	AER	Pre- and post-project implementation water quality, stormwater and toxic contaminants monitoring below Bonneville Dam
CRE-20, 21, 22, 23	UR	Determine sources, concentrations, timing, types, and pathways of water quality and toxic contaminant pollutants; sublethal and lethal thresholds in fish and food web

TABLE 6-6
Monitoring Guidance for Estuary Recovery Plan Module RME. Adapted from Appendix C, Johnson et al. (2008).

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
CRE-1	Periodic mapping and areal measurement of riparian habitats and their condition	Complete census with ground-truthing	Estuary-wide every 5 years	Length of riparian habitat by type of habitat	GIS-linked aerial photography, Landsat imagery and videography (Evans et al. 2006)	Proportions for each riparian habitat type	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership
CRE-2	Water temperature monitoring in the estuary to establish baseline	Stratified random sampling by reach	At representative sites throughout the estuary essentially continuously	Water temperature	Data loggers (Callaway et al. 2001)	Maximum daily/weekly maximum, seasonal averages	Trend analysis	BPA/NPCC, USGS	BPA/NPCC Fish and Wildlife Program
	Hydrosystem temperature experiment	Modeling	Estuary-wide	Water temperature	Hydrodynamic model	Maximum daily/weekly maximum, seasonal averages	Compare/ contrast	BPA/NPCC, EPA, USGS	Ibid.
	Reservoir heating study and downstream effects	Systematic sampling and modeling	At representative sites throughout the estuary essentially continuously	Water temperature	Data loggers (Callaway et al. 2001)	Maximum daily/weekly maximum, seasonal averages	Compare/ contrast	BPA/NPCC	Ibid.
CRE-3	Continuous monitoring of Columbia River discharge at Beaver Terminal in the estuary	Systematic sampling	Hourly sampling at Beaver Terminal	Stream discharge (cfs)	USGS gauging station	Annual maximum and minimum, seasonal averages	Trend analysis	USGS	USGS program

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
CRE-4	Continuous monitoring of Columbia River discharge at Beaver Terminal in the estuary and at Bonneville Dam	Systematic sampling	Hourly sampling at Beaver Terminal and BON	Stream discharge (cfs)	USGS gauging station	Annual maximum and minimum, seasonal averages	Trend analysis	USGS, USACE	USGS program (See CRE-3); also USACE O&M program for mainstem dams
	Plume turbidity monitoring using remote sensing	Complete census with ground-truthing	Plume-wide every 5 years	Turbidity	GIS-linked aerial photography	Time series of turbidity maps	Trend analysis	BPA/NPCC, NOAA	BPA/NPCC Fish and Wildlife Program (See CRE-2)
	Flood, habitat, and constraints effects study(s)	Modeling effort	Estuary-wide	Inundation	Hydrodynamic model	Cumulative inundation curves	Compare/ contrast	BPA/NPCC, NOAA	USACE's AFEP
CRE-5	Effects of reservoir sediment entrapment	Complete census	All 13 main-stem Snake and Columbia dams every 5 years	Thickness of reservoir sediment	Acoustic bottom typing (multibeam sonar)	Sediment maps	Trend analysis	USACE	USACE's AFEP (See CRE-4)
CRE-6	Evaluation of beneficial use of dredged material – create shallow-water habitat	Before-after-control-impact (BACI)	Site-specific, 1 year before and 5 years after	Vegetation, bathymetry	Roegner et al. 2009, bathymetry	Percent cover, shallow-water habitat	Effectiveness evaluation	USACE	USACE's Sediment Management Program
CRE-7	Dredge technique and operations study	Focused field experiments	TBD	Crab entrainment	Pearson et al. 2006	Entrainment rates	Statistical analysis	USACE	USACE's Sediment Management Program (See CRE-6)
CRE-8	Periodic mapping and length and density measurements of pile structures	Complete census with ground-truthing	Estuary-wide every 5 years	Length of pile structure	GIS-linked videography (Evans et al. 2006)	Length and locations of pile structure	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1)
	Monitor physical and biological effects of pile removal	BACI	Site-specific, 1 year before and 3 years after	Water velocity, fish species composition and abundance	Data loggers (Callaway et al. 2001), fish by Roegner et al. 2009	Annual max and min velocity, fish species composition proportions	Effectiveness evaluation	USACE	Ibid.

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
	Study fundamental physical and biological characteristics to understand where removal would be advantageous	Systematic sampling	Selected sites for all four seasons over 3 years	Ibid.	Ibid.	Ibid.	Ecological characterization	Ibid.	Ibid.
CRE-9	Periodic mapping and areal measurement of off-channel habitat types	Complete census with ground-truthing	Estuary-wide every 5 years	Length of riparian habitat by type of habitat	GIS-linked aerial photography	Amount of off-channel habitat	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8)
CRE-10	Periodic mapping and length measurements of dike structures	Complete census with ground-truthing	Estuary-wide every 5 years	Length of dike/levee structures	GIS-linked aerial photography	Length of dike/levee structures	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9)
	Effectiveness monitoring studies of tidal reconnections	BACI	Site-specific, 1 year before and 5 years after	Hydrology, vegetation, fish	Roegner et al. 2009	Water surface elevation, percent cover, fish species comosition proportions	Statistical comparison	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9), BPA/NPCC Fish and Wildlife Program (See CRE-2, 4), USACE's AFEP (See CRE-4,5)
	Ecological importance of tidal reconnections	BACI	Site-specific, 1 year before and 5 years after	Prey availability, fish diet, fish residence time, fish stock	Roegner et al. 2009	Diet composition charts	Ecological characterization	BPA/NPCC, USACE, NOAA	Ibid.
CRE-11	Periodic mapping and areal measurements of over-water structures	Complete census with ground-truthing	Estuary-wide every 5 years	Length of over-water structures	GIS-linked aerial photography and videography	Length of over-water structures	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9, 10)
	Track construction permits for shoreline structures	Census	Estuary-wide annually	No. and location of shoreline structures	Contact permitting agencies	Map of structures planned or under construction	Trend analysis	USACE	USACE Regulatory Program

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
	Study fundamental physical and biological characteristics	Systematic sampling	Selected sites for all four seasons over 3 years	Water velocity, light, fish species composition and abundance	Data loggers (Callaway et al. 2001), fish by Roegner et al. 2009	Annual max and min velocity and light levels, fish species composition proportions	Ecological characterization	USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9, 10), BPA/NPCC Fish and Wildlife Program (See CRE-2, 4, 10), USACE's AFEP (See CRE-4, 5, 10)
CRE-12	Total stranding estimate for entire estuary	Stratified random sampling by reach	Estuary-wide over all four seasons of 1 year	Number of juvenile salmonids stranded	Direct counts	Extrapolation to total no. stranded; map of stranding densities	Correlation analysis of factors associated with stranding	USACE	USACE's Channel Improvement Project
	Factors and stranding reduction study	BACI	Selected sites	Ibid.	Ibid.	Average no. stranded w/ and w/o the reduction device	Statistical comparison	USACE	Ibid.
CRE-13	Monitor trends in piscivorous predator abundance	Stratified random sampling by reach	Estuary-wide annually	Catch per unit effort	Electrofishing	Predator densities by location	Trend analysis	BPA/NPCC, USACE, NOAA	USACE's AFEP (See CRE-4, 5, 10, 11)
CRE-14	Pinniped predation monitoring	Systematic sampling	At BON during spring and summer	Number of pinnipeds	Observers	Weekly average abundance	Trend analysis	BPA/NPCC, USACE	USACE's AFEP (See CRE-4, 5, 10, 11, 13)
	Effectiveness of actions (monitor actions under Sec. 120)	BACI	Ibid.	Ibid.	Ibid.	Average abundance	Statistical comparison	USACE	Ibid.
	Magnitude of pinniped impact	Stratified random sampling by reach	Estuary-wide annually	Number of pinnipeds; number of salmon and steelhead consumed per predator; sampling rate	Observers, scat analysis	Estimate of the total number of salmon and steelhead consumed	Trend analysis	NOAA	Ibid.

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
CRE-15	Inventory and map invasive plants	Stratified random sampling by reach	Estuary-wide every 5 years	Species composition, abundance, distribution	Site surveys (Sytsma et al. 2004)	Percent cover, maps	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9, 10, 11)
	Effectiveness monitoring	BACI	At selected sites over 3 years	Ibid.	Ibid.	Average percent cover	Statistical comparison	Ibid.	Ibid.
CRE-16	Tern monitoring	Systematic sampling	Reach A during April-August annually	Number of birds	Observers	Number of mating pairs, total local population size	Trend analysis	BPA/NPCC, USACE, NOAA, USFWS	USACE's AFEP (See CRE-4, 5, 10, 11, 13, 14)
	Effectiveness of habitat shift	BACI	Reach A during April-August for 3-5 years	Ibid.	Ibid.	Ibid.	Statistical comparison	Ibid.	Ibid.
CRE-17	Double-crested cormorant monitoring	Systematic sampling	Reach A during April-August annually	Number of birds	Observers	Number of mating pairs, total local population size	Trend analysis	BPA/NPCC, USACE, NOAA, USFWS	USACE's AFEP (See CRE-4, 5, 10, 11, 13, 14, 16)
	Methods to reduce cormorant abundance	Site experiments	Reach A over 1-3 years	Ibid.	Ibid.	Ibid.	Compare/ contrast	Ibid.	Ibid.
CRE-18	Monitor passage of adult shad at BON	Census	Continuous monitoring at BON	Number of adult shad	Observers	Total number per year, weekly and monthly averages	Trend analysis	USACE	BPA/NPCC Fish and Wildlife Program (See CRE-2, 4, 10, 11), USACE's AFEP (See CRE-4, 5, 10, 11, 13, 14, 16, 17)
	Evaluate effectiveness of control methods	Site experiments	Selected sites	Ibid.	Seine, sonar	Number of shad by treatment	Statistical comparison	BPA/NPCC, USACE, NOAA	Ibid.
	Assess ecological effects of shad	Systematic sampling	Selected sites for summer over 3 years	Number of shad, diet, distribution, sex ratio	Various	Total population size, fecundity, etc.	Ecological characterization	BPA/NPCC	Ibid.

Mngt. Action	Monitoring Need[1]	Sampling Design	Spatial/ Temporal Scale	Measured Variables	Measurement Protocols	Derived Variables	Analysis	Possible Funding Entities	Possible Implementation & Coordination
CRE-19	Monitor trends in abundance, distribution, and species composition of invasive invertebrates	Stratified random sampling by reach	Estuary-wide every 5 years	Species composition, abundance, distribution	Site surveys (Sytsma et al. 2004)	Density distribution maps	Trend analysis	BPA/NPCC, USACE, NOAA	Estuary Partnership (See CRE-1, 8, 9, 10, 11, 15)
CRE-20, 21, 22, 23	Water quality and toxics monitoring downstream of BON	Stratified random sampling by reach, directed source and load tracking	Estuary-wide annual	Concentrations and loads of pollutants, contaminants by source and type	Various	Maps of distribution of pollutant concentration loads, pathways, and sources by type	Every 3 years - trend analysis; concentration loads, and yields by tributary and source	EPA, NOAA, USGS, ODEQ, WDOE	Estuary Partnership (See CRE-1, 8, 9, 10, 11, 15, 19)
	Fish health, sublethal and lethal thresholds	Focused experiments	Laboratory	Fish health/ mortality	Ibid.	Dose response curves	Statistical analysis	Ibid.	Ibid.

[1]Monitoring needs are those identified in Table 6-4.

TABLE 6-7
Estimated Cost and Schedule for Monitoring Needs (includes ongoing projects in some cases)

Management Action	Monitoring Need	Unit	Est. Cost	Schedule
CRE-1: Protect intact riparian areas in the estuary and restore riparian areas that are degraded.	Periodic mapping and areal measurement of riparian habitats and their condition using aerial photography to inform prioritization efforts	Every 5 years, base flyover for data acquisition @ $250K and analysis for riparian zones @ $200K	$1M base plus $800K riparian	2007-2022
CRE-2: Operate the hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	Water temperature monitoring in the estuary to establish baseline	Continuous monitoring at four sites (Bonneville Dam, Beaver, St. Helens, and Astoria) for 3 years @ $20K per year and one retrospective study of temperature	$60K (new data from Beaver, St. Helens) plus $50K study	2007-2009
	Monitoring during the hydrosystem temperature experiment	Continuous monitoring at four sites (Bonneville Dam, Beaver, St. Helens, and Astoria) for 5 years @ $20K per year	$100K	2010-2014
	Reservoir heating study and downstream effects	see Table 5-6	see Table 5-6	see Table 5-6
CRE-3: Protect and/or enhance estuary instream flows influenced by Columbia River tributary/mainstem water withdrawals and other water management actions in tributaries.	Continuous monitoring of Columbia River discharge at Beaver Terminal in the estuary	Data collection and dissemination are routine and ongoing.	$0 (already covered)	2007-2035
CRE-4: Adjust the timing, magnitude and frequency of hydrosystem flows (especially spring freshets) entering the estuary and plume to better reflect the natural hydrologic cycle, improve access to habitats, and provide better transport of coarse sediments and nutrients in the estuary and plume.	Continuous monitoring of Columbia River discharge at Beaver Terminal in the estuary and at BON dam	See CRE-3	$0 (already covered)	2007-2035
	Plume turbidity monitoring using remote sensing (satellite)	3 years @ $100K/year	$300K	2009-2011
	Flood, habitat, and constriant study(s)	see Table 5-6	see Table 5-6	see Table 5-6
CRE-5: Study and mitigate the effects of entrapment of fine sediment in reservoirs, to improve nourishment of the estuary and plume.	Effects of reservoir sediment entrapment	see Table 5-6	see Table 5-6	see Table 5-6
CRE-6: Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	Evaluate the beneficial use of dredged material – create shallow-water habitat	see Table 5-6	see Table 5-6	see Table 5-6
CRE-7: Reduce entrainment and habitat effects resulting from main- and side-channel dredge activities and ship ballast intake in the estuary.	Dredge technique and operations study	see Table 5-6	see Table 5-6	see Table 5-6

Management Action	Monitoring Need	Unit	Est. Cost	Schedule
CRE-8: Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	Periodic mapping and length and density measurements of pile structures using the Estuary Partnership's estuary GIS system	One assessment every 5 years @ $200K per assessment	$800K	2007-2022
	Monitor physical and biological effects of pile removal	see Table 5-6	see Table 5-6	see Table 5-6
	Study fundamental physical and biological characteristics to understand where removal would be advantageous	One study for 3 years @ $250K/year	$750K	2007-2009
CRE-9: Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high-quality habitat.	Periodic mapping and areal measurement of off-channel habitat types to inform prioritization and monitoring efforts	See CRE-1 cost for base flyover, plus analysis of off-channel habitats every 5 years @ $200K per assessment	$800K	2007-2022
CRE-10: Breach, lower, or relocate dikes and levees to establish or improve access to off-channel habitats.	Periodic mapping and length measurements of dike structures using the Estuary Partnership's estuary GIS system.	See CRE-9; additional analysis @ $50K per assessment every 5 years	$200K	2007-2022
	Effectiveness monitoring studies of tidal reconnections	Two case studies each in Reaches A-E and one study each in Reaches F-H with samplings in Years 0, 1, 4, 7 @ $100K per sampling-year	$5.2M	2007-2035
	Ecological importance of tidal reconnections	Building on the data from the effectiveness monitoring, one study for 5 years @ $400K per year	$2M	2007-2011
CRE-11: Reduce the square footage of over-water structures in the estuary.	Periodic mapping and areal measurements of over-water structures using the Estuary Partnership's estuary GIS system.	Assessments every 5 years @ $250K per assessment	$1M	2007-2022
	Track permits for construction of shoreline structures	Annual compilation and reporting @ $60K per year	$1.5M	2007-2031
	Study fundamental physical and biological characteristics to understand where removal would be advantageous	One study for 3 years @ $250K/year	$750K	2008-2010
CRE-12: Reduce the effects of vessel wake stranding in the estuary.	Total stranding estimate for entire estuary	One study with sampling three seasons per year at eight sites for 2 years @ $1M per yr	$2M	2009-2010

Management Action	Monitoring Need	Unit	Est. Cost	Schedule
	Factors and stranding reduction study	see Table 5-6	see Table 5-6	see Table 5-6
CRE-13: Manage pikeminnow and other piscivorous fish, including introduced species, to reduce predation on salmonids.	Monitor trends in predator abundance	see Table 5-6	see Table 5-6	see Table 5-6
CRE-14: Identify and implement actions to reduce salmonid predation by pinnipeds.	Pinniped predation monitoring	One study estuary-wide for 5 years @ $250K per year	$2.5M	2008-2012
	Effectiveness of actions. Monitor actions under Sec. 120	Study every 5 years for 20 years @ $200K (see above)	$0 (already covered)	2013-2032
	Magnitude of pinniped impact in estuary	See pinniped predation monitoring above	$0 (already covered)	2008-2012
CRE-15: Implement education and monitoring projects and enforce existing laws to reduce the introduction and spread of invasive plants.	Inventory and map invasive plants	see Table 5-6	see Table 5-6	see Table 5-6
	Effectiveness monitoring	see Table 5-6	see Table 5-6	see Table 5-6
CRE-16: Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	Tern monitoring	see Table 5-6	see Table 5-6	see Table 5-6
	Effectiveness of habitat shift	see Table 5-6	see Table 5-6	see Table 5-6
CRE-17: Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.	Cormorant monitoring	see Table 5-6	see Table 5-6	see Table 5-6
	Methods to reduce cormorant abundance	see Table 5-6	see Table 5-6	see Table 5-6
CRE-18: Reduce the abundance of shad in the estuary.	Monitor passage of adult shad at Bonneville Dam	Data collection and dissemination are routine and ongoing.	$0 (already covered as part of adult fish counts)	2007-2035
	Evaluate effectiveness of control methods	see Table 5-6	see Table 5-6	see Table 5-6
	Assess ecological effects of shad	One study for 3 years @ $300K per year	$900K	2008-2010
CRE-19: Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.	Monitor trends in abundance, distribution, and species composition of invasive invertebrates	Recurring study every 3 years for 30 years @ $500K per year	$5M	2008-2037

Management Action	Monitoring Need	Unit	Est. Cost	Schedule
CRE-20: Implement pesticide and fertilizer best management practices to reduce estuarine and upstream sources of nutrients and toxic contaminants entering the estuary.	WQ/toxics monitoring downstream of Bonneville Dam	Annual ambient and directed sampling for 25 years @ $1M/year	$25M	2008-2032
	Pre- and post-project monitoring	Twice annual upstream + downstream sites @ $10K per project @ one project per year for 25 years	$250,000	2008-2032
	Source tracking, fish health, sublethal and lethal thresholds	One study for 5 years @ $500K; fish health @ 5-6 sites per year @ $250K for 25 years; one study for eight priority toxics @ $1.5M for 3 years	$8.25M	2008-2032
CRE-21: Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	WQ/toxics monitoring	See CRE-20	See CRE-20	See CRE-20
	Pre- and post-project monitoring	Ibid.	Ibid.	Ibid.
	Source tracking, fish health, sublethal and lethal thresholds	Ibid.	Ibid.	Ibid.
CRE-22: Restore or mitigate contaminated sites.	WQ/toxics monitoring	See CRE-20	See CRE-20	See CRE-20
	Pre- and post-project monitoring	Ibid.	Ibid.	Ibid.
	Source tracking, fish health, sublethal and lethal thresholds	Ibid.	Ibid.	Ibid.
CRE-23: Implement stormwater best management practices in cities and towns.	Stormwater monitoring	see Table 5-6	see Table 5-6	see Table 5-6
	Directed stormwater monitoring	Twice annual @ 5 cities @ $24K per site for 25 years	$3M	2008-2032
	Source tracking, improve BMPs and regulations	1 study for 5 years @ $500K (see CRE-20); 1 study for 3 years @ $1.5M	$2M	2008-2013

CHAPTER 7

Perspectives on Implementation

Substantial investment is being made in the Columbia River basin to recover listed Chinook, coho, steelhead, and chum. How much of this investment should be made in the estuary? How much do the estuary and plume environments contribute to the survival of upstream ESUs, and is recovery of upstream ESUs possible without a healthier estuary ecosystem? If not, what does the information in Chapters 3, 4, and 5 tell us about which management actions to implement in the estuary?

Chapter 7 explores issues related to the selection of management actions to be implemented in the estuary and how those choices will shape future conditions for salmonids in the estuary and plume. It also suggests next steps in implementation and identifies implementation challenges.

Putting the Estuary in Context

This recovery plan module reflects current scientific understanding that the Columbia River estuary and plume provide habitat that wild salmonids need to complete their life cycles. Historically, juveniles from hundreds of distinct salmonid populations, at various life history stages, used the estuary for refuge and rearing as they prepared physiologically for life in the ocean. Over evolutionary time populations developed life history strategies in which juveniles from different populations staggered their use of the estuary throughout the year, exploiting estuarine habitats in different ways for different lengths of time. Although the estuary posed risks to juvenile salmonids, the diversity in life history strategies allowed salmon and steelhead to take maximum advantage of estuarine resources, which offered tremendous opportunities for refuge and growth. Unlike an upstream tributary, through the year the estuary provided habitat for all of the salmonid populations in the Columbia River basin during a critical stage in their life cycles.

Over the last 200 years the ability of the Columbia River estuary to meet the needs of salmon and steelhead has been seriously compromised. There is no question about the extent of changes in the estuary: the timing, magnitude, and duration of flows do not resemble those of historical flows, access to the estuary floodplain has been virtually eliminated, sediment transport processes that depend on flows and upstream sediment sources are radically different than they were historically, water quality has degraded as a result of contamination, temperatures are approaching and sometimes exceeding lethal limits, and there have been fundamental changes at the base of the estuarine food web, with associated alterations in inter- and intra-species relationships. A central premise of this recovery plan module is that although the estuary ecosystem is degraded, it can be improved, and that a healthier estuary ecosystem would contribute meaningfully to the basinwide recovery of ESA-listed salmonids.

Factors That Influence Decision Making

Decisions about implementation would be easy if protecting and restoring salmonids were the only consideration. However, as much as we value healthy native fish runs, as a society we also value a stable economy, financial opportunity for individuals and businesses, public safety, and property rights. These values will play into decisions about which management actions to implement, as will the three factors used to evaluate the management actions in Chapter 5: cost, constraints, and potential benefits to salmonids.

Also affecting choices about implementation is scientific uncertainty. Although fisheries science has matured over the last 100 years, how salmonids interact in complex ecosystems is not well understood; this is especially true in the estuary and plume. Yet we cannot wait until uncertainty has been eliminated before taking action. In the face of scientific uncertainty, then, decisions about implementing management actions will have to be made using the most current scientific information available, combined with best professional judgment. Historically, it has been a mix of science and policy choices that have guided decisions that affected the estuary; it is likely that these same forces will also determine the effectiveness of science-driven recovery efforts.

Significance of Constraints to Implementation

Not a single management action identified in Table 5-1 will be easy to implement. In one way or another, implementation of each of the 23 actions is constrained, in some cases greatly. Understanding the nature and magnitude of constraints to the implementation of management actions is important for several reasons. First, it grounds the actions in the real world and tempers expectations for results. Second, it provides insights into the level of effort that would be required for an action to have a sizable impact on salmonid populations. Third and most important, it reveals that every proposed action in this recovery plan module has significant obstacles to implementation.

Because it will be difficult to implement any single action fully and gain all of its potential benefit to salmonids, it will be important to implement a relatively large number of the proposed management actions. In other words, if each management action in the estuary has significant constraints, it may take partial implementation of all or most of the actions to improve the health of the estuary ecosystem to the point that the ecosystem provides the benefits that salmonids need to recover.

To illustrate the relative constraints of different actions, Table 7-1 presents management actions by degree of constraint to implementation, in descending order.

Table 7-1
Management Actions Sorted by Degree of Constraint

#	Action	Degree of Constraint
CRE-02	Operate the hydrosystem to reduce reservoir heating.	5
CRE-03	Protect/enhance instream flows influenced by water withdrawals and other water management actions in tributaries.	5
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows.	5
CRE-05	Mitigate entrapment of fine sediment in reservoirs.	5
CRE-18	Reduce shad abundance.	5
CRE-19	Prevent aquatic invertebrate introductions.	5
CRE-14	Reduce predation by pinnipeds.	4
CRE-15	Reduce invasive plants.	4
CRE-17	Redistribute cormorants.	4
CRE-21	Identify and reduce sources of pollutants.	4
CRE-20	Implement pesticide/fertilizer BMPs.	4
CRE-9	Protect/restore high-quality off-channel habitat	3
CRE-10	Breach, lower, or relocate dikes and levees.	3
CRE-12	Reduce vessel wake stranding.	3
CRE-22	Restore or mitigate contaminated sites.	3
CRE-11	Reduce over-water structures.	3
CRE-01	Protect/restore riparian areas.	3
CRE-06	Use dredged materials beneficially.	3
CRE-16	Redistribute Caspian terns.	2
CRE-07	Reduce entrainment/habitat effects of dredging and ballast.	2
CRE-13	Manage pikeminnow and other piscivorous fish.	2
CRE-23	Implement stormwater BMPs.	2
CRE-08	Remove or modify pilings and pile dikes	2

Another useful table when considering implementation constraints is Table 5-3, which shows the differences in potential benefit to salmonids if implementation of actions is unconstrained, versus constrained, which represents a more realistic scenario. However, although Table 5-3 demonstrates the size of the gap between unconstrained and constrained implementation of actions, it does not adequately characterize the magnitude of response that might be expected from constrained implementation. The next section of this document is intended to help show the potential benefit from constrained implementation of actions.

Management Actions Offering the Greatest Survival Benefits

If we were to increase our investment in restoration of the Columbia River estuary by an order of magnitude, what would the ecological return on that investment be? Our ability to answer that question is limited by a lack of understanding of how much mortality actually occurs in the estuary and plume. Still, we do have some information about potential gains that reasonably could be expected as a result of such investment.

Juvenile Survival Improvement. In Chapter 5, survival improvement targets were developed as a tool for comparing the potential benefits of implementing different management actions. This planning exercise used the best available information about estuary mortality for wild, ESA-listed stream- and ocean-type juveniles and then established a 20 percent survival improvement target for the 22 management actions that would affect the survival of juveniles. The survival improvement targets were then allocated across the various management actions to help characterize where survival gains might occur. The results are not intended to represent a deterministically based analysis; however, they do reflect information in the scientific literature, especially about mortality resulting from terns, cormorants, ship wake stranding, contaminants, and pinnipeds.

Tables 7-2 and 7-3 summarize the results of this planning exercise, sorting actions by their potential to improve survival of stream- and ocean-type juveniles, respectively, assuming that implementation of the actions is constrained. This ordering is simply an exercise to hypothesize where survival improvements equal to 20 percent of the number of juveniles exiting the estuary and plume might be expected for stream-type and ocean-type juveniles.

For stream-type salmonids, the following observations can be made from Table 7-2:

- Approximately 60 percent of the survival improvements are assigned to the top five actions, which include adjusting flow, protecting or restoring off-channel habitat, restoring or mitigating contaminated sites, and managing birds that prey on salmonids.
- Approximately 30 percent of the survival improvements are assigned to establishing or improving access to off-channel habitat, protecting and restoring riparian areas, reducing sources of pollutants, managing piscivorous fish, and removing or modifying pilings and pile dikes.
- Approximately 10 percent of the survival improvements are assigned across the remaining actions, with varying degrees of improvements.

For ocean-type salmonids, the following observations can be made from Table 7-3:

- Approximately 65 percent of the survival improvements are assigned to the top five actions, which include adjusting flows, establishing or improving access to off-channel habitat, protecting or restoring off-channel habitat, and addressing issues of contamination.
- Approximately 30 percent of the survival improvements are assigned to protecting and restoring riparian areas, reducing reservoir heating, removing or modifying pilings and pile dikes, reducing vessel wake stranding, using dredged materials beneficially,

managing piscivorous fish, and implementing pesticide, fertilizer, and stormwater BMPs.

- Approximately 5 percent of the survival improvements are assigned across the remaining actions, with varying degrees of improvements.

Table 7-2
Management Actions Sorted by Benefit to Stream-type Juveniles

#	Action	Survival Target (Stream Types)	Percentage of Target Improvements
CRE-16	Redistribute Caspian terns.	350,000	~60%
CRE-17	Redistribute cormorants.	250,000	
CRE-09	Protect/restore high-quality off-channel habitat.	150,000	
CRE-22	Restore or mitigate contaminated sites.	142,000	
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows.	125,000	
CRE-13	Manage pikeminnow and other piscivorous fish.	122,000	~30%
CRE-10	Breach, lower, or relocate dikes and levees.	100,000	
CRE-01	Protect/restore riparian areas.	100,000	
CRE-08	Remove or modify pilings and pile dikes	100,000	
CRE-21	Identify and reduce sources of pollutants.	72,000	
CRE-20	Implement pesticide/fertilizer BMPs.	42,000	~10%
CRE-23	Implement stormwater BMPs.	30,000	
CRE-02	Operate the hydrosystem to reduce reservoir heating.	20,000	
CRE-03	Protect/enhance instream flows influenced by water withdrawals and other water management actions in tributaries.	20,000	
CRE-06	Use dredged materials beneficially.	15,000	
CRE-15	Reduce invasive plants.	15,000	
CRE-07	Reduce entrainment/habitat effects of dredging and ballast.	10,000	
CRE-05	Mitigate entrapment of fine sediment in reservoirs.	5,000	
CRE-18	Reduce shad abundance.	5,000	
CRE-11	Reduce over-water structures.	3,000	
CRE-19	Prevent aquatic invertebrate introductions.	2,000	
CRE-12	Reduce vessel wake stranding.	2,000	
	Total:	1.68 million	

TABLE 7-3
Management Actions Sorted by Benefit to Ocean-type Juveniles

#	Action	Survival Target (Ocean Types)	Percentage of Target Improvements
CRE-10	Breach, lower, or relocate dikes and levees.	450,000	~65%
CRE-09	Protect/restore high-quality off-channel habitat.	400,000	
CRE-22	Restore or mitigate contaminated sites.	300,000	
CRE-21	Identify and reduce sources of pollutants.	275,000	
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows.	225,000	
CRE-01	Protect/restore riparian areas.	150,000	~30%
CRE-08	Remove or modify pilings and pile dikes	150,000	
CRE-13	Manage pikeminnow and other piscivorous fish.	140,000	
CRE-02	Operate the hydrosystem to reduce reservoir heating.	90,000	
CRE-23	Implement stormwater BMPs.	65,000	
CRE-12	Reduce vessel wake stranding.	55,000	
CRE-20	Implement pesticide/fertilizer BMPs.	50,000	
CRE-06	Use dredged materials beneficially	50,000	
CRE-03	Protect/enhance instream flows influenced by water withdrawals and other water management actions in tributaries.	25,000	~5%
CRE-11	Reduce over-water structures.	25,000	
CRE-15	Reduce invasive plants.	20,000	
CRE-07	Reduce entrainment/habitat effects of dredging and ballast.	8,000	
CRE-19	Prevent aquatic invertebrate introductions.	8,000	
CRE-05	Mitigate entrapment of fine sediment in reservoirs.	5,000	
CRE-18	Reduce shad abundance.	5,000	
CRE-16	Redistribute Caspian terns.	2,000	
CRE-17	Redistribute cormorants.	2,000	
	Total:	2.5 million	

While many of the actions are highly constrained, the planning exercise summarized in Tables 7-2 and 7-3 assumes that, even with incremental changes associated with constrained implementation, certain actions could yield significant results, especially when coupled with complementary actions. For example, ocean-type juveniles rely heavily on off-channel habitats for food sources and rearing opportunities. The two primary actions intended to improve access to off-channel habitats are CRE-10, "Breach, lower, or relocate dikes and levees," and CRE-4, "Adjust the timing, magnitude, and frequency of hydrosystem flows." Implementation of both of these actions is highly constrained, yet they could have synergistic effects and their joint implementation—even if only partial—could result in significant survival improvements for ocean-type salmonids. In contrast, if only one of these actions were implemented (or, worse yet, neither), other actions would need to be implemented as fully as possible in an attempt to compensate for the foregone opportunity to address one of the main factors limiting juvenile salmonid performance in the estuary.

Adult Survival Improvement. Because CRE-14, "Reduce predation by pinnipeds," is the only action that directly addresses the adult life history stage of salmonids, this action is treated separately and is not included in Tables 7-2 and 7-3. In 2010, which saw the largest spring Chinook and steelhead runs from 2002 to 2010, pinniped predation on spring Chinook and steelhead (both of which are stream types) at Bonneville Dam was estimated to be 2.2 percent. This equates to 6,081 spring Chinook and steelhead out of a run size of 267,194 fish (U.S. Army Corps of Engineers 2010). Projects to reduce pinniped predation have had limited success, and more stringent management techniques are constrained by protections afforded by the Marine Mammal Protection Act. Although the act does provide for lethal control, the process for implementing that provision is challenging. In 2008, NMFS granted authority under Section 120 of the Marine Mammal Protection Act to the states of Oregon, Washington, and Idaho to intentionally take, by lethal methods, individually identifiable California sea lions that prey on Pacific salmon and steelhead at Bonneville Dam, but the effectiveness of this approach is unknown. Given these constraints, PC Trask & Associates, Inc., in consultation with NMFS Northwest Regional Office staff, estimated that CRE-14 might result in a 17 percent reduction in pinniped-related mortality of adults at Bonneville Dam each year (approximately 1,034 fish annually as applied to 2010 run returns).

Costs for Constrained Implementation of Management Actions

As discussed in Chapter 5, estimating the cost of the management actions in this module is inherently difficult and involves significant uncertainties. This is partly because in many cases, the constraints to implementation have not yet been explored in enough detail to be able to determine what is and is not possible, and key scientific and technical questions about the estuary have not yet been answered. In Chapter 5, Table 5-6 established cost estimates for constrained implementation of actions by assuming an optimistic view—that constraints can be reduced through focused effort and that positive changes in the estuary can be made. A more pessimistic view would likely yield a significantly lower cost estimate, with correspondingly smaller survival improvements. Costs were assigned at the project scale to help identify possible components to actions, with the expectation that future refinements would yield a more sophisticated estimate. Finally, project costs were estimated over a 25-year time horizon.

Table 7-4 organizes management actions by total estimated cost (from Table 5-6). The following observations can be made:

- Costs for the top six actions total $332 million, or about 63 percent of the entire budget. The actions include restoring contaminated sites, modifying flows, reducing sources of pollutants, establishing or improving access to off-channel habitats, protecting or restoring off-channel habitats, and protecting and restoring riparian areas.
- Costs for the next six actions on the list equal $108 million, or about 20 percent of the budget. This group of actions consists of reducing reservoir-related temperature changes, implementing stormwater BMPs, addressing vessel wake stranding, removing or modifying pilings and pile dikes, and managing fish and pinnipeds that prey on salmonids.
- The final 11 actions on the list equal $88 million, or about 17 percent of the budget.

TABLE 7-4
Management Actions Sorted by Estimated Cost

#	Action	Cost of Action	Cost per Group of Actions
CRE-10	Breach, lower, or relocate dikes and levees.	$75 million	~$332 million, or 63% of total
CRE-09	Protect/restore high-quality off-channel habitat.	$68 million	
CRE-22	Restore or mitigate contaminated sites.	$60.5 million	
CRE-21	Identify and reduce sources of pollutants.	$46 million	
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows.	$44.5 million	
CRE-01	Protect/restore riparian areas.	$38 million	
CRE-08	Remove or modify pilings and pile dikes	$27.25 million	~$108 million, or 20% of total
CRE-02	Operate the hydrosystem to reduce reservoir heating.	$20 million	
CRE-23	Implement stormwater BMPs.	$19.5 million	
CRE-14	Reduce predation by pinnipeds.	$15 million	
CRE-13	Manage pikeminnow and other piscivorous fish.	$13 million	
CRE-12	Reduce vessel wake stranding.	$13 million	
CRE-15	Reduce invasive plants.	$12.5 million	~$88 million, or 17% of total
CRE-17	Redistribute cormorants.	$10.5 million	
CRE-20	Implement pesticide/fertilizer BMPs.	$12.5 million	
CRE-03	Protect/enhance instream flows influenced by water withdrawals and other water management actions in tributaries.	$10 million	
CRE-16	Redistribute Caspian terns.	$10 million	
CRE-05	Mitigate entrapment of fine sediment in reservoirs.	$8 million	
CRE-06	Use dredged materials beneficially.	$6 million	
CRE-11	Reduce over-water structures.	$5.8 million	
CRE-18	Reduce shad abundance.	$5.5 million	
CRE-07	Reduce entrainment/habitat effects of dredging and ballast.	$4.5 million	
CRE-19	Prevent aquatic invertebrate introductions.	$3 million	
	Total:	$528.05 million	

As also discussed in Chapter 5, there is significant uncertainty in these cost estimates because of the ambiguity about the degree to which constraints to implementation can be overcome, the level of effort that would be required to achieve a measurable result, and how new information could change current understanding about the cost and effectiveness of management actions. However, it is assumed that if restoring the ecosystem of the Columbia River estuary were established as a goal, this would require financial investment on a par with that for other major ecosystem recovery efforts around the United States.

Cost-Effectiveness of Management Actions

Cost-effectiveness is an important consideration when attempting to achieve large goals with limited resources, and the more limited the resources with respect to the goal, the more important it is that the maximum benefit be obtained from each expenditure. In the case of the Columbia River estuary, improving conditions for salmonids is likely to be an expensive and long-term effort—one that will require careful consideration of the survival benefits and costs of possible actions.

The linkage between the survival benefits and costs in this recovery plan module is difficult to characterize accurately because of the margin of error that, at this point, exists in both the estimated costs and the survival targets. Because the survival improvement targets were allocated across the set of actions as a planning exercise rather than as results of a scientific analysis, it is the allocation that is most important, not the target numbers themselves. In the case of costs, estimates were made assuming that constraints to implementation of actions could be partially overcome; this assumption served as a way to explore the degree of constraints and the level of effort that would be required to bring about significant benefits to salmonids. The resulting costs should be viewed as preliminary numbers useful in starting critical discussions about decisions that will shape the future of the estuary.

Understanding that, as outlined above, there are limitations governing the survival improvement targets and cost estimates, these sets of numbers can be compared to provide clues about which management actions might be the most cost-effective. Table 7-5 makes such a comparison, using cost information from Table 7-4 and target survival improvements from Table 7-3 to estimate the cost-effectiveness of each action, expressed as a cost/survival index. The actions are sorted in ascending order to show the most cost-effective actions first.

Table 7-5 is intended as a general indication of cost-effectiveness to help frame the discussion about implementing management actions. Also, some actions were assigned very conservative survival improvement numbers because of the level of uncertainty about underlying ecological processes. This is the case with several actions related to the food web because the connection between food web changes and effects on juveniles is not fully defined. As a result, the cost-effectiveness ratings of these actions appear high.

TABLE 7-5
Management Actions Sorted by Cost/Survival Index

#	Action	Survival (Ocean Types)	Survival (Stream Types)	Total Survival	Cost of Action	Cost/ Survival Index
CRE-16	Redistribute Caspian terns.	2,000	350,000	352,000	$10 million	28
CRE-17	Redistribute cormorants.	2,000	250,000	252,000	$10.5 million	42
CRE-13	Manage pikeminnow and other piscivorous fish.	140,000	122,000	262,000	$13 million	50
CRE-06	Use dredged materials beneficially.	50,000	15,000	65,000	$6 million	92
CRE-08	Remove or modify pilings and pile dikes	150,000	100,000	250,000	$27.25 million	109
CRE-09	Protect/restore high-quality off-channel habitat.	400,000	150,000	550,000	$68 million	124
CRE-04	Adjust the timing, magnitude, and frequency of hydrosystem flows.	225,000	125,000	350,000	$44.5 million	127
CRE-21	Identify and reduce sources of pollutants.	275,000	72,000	347,000	$46 million	133
CRE-20	Implement pesticide/fertilizer BMPs.	50,000	42,000	92,000	$12.5 million	136
CRE-10	Breach, lower, or relocate dikes and levees.	450,000	100,000	550,000	$75 million	136
CRE-22	Restore or mitigate contaminated sites.	300,000	142,000	442,000	$60.5 million	137
CRE-01	Protect/restore riparian areas.	150,000	100,000	250,000	$38 million	152
CRE-02	Operate the hydrosystem to reduce reservoir heating.	90,000	20,000	110,000	$20 million	182
CRE-23	Implement stormwater BMPs.	65,000	30,000	95,000	$19.5 million	205
CRE-11	Reduce over-water structures.	25,000	3,000	28,000	$5.8 million	207
CRE-03	Protect/enhance instream flows influenced by water withdrawals and other water management actions in tributaries.	25,000	20,000	45,000	$10 million	222
CRE-12	Reduce vessel wake stranding.	55,000	2,000	57,000	$13 million	228
CRE-07	Reduce entrainment/habitat effects of dredging and ballast.	8,000	10,000	18,000	$4.5 million	250
CRE-19	Prevent aquatic invertebrate introductions.	8,000	2,000	10,000	$3 million	300
CRE-15	Reduce invasive plants.	20,000	15,000	35,000	$12.5 million	357
CRE-18	Reduce shad abundance.	5,000	5,000	10,000	$5.5 million	550
CRE-05	Mitigate entrapment of fine sediment in reservoirs.	5,000	5,000	10,000	$8 million	800

The following observations can be made from Table 7-5:

- The median of all assigned cost/survival index numbers is 144. (The median is the middle number of a group of numbers, with half the numbers having values greater than the median and half having values less than the median).
- Some of the actions that appeared most cost-prohibitive in Table 7-4, such as establishing or improving access to off-channel habitat (CRE-10), adjusting flows (CRE-04), and restoring or mitigating contaminated sites (CRE-22), emerge as cost-effective when viewed in the context of the survival improvements they could bring about. All three of these actions have a cost/survival index value that is less than the median and that puts them in the top—or more cost-effective—half of Table 7-5.
- Several actions, including redistributing terns (CRE-16), redistributing cormorants (CRE-17), and managing piscivorous fish such as pikeminnow (CRE-13), appear to be very cost-effective.

In this planning exercise, the total survival improvement of actions listed above the median is 3.5 million juveniles (2.0 million ocean type and 1.5 million stream type), or about 17 percent of the total number of juveniles currently thought to be exiting the estuary.

Improving Ecosystem Health

The Columbia River estuary and plume ecosystems are degraded compared to historical conditions. One hypothesis of this recovery plan module is that if the estuary and plume remain in their degraded state, recovery of all 13 ESUs may not be possible. The remainder of this section is intended to help characterize choices that will ultimately govern the health of the estuarine ecosystem in the Columbia River.

Is there really a problem for salmonids in the estuary? Sources such as *Salmon at River's End* (Bottom et al. 2005), and emerging micro-acoustic tagging studies make clear that the mortality rate in the estuary is very high and almost certainly approaches 50 percent for some ESUs. This alone argues for discarding the old paradigm of the estuary as primarily a transportation corridor for salmonids on their journey to the ocean. Stream- and ocean-type salmonids clearly rely on estuary and plume habitats for crucial rearing and refuge opportunities during one of the stages in their life cycles. Chapters 3 and 4 of this estuary recovery module describe the mechanisms by which a degraded estuarine ecosystem puts juvenile salmonids at risk.

Is ecosystem restoration necessary in the estuary, or can we surgically reduce specific threats to improve salmonid survival? Ecosystem health in the estuary and plume is the cumulative result of many stressors that originate within the estuary and also outside of the estuary. The level of constraint observed in each of the management actions identified in this estuary recovery module is high, and it is extremely unlikely that one or more actions could be implemented to the degree that they would essentially eliminate a threat to salmonids. Thus each management action should be implemented to the greatest degree practical, unless it is proven that to do so would seriously undermine public safety, the economy, or property rights.

What suite of actions is most important to implement for ocean-type salmonids? There is no single correct answer to this question. In the long term, ecosystem restoration will provide the most stable, self-supporting conditions for salmonids and other native species. Ocean-type juvenile salmonids rear longer in the estuary than stream types do and therefore would benefit the most from improved ecosystem health.

The analysis and planning exercises in this recovery plan module suggest that the following actions are most important for ocean-type salmonids:

- CRE-01: Protect/restore riparian areas.
- CRE-02: Operate the hydrosystem to reduce reservoir heating.
- CRE-04: Adjust the timing, magnitude, and frequency of hydrosystem flows.
- CRE-08: Remove or modify pilings and pile dikes.
- CRE-09: Protect/restore high-quality off-channel habitat.
- CRE-10: Breach, lower, or relocate dikes and levees.
- CRE-13: Manage pikeminnow and other piscivorous fish.
- CRE-21: Identify and reduce sources of pollutants.
- CRE-22: Restore or mitigate contaminated sites.

Implementing this suite of actions would cost approximately $392.3 million and would be expected to yield survival improvements of roughly 2.2 million wild, ESA-listed ocean-type juveniles, or 88 percent of the survival target for ocean-type salmonids. In other words, for ocean-type juveniles, 88 percent of the gain to be had from the management actions could be achieved by implementing these nine actions.

What suite of actions is most important to implement for stream-type salmonids? Stream-type salmonids prefer deeper waters with higher velocities than ocean-types do. They also reside in the estuary for shorter periods of time, but they tend to use the plume more extensively than do ocean-type salmonids. Stream-type juveniles are thought to actively feed in the estuary; information indicates that stream types travel out of the channel to forage and may encounter predators such as the northern pikeminnow (Casillas 2006). For stream types, it is very important to reduce Caspian tern and double-crested cormorant predation. In addition, predation by pinnipeds on adult spring Chinook and winter steelhead is a significant threat.

The analysis and planning exercises in this recovery plan module suggest that the following actions are most important for stream-type salmonids:

- CRE-01: Protect/restore riparian areas.
- CRE-04: Adjust the timing, magnitude, and frequency of hydrosystem flows.
- CRE-08: Remove or modify pilings and pile dikes.
- CRE-09: Protect/restore high-quality off-channel habitat.
- CRE-10: Breach, lower, or relocate dikes and levees.
- CRE-13: Manage pikeminnow and other piscivorous fish.
- CRE-14: Reduce predation by pinnipeds.
- CRE-16: Redistribute Caspian terns.
- CRE-17: Redistribute cormorants.
- CRE-21: Identify and reduce sources of pollutants.
- CRE-22: Restore or mitigate contaminated sites.

Implementing this suite of actions would cost approximately $407.8 million and would be expected to yield survival improvements of roughly 5,000 stream-type adults (ESA-listed and non-listed adults) and 1.51 million wild, ESA-listed stream-type juveniles, or 90 percent of the survival target for stream-type juveniles. In other words, for stream-type juveniles, 90 percent of the gain to be had from the management actions could be achieved by implementing these 11 actions.

How cost-effective are the top actions for ocean- and stream-type salmonids? Of the top 11 priority actions for stream- and ocean-type salmonids, nine are listed at or above the median cost/survival index.

What would be gained by implementing actions that benefit both ocean- and stream-type salmonids? The lists of priority actions identified above for ocean- and stream-type salmonids contain eight actions that are predicted to benefit both types of salmonids. These actions are as follows:

- CRE-01: Protect/restore riparian areas.
- CRE-04: Adjust the timing, magnitude, and frequency of hydrosystem flows.
- CRE-08: Remove or modify pilings and pile dikes.
- CRE-09: Protect/restore remaining high-quality off-channel habitat.
- CRE-10: Breach, lower, or relocate dikes and levees.
- CRE-13: Manage pikeminnow and other piscivorous fish.
- CRE-21: Identify and reduce sources of pollutants.
- CRE-22: Restore or mitigate contaminated sites.

Implementing this set of actions would cost approximately $372.25 million and would be expected to yield survival improvements of roughly 3 million wild, ESA-listed juvenile salmonids (ocean- and stream-types combined). Although the majority of these would be ocean types, there is an argument to be made for favoring actions that would benefit both salmonid types—namely, that implementing such actions would be likely to provide benefits across the spectrum of life history strategies that juvenile salmonids of both types employ in the estuary. Many of the actions that benefit stream-type salmonids would also benefit ocean types displaying less dominant life history strategies, while many actions benefiting ocean-type salmonids would also benefit stream types displaying less dominant life history strategies. Actions that benefit both ocean and stream types, then, presumably would affect a wide range of less dominant life history strategies and thus would help preserve the diversity that contributes to salmonids' ability to persist in the face of changing environmental conditions.

However, this is not to suggest implementation only of those actions that would benefit both ocean- and stream-type juveniles because there are limitations to this approach. For instance, avian and pinniped predation actions, which would primarily benefit stream types, are cost-effective and critical to improving the survival of stream-type salmonids.

Will management actions have synergistic effects? Many of the management actions could have far-reaching effects if they were implemented together, either because they address multiple interrelated threats, such as flow regulation and impaired sediment transport, or because their effects could amplify the benefits of other, complementary management actions. An example would be the two actions of improving flows and establishing access to off-channel habitat by breaching dikes or levees. Although each action by itself would increase salmonid access to off-channel habitat, implementing both actions has the potential to offer exponentially greater access, as well as contribute macrodetrital inputs to the food web and offer other ecosystem benefits. Although such benefits are difficult to quantify, the potential for synergistic effects of complementary actions is real and should be taken into consideration when management actions are selected.

The U.S. Army Corps of Engineers currently is studying the cumulative effects of various combinations of restoration activities in the estuary; results of the study are expected to provide valuable data on the potential synergistic effects of the management actions presented in the estuary recovery plan module. Meanwhile, several actions have the potential to be complementary in their effects, at the very least, and possibly to offer significant synergistic benefits. While it is not possible to identify all such actions, examples include using dredged materials to reduce vessel wake stranding (CRE-6 and CRE-12) or improving access to off-channel habitats by breaching dikes and adjusting flows (CRE-10 and CRE-4). At the same time, management actions need to be sequenced to avoid possible negative synergistic effects, such as by restoring contaminated sites (CRE-22) in off-channel habitat before restoring access to that habitat through dike breaching and flow modifications (CRE-10 and CRE-4). Considering the possible complementary, cumulative, or synergistic effects of management actions and sequencing actions for maximum benefit will be important aspects of implementing the estuary recovery plan module.

What about the lower ranking actions? In many ways, the lower ranking actions are the most difficult to characterize in terms of survival improvements and costs. Low ratings may be due more to a lack of scientific information than a lack of effectiveness. For example, basic changes to the food web in the estuary as a result of increased phytoplankton production or the introduction of aquatic invertebrates may have profound effects on the estuary, but the degree of impact is unknown. These threats must be more fully understood if their contribution to overall ecosystem health is to be determined with accuracy.

What planning tasks remain? The process of developing this estuary recovery plan module pointed to several areas where recovery planning for the estuary could be refined. Additional scientific information about juvenile mortality in the estuary would clarify the ecological significance of the estuary relative to tributaries and the middle and upper mainstem Columbia River. A finer scale analysis of limiting factors, threats, and the benefits of management actions would aid in prioritizing actions and focusing them in the geographical areas where they would be most beneficial. Testing the assumptions underlying the allocation of benefits across management actions would increase the value of survival improvement targets as a planning tool, as would further evaluation of the constraints to implementation of the management actions. Lastly, understanding the potential cumulative or synergistic effects of management actions could lead to implementation decisions that would enhance the benefits of actions. Obtaining more information about these topics—mortality in the estuary, biological effects at a finer level, potential benefits of management actions, and synergistic effects—could represent the next level of planning for salmon recovery in the estuary.

Implementation Issues

Implementation of the 23 actions in the module will require the efforts of a variety of Federal, state, and local agencies, organizations, private enterprises, and citizens. (Some potential implementers have been identified in Table 5-6.) While many of these entities have already been working to identify, prioritize, and implement salmon and steelhead recovery actions, effective implementation of all module actions will require additional coordination.

Goals of coordination include using existing processes, programs, and forums efficiently; ensuring the appropriate scale, scope, and sequencing of projects; coordinating funding; tracking and reporting on implementation progress; coordinating monitoring efforts; and providing data management. In addition, implementing the module will require further evaluation of the constraints associated with the 23 actions as well as consideration of potential cumulative and synergistic effects. Also, implementers of module actions will need to remain abreast of current scientific information and ensure that it is continually incorporated into implementation decisions. Although some elements of these larger processes are in place, additional organizational capacity is necessary if these needs are to be adequately addressed.

Table 5-6 includes a rudimentary schedule for implementing each of the 23 management actions described in Chapter 5, but this schedule will need to be refined as the considerations mentioned above are addressed. The first step in coordinated implementation of the module will be a conversation among all relevant entities and stakeholders to discuss near-term implementation priorities, with a goal of developing a 5-year implementation plan that provides specificity and certainty regarding near-term actions and that identifies lead entities for implementation of specific actions or projects. Given the complexities involved in implementing the full suite of module actions, this conversation also will be an opportunity to explore options for and recommend an organizational structure for coordinating and overseeing implementation of the module. The Lower Columbia River Estuary Partnership, a National Estuary Program established to bring about collaboration, would be an appropriate convener of this discussion.

Education and outreach are important aspects of module implementation. Threats to salmonids in the estuary are likely to continue unabated unless resource users in the Columbia River basin make different choices about consumption and development—choices that may be socially and politically challenging. In the face of social and political obstacles, education is one way of garnering support for implementation of the management actions; in fact, education about stewardship and the ecosystem benefits that implementation would provide is an essential component of the management actions in the module; to the extent possible, these education efforts should be coordinated to create efficiencies.

Relationship of the FCRPS BiOp to the Estuary Module

Drafts of this module were available during the Federal Columbia River Power System (FCRPS) Biological Opinion (BiOp) remand collaborative process, which led to the 2008-2018 FCRPS Biological Opinion and Supplemental Comprehensive Analysis (National Marine Fisheries Service 2008a and 2008b). Among the provisions of the 2008 FCRPS Biological Opinion (2008 BiOp) were requirements for the Federal action agencies to implement habitat improvement and predation control actions in the estuary. Estimates of the survival benefits that would be gained from those actions were included in the 2008 BiOp, and those survival estimates were derived from the allocation of survival improvements among actions in this module.

In February 2010, NMFS issued the 2010 Supplemental BiOp for the FCRPS (National Marine Fisheries Service 2010), which integrated elements from the 2008 BiOp and Adaptive Management Implementation Plan (AMIP). The AMIP included accelerated and enhanced actions to protect Columbia Basin salmon and steelhead, including (1) commitments to additional estuary actions under an agreement with the state of Washington, and (2) efforts to control native predators and invasive species. The AMIP also included enhanced research and monitoring and incorporated specific biological triggers for contingencies linked to unexpected declines in the abundance of listed fish.

The 2010 Supplemental BiOp retained the estimates of survival improvements from estuary habitat and predation control actions that had been incorporated into the 2008 BiOp and that were based on a draft version of this estuary module. The 2010 Supplemental BiOp also summarized and assessed relevant new information that had become available since the 2008 BiOp was issued, including information on climate change, juvenile salmonid use of the estuary and plume, predation, toxics, and ecological interactions between hatchery- and natural-origin fish. The new information summarized in the 2010 BiOp will be useful in informing implementation decisions regarding actions in the module.

Actions in the 2008 BiOp and its 2010 Supplement that relate to estuarine habitat, predation, and flow will contribute to implementation of actions in this module. The module, however, identifies habitat, predation, and flow actions that are larger in scope than the actions that will be implemented under the 2008 BiOp and its 2010 Supplement. NMFS projects that the 2008 BiOp actions related to estuarine habitat, flow, and predation will yield only a portion of the total survival improvements that the estuary module hypothesizes are possible for actions in those categories. The intent of the estuary module was to lay out the full suite of limiting factors and threats affecting the estuary; to identify actions or assessments needed to address—or inform the potential to address—those limiting factors and threats; and to provide a basis for future discussions and societal decisions about recovery efforts in the Columbia River estuary.

Preparation for Decision Making

Chapter 7 is intended to help organize a much-needed conversation about recovery efforts in the estuary, plume, and other ecosystems that salmonids depend on to complete their life cycles. While there are many decisions to be made, perhaps the most important is what our level of effort and commitment will be to improving conditions in the estuary. This boils down to deciding how much we are willing to do to recover salmon and steelhead in the Columbia River basin and how comfortable we are with the sacrifices that will be necessary.

The planning exercises in Chapters 5 and 7 were based on the best available science pertaining to limiting factors and threats. However, although science can help inform the key analyses in these chapters (the identification of management actions, constraints evaluation, survival improvement targets, and cost estimates), it cannot tell us which management actions to implement. This is so partly because of the gaps in our understanding of the physical and biological world of the estuary but also because other decision-making processes come into play when we make choices about the future and what we most value. Ultimately, the degree to which the estuary module is implemented will be determined by the social and political will of the region, and what current and future residents of the basin are willing to pay for—or do without—in order to return salmon and steelhead to viable levels.

Perhaps the single most important conclusion that can be made about the prioritization of management actions is that threats remain threats to salmonids because tough choices have yet to be made—choices that are difficult because of the myriad conflicting goals of the various public, private, individual, and organizational interests within the Columbia River basin. The variety and extent of those interests are reflected in the high degree of constraint for each of the 23 management actions identified in the recovery plan module. The take-home message from this is that the estuary and plume are crucial to ocean- and stream-type salmonids and that achieving a meaningful boost in survival from these ecosystems will require a major investment and implementation of all 23 management actions, to the extent possible.

CHAPTER 8

References

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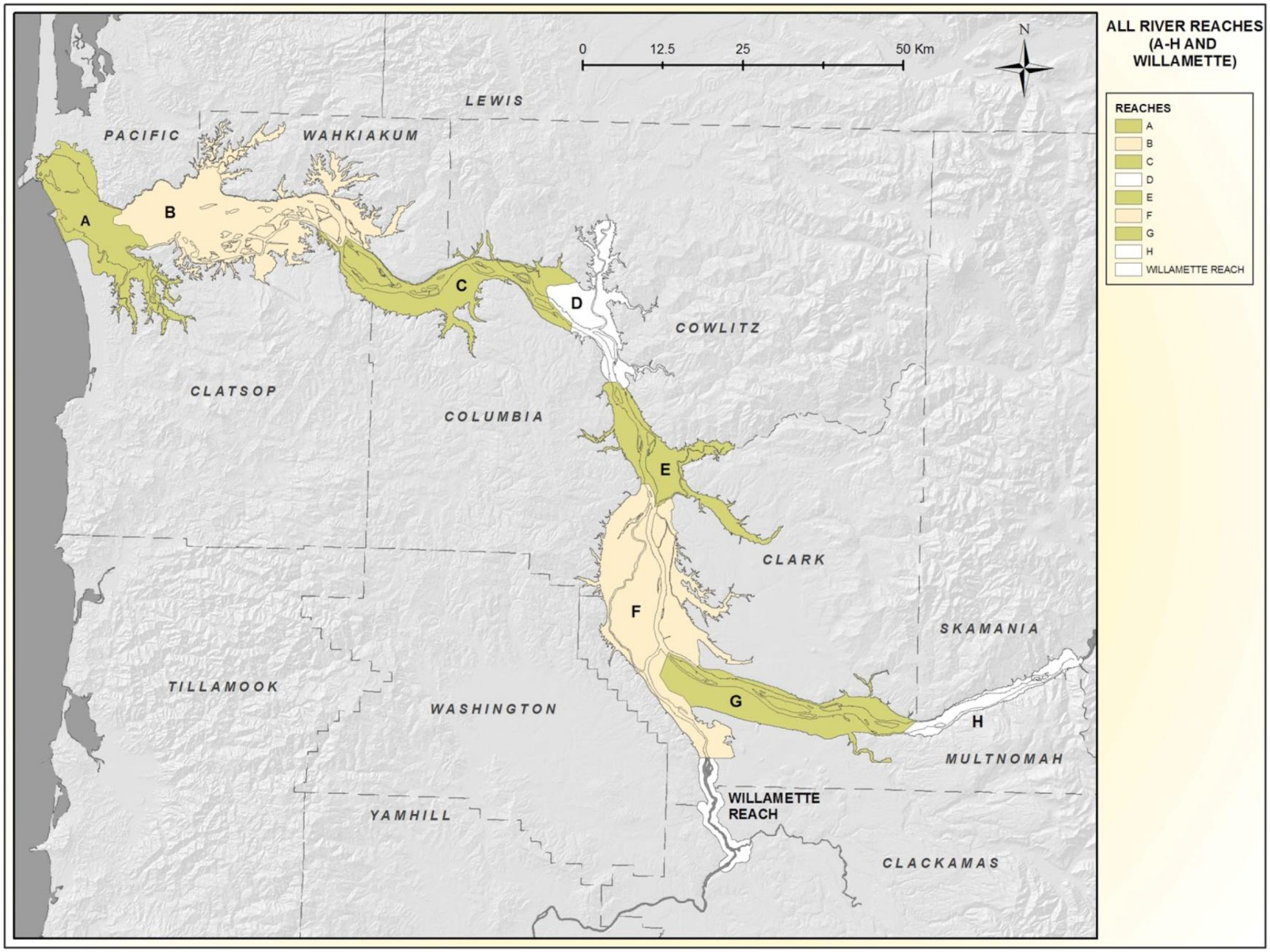
APPENDIX A

Selected Threats to Salmonids by Reach

APPENDIX A


ALL RIVER REACHES (A-H AND WILLAMETTE)
REACHES
A
B
C
D
E
F
G
H
WILLAMETTE REACH
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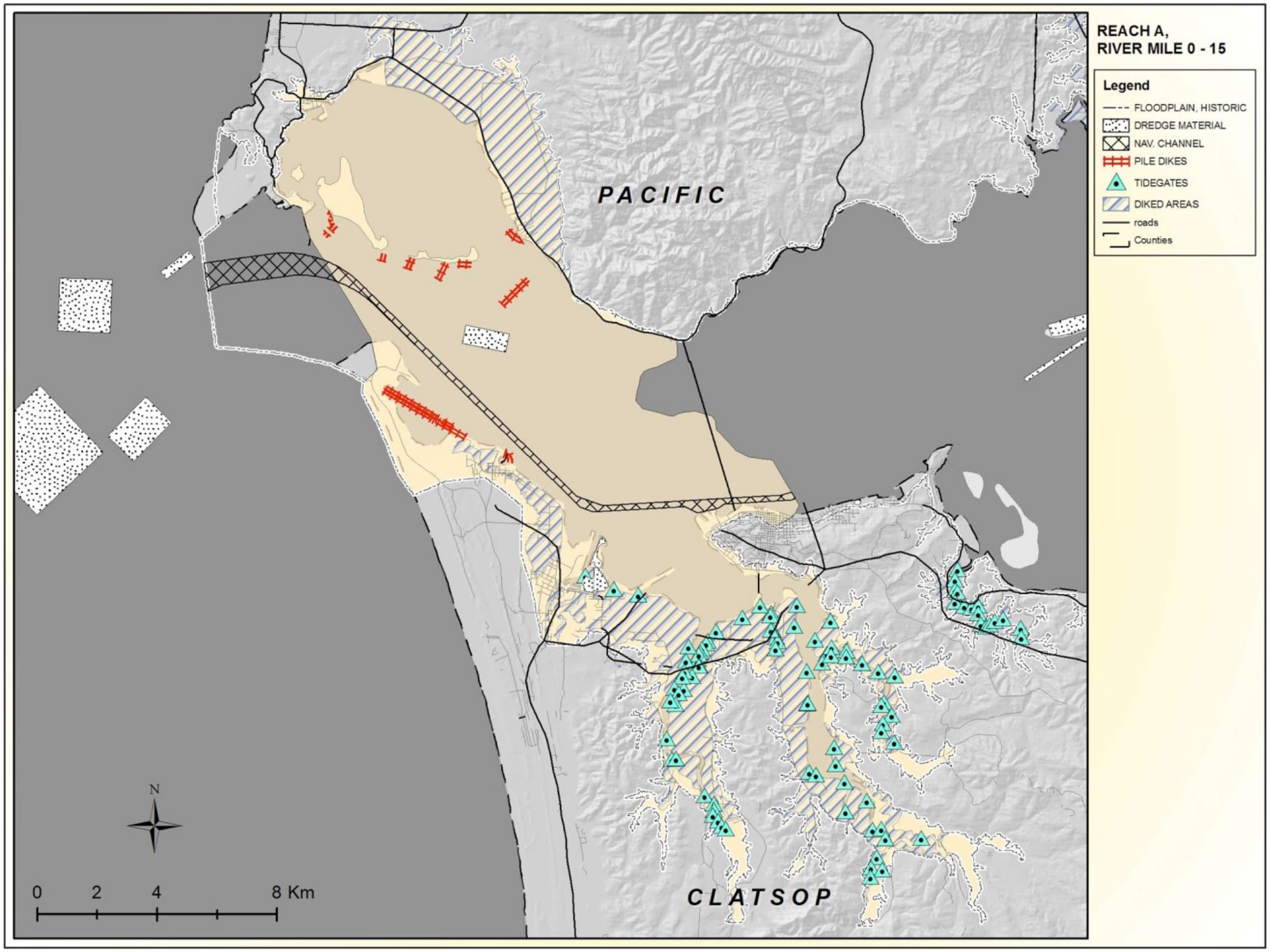
12.5
25
50 Km
N
LEWIS
PACIFIC
WAHKIAKUM
COWLITZ
CLATSOP
COLUMBIA
CLARK
SKAMANIA
TILLAMOOK
WASHINGTON
MULTNOMAH
YAMHILL
CLACKAMAS
WILLAMETTE REACH


REACH A,
RIVER MILE 0 - 15
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
PACIFIC
CLATSOP
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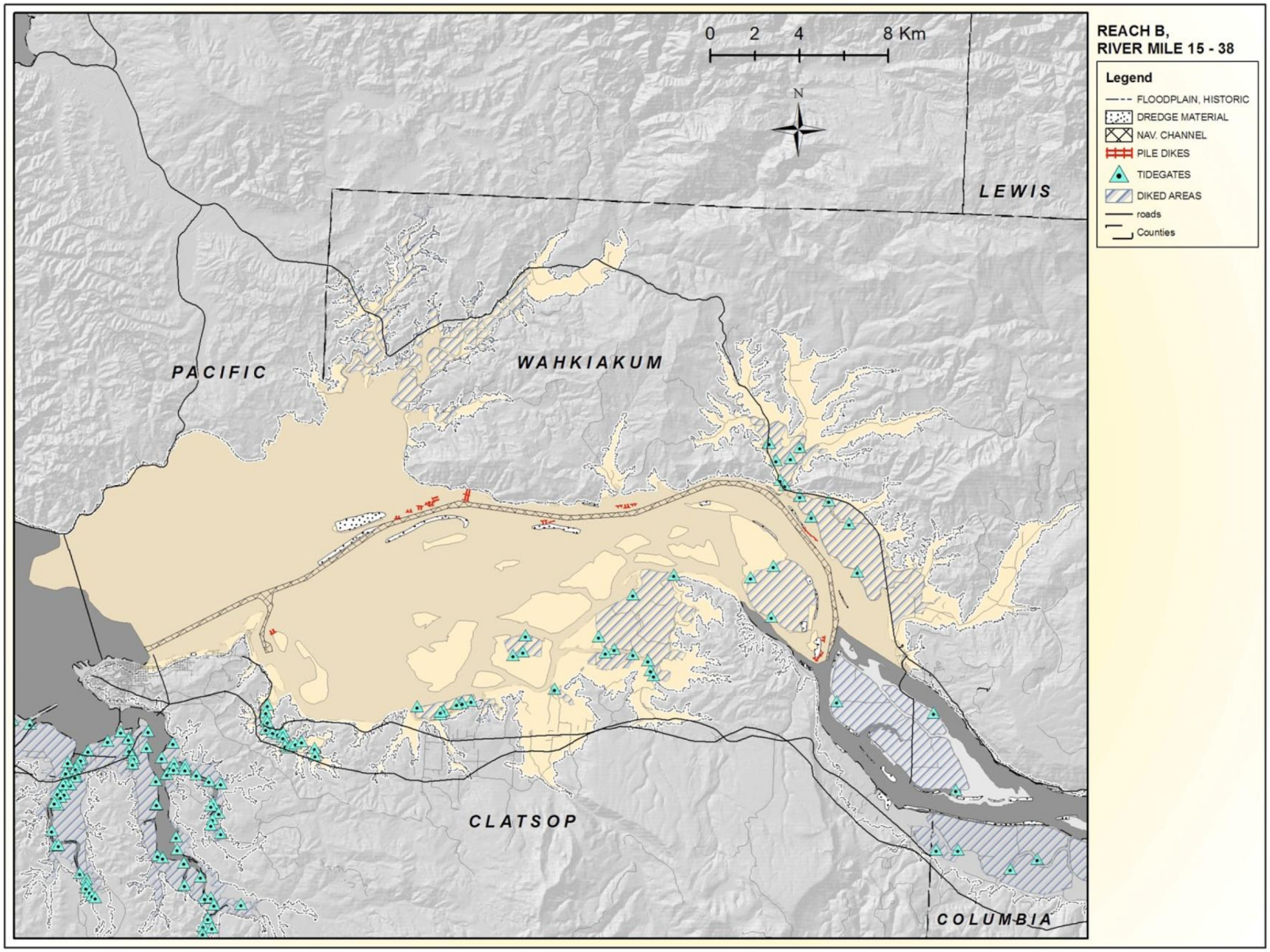
8 Km



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DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
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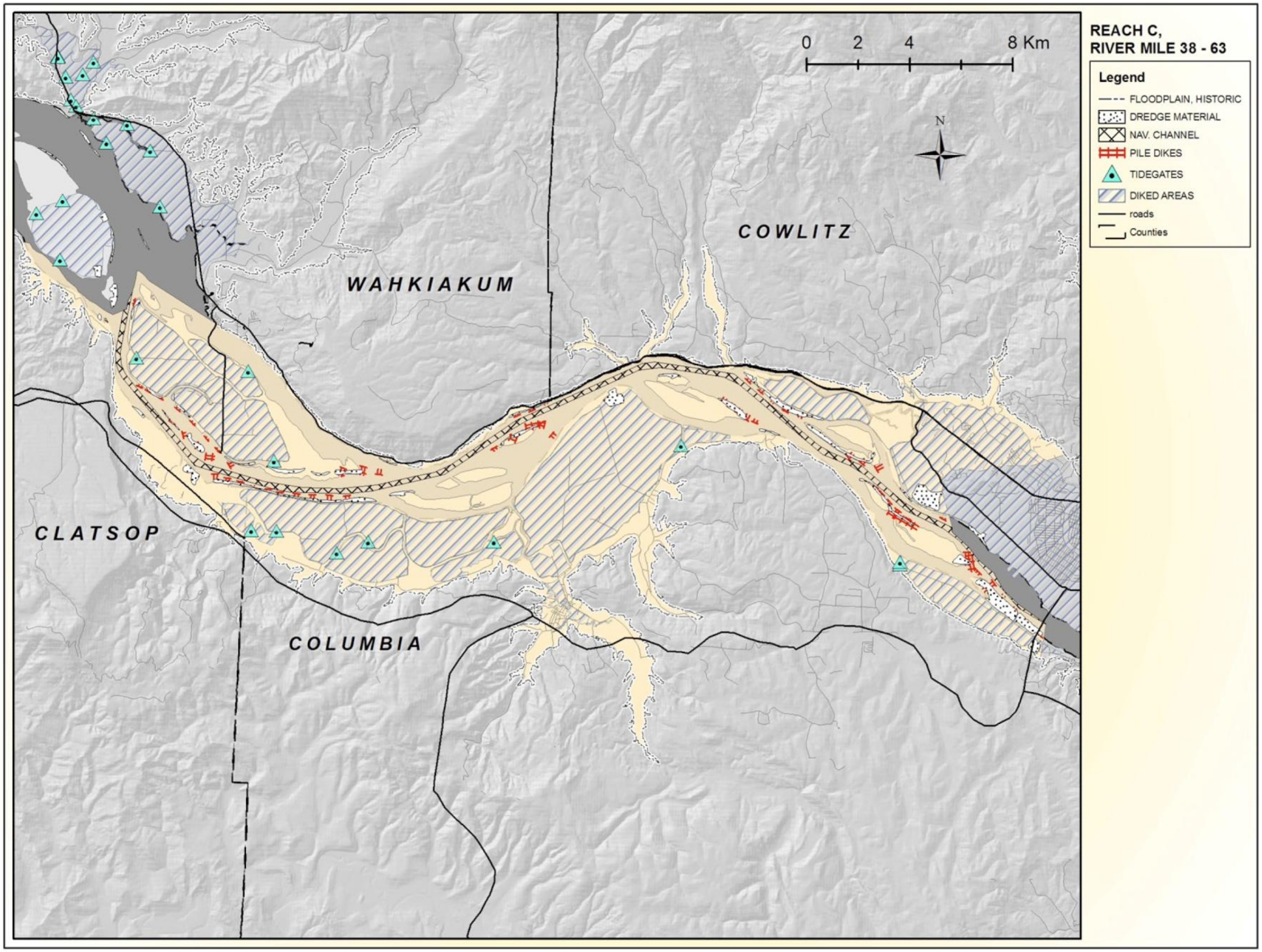
LEWIS
PACIFIC
WAHKIAKUM
CLATSOP
COLUMBIA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DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
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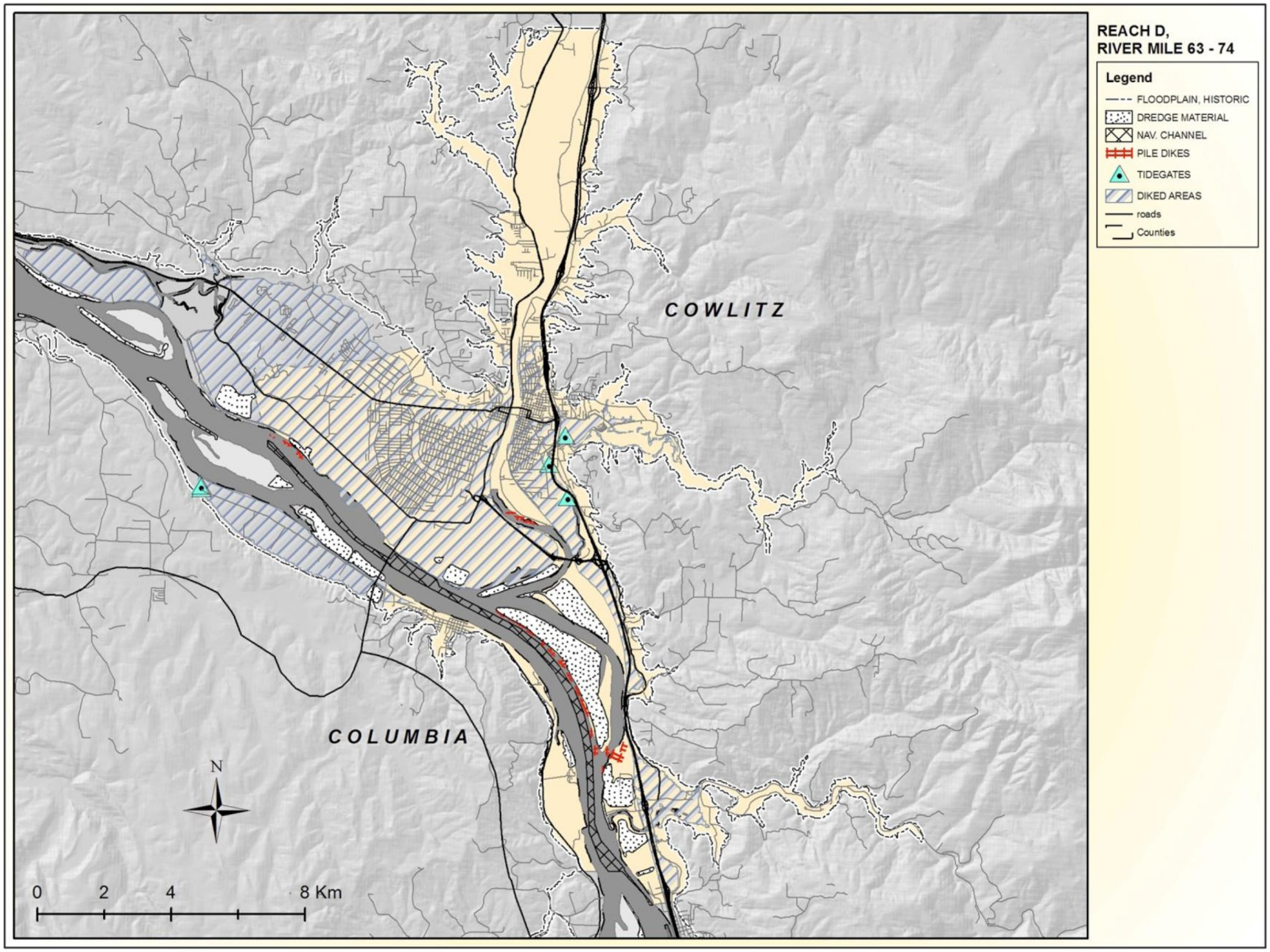
WAHKIAKUM
COWLITZ
CLATSOP
COLUMBIA

APPENDIX A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NAV. CHANNEL
PILE DIKES
TIDEGATES
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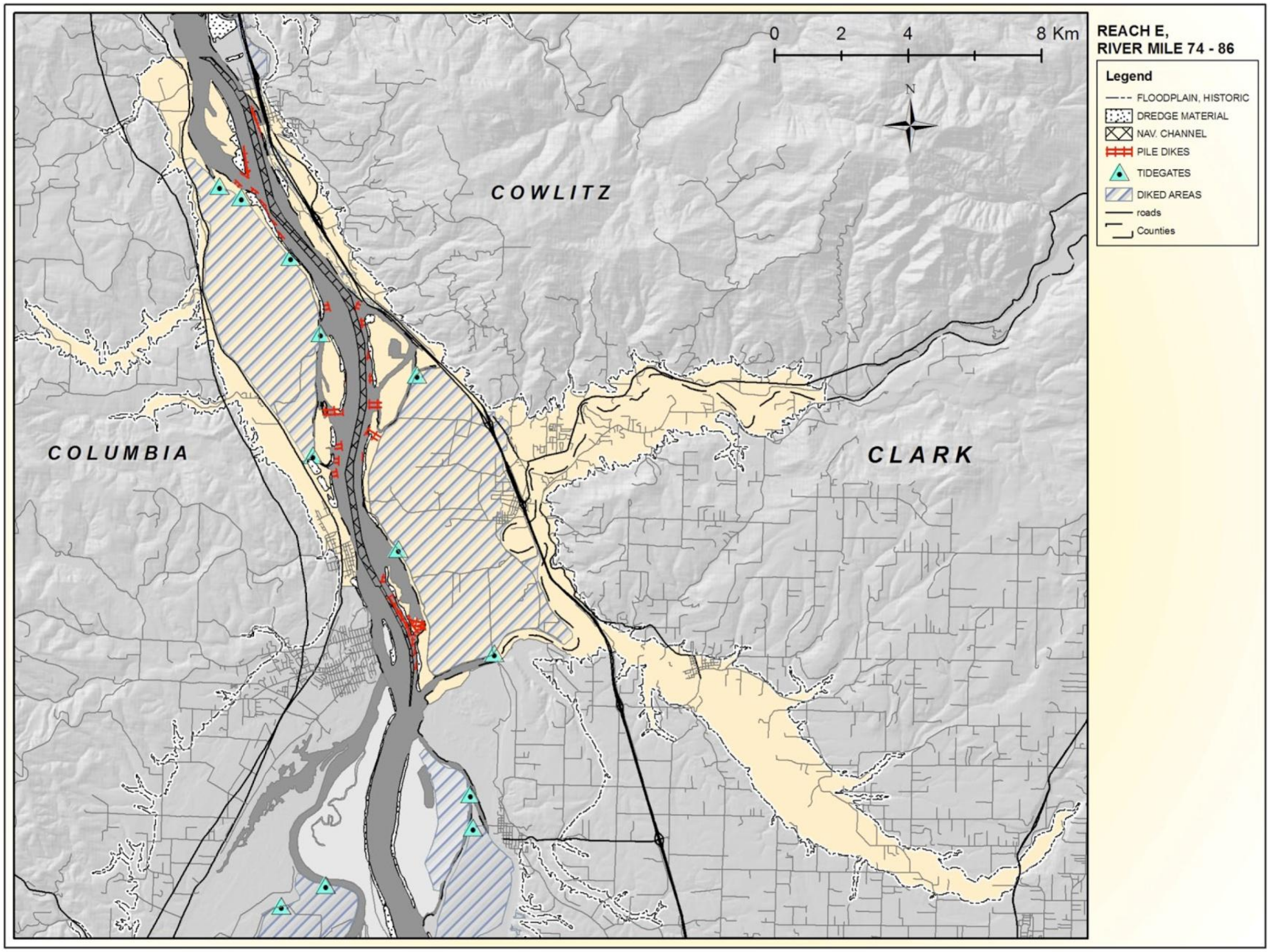
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NAV. CHANNEL
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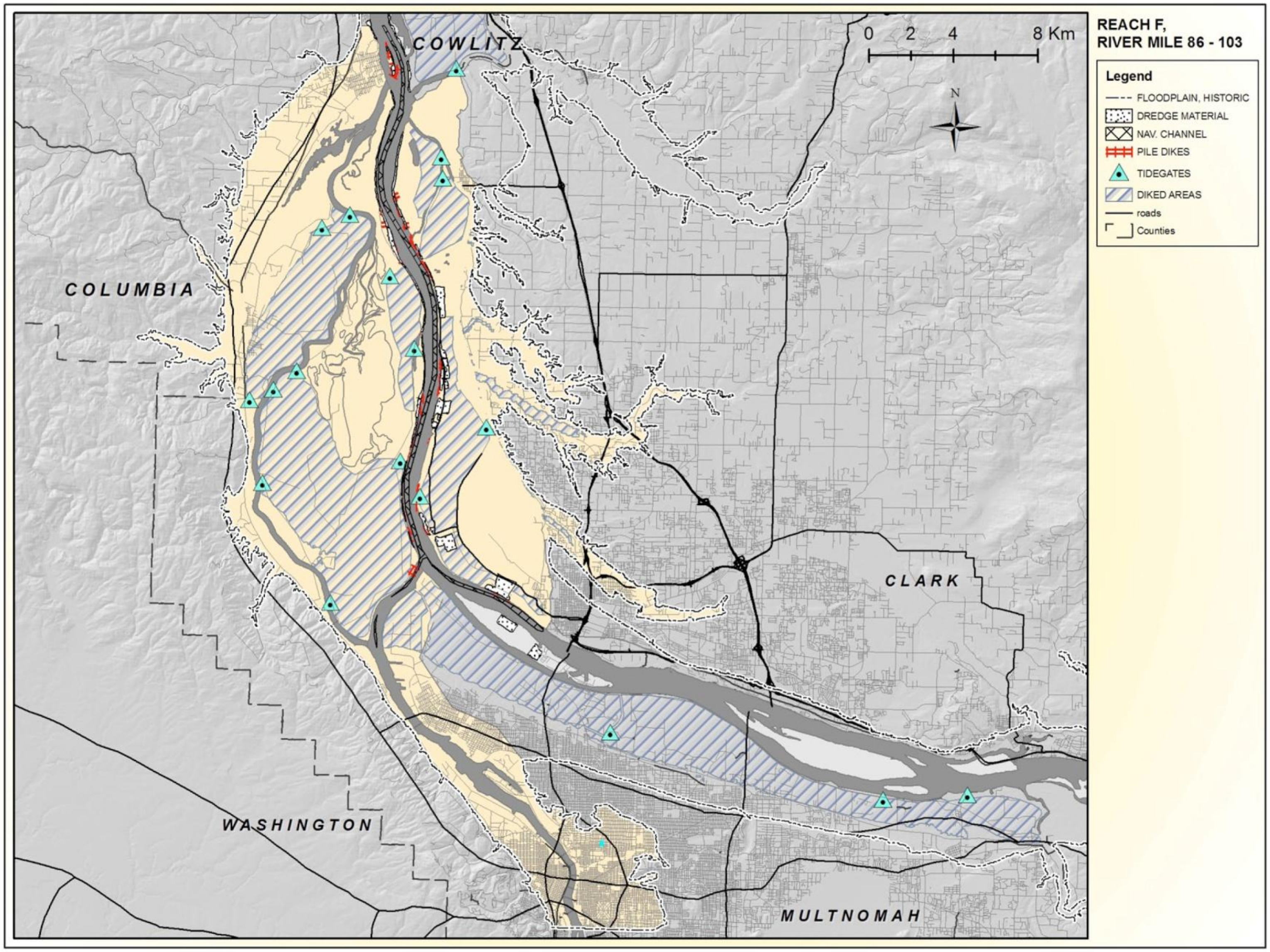
COWLITZ
COLUMBIA
CLARK



REACH F,
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DREDGE MATERIAL
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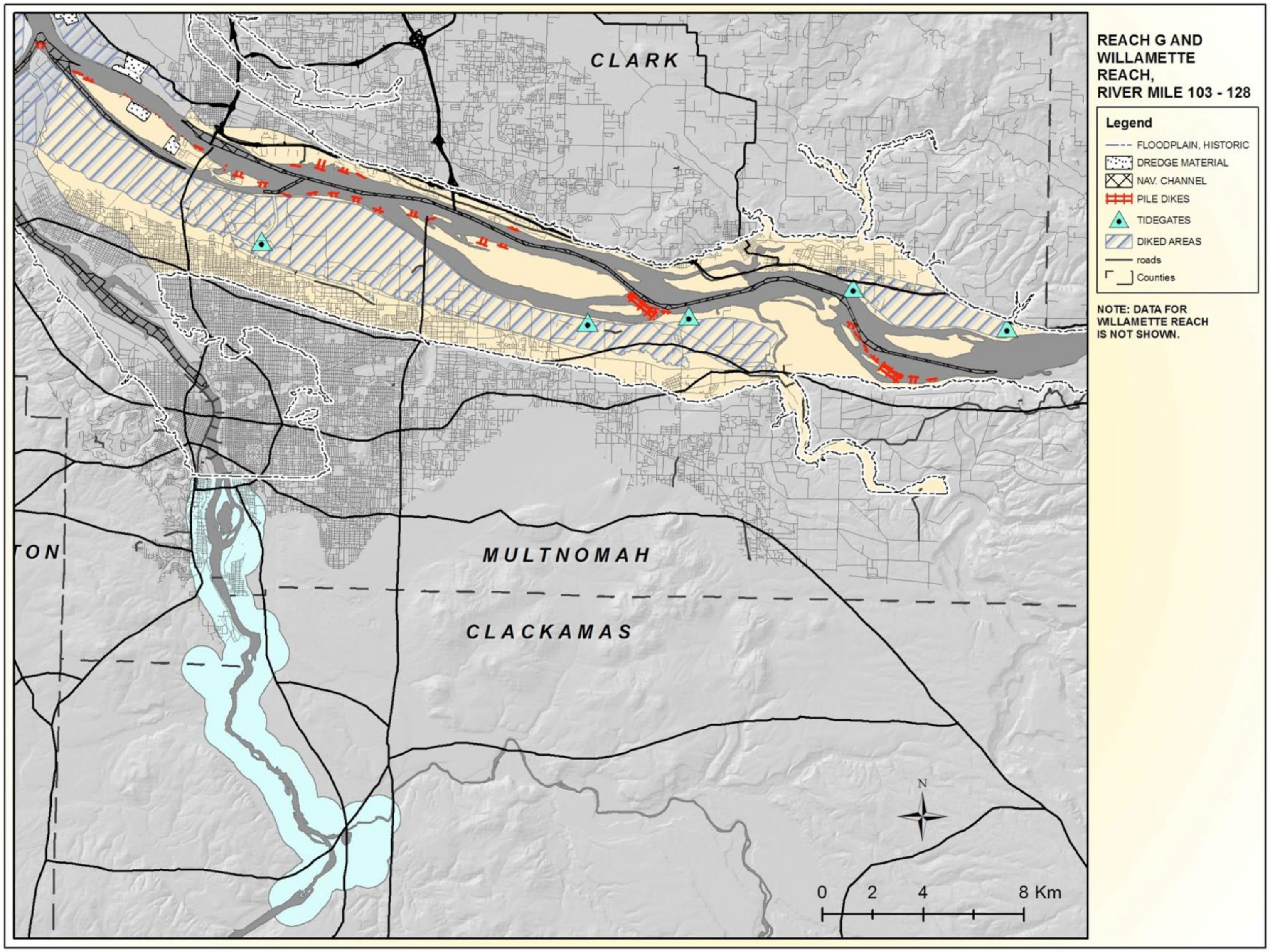
COLUMBIA
CLARK
WASHINGTON
MULTNOMAH


REACH G AND WILLAMETTE REACH, RIVER MILE 103 - 128
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FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
NOTE: DATA FOR WILLAMETTE REACH IS NOT SHOWN.
CLARK
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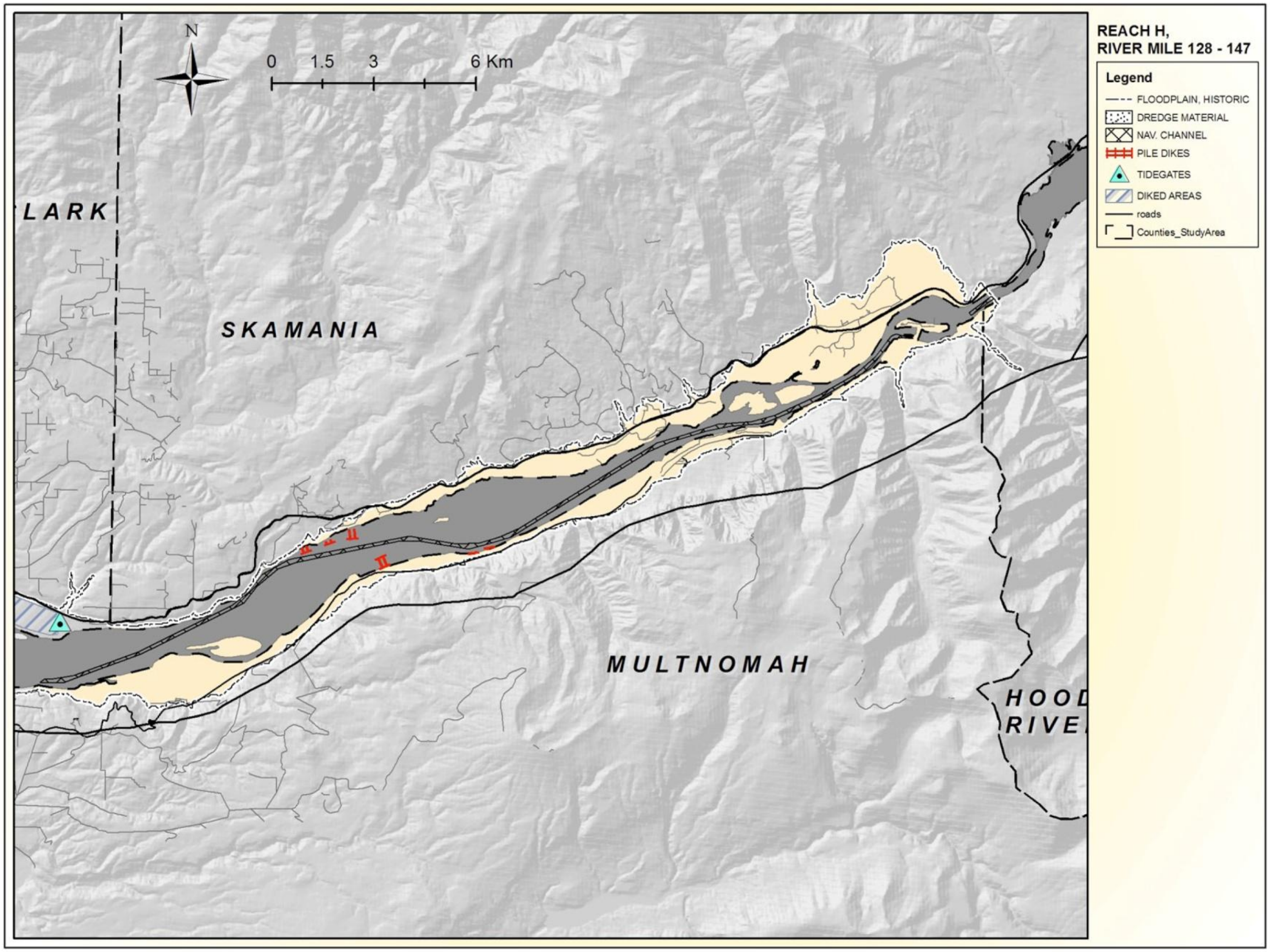
APPENDIX A



REACH H,
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DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties_StudyArea
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0 1.5 3 6 Km
LARK
SKAMANIA
MULTNOMAH
HOOD
RIVE

APPENDIX B

Development of Survival Improvement Targets

APPENDIX B

Development of Survival Improvement Targets

The survival improvement targets in Table 5-5 are a planning tool intended to help initiate a comprehensive discussion about salmonid mortality in the estuary and plume. This tool is an important first step in setting recovery targets for salmonids in the estuary and also for the Columbia River basin. PC Trask & Associates, Inc., developed the survival improvement targets because, in many cases, estimates of mortality resulting from individual limiting factors and of the effectiveness of management actions in reducing threats and limiting factors do not exist. On the other hand, there are reliable estimates of mortality resulting from several of the predators, ship wake stranding, and toxic contamination, and emerging acoustic wire tagging studies are helping to estimate the extent of mortality that juvenile salmonids experience during residency in the estuary.

PC Trask & Associates, Inc., took the following steps to develop the survival improvement targets:

1. Determined the abundance of wild, ESA-listed ocean- and stream-type juveniles entering the estuary using Ferguson (2006b), which estimated 25 million ocean-type juveniles and 14.3 million stream-type juveniles for 2006.
2. Assumed a 50 percent overall juvenile mortality rate for ocean-type salmonids in the estuary and a 40 percent mortality rate for stream-type juveniles. PC Trask & Associates, Inc., reached the 50 percent mortality estimate for ocean type juveniles by taking the 35 percent rate from 2005 micro-acoustic tagging results (Ferguson 2006b) and adding an additional 15 percent to account for smaller ocean-type juveniles not tracked by the study. PC Trask & Associates, Inc., reached the 40 percent mortality estimate for stream-type juveniles by taking the 25 percent rate from the same micro-acoustic tagging study and adding 15 percent to account for presumed deaths occurring in the plume. Continued annual study results will help refine these estimates over time.
3. Used a survival improvement target of 20 percent for both ocean- and stream-type juveniles. The 20 percent number is not scientifically based; instead, it represents a planning target that will require refinement as the extent to which actions are implemented and effective becomes clearer. Survival improvement numbers attempt to reflect wild, ESA-listed fish only. In most cases, known mortality to salmonids (such as from terns) does not break out wild fish from hatchery fish or ESA-listed fish from non-listed fish.
4. Allocated the two targets described above across 22 actions (CRE-14, “Reduce predation by pinnipeds,” was treated separately for adult mortality), based on an extensive literature review and personal communication with various agency staff. PC Trask & Associates, Inc., evaluated each action using limiting factor information from Chapter 3, threat information from Chapter 4, and action evaluations from Chapter 5. As a result, the allocation takes into consideration a combination of factors, including the magnitude of the limiting factor, the degree of the associated threat(s), how well the action

addresses the threat, how constrained implementation of the action is likely to be, and the assumption that a considerable level of effort will be applied to implementing each action.

5. Assigned survival improvement targets on a relative scale across all of the actions. The reader should not view the survival improvement targets as an absolute numerical result for each action, but rather a relative indication of the importance of each action. In cases where the scientific community has determined the mortality associated with a particular limiting factor and developed a management plan with mortality reduction goals, such as with predation by Caspian terns, PC Trask & Associates, Inc., used these numbers to the degree possible.

Survival improvement targets are intended to be correlated with cost estimates presented in Table 5-6 for constrained implementation of the management actions. The resulting cost/survival estimates (see Table 7-5) are intended to initiate discussions about the validity of cost estimates and potential survival improvement targets; the cost/survival index values in Table 7-5 are highly uncertain because of the gross assumptions on both sides of the equation.

Disclaimer: Survival improvement numbers are for illustration only and are intended to demonstrate social choices in the face of significant uncertainty.
Literature sources generally do not prescribe actions, and relatively few actions have been specifically evaluated for associated survival estimates.

Table B-1
Notes on Development of Survival Improvement Targets

Action	Notes
CRE-1: Protect/restore riparian areas.	Estimate is unsupported in the literature. Estimate was assigned a high value in recognition of its importance relative to food sources and shoreline habitats. This is a protection action that is intended to reduce the potential for increased threat over time.
CRE-2: Operate the hydrosystem to reduce reservoir heating.	Estimate is unsupported in the literature. Estimate was assigned a relatively high value because temperatures commonly exceed 19 degrees Celsius and are doing so more frequently and for longer periods of time. (Nineteen degrees Celsius is considered the upper range of survival for salmonids). Estimate is based on a relatively large level of effort to reduce the threat. It is likely that mitigation will be required in tributaries to implement the action.
CRE-3: Protect/enhance instream flows influenced by withdrawals and other water management actions in tributaries.	Estimate is unsupported in the literature. This is a protection action that is intended to reduce the potential for increased threat. Estimate is closely aligned with CRE-4 and probably has overlapping benefits.

CRE-4: Adjust the timing, magnitude, and frequency of hydrosystem flows.	Estimate is unsupported in the literature. The action affects nearly every facet of estuary ecosystem health. Estimate is intended to demonstrate that changes to the hydrograph are possible and that small increments of change may produce a significant survival improvement. This action is worthy of further analysis that may help support a more defensible survival estimate.
CRE-5: Mitigate entrapment of fine sediment in reservoirs.	Estimate is unsupported in the literature. Estimate was assigned a low survival improvement because of the high degree of uncertainty about its potential to improve salmonid survival. Entrapment of sediment may have significantly larger effects.
CRE-6: Use dredged materials beneficially.	Estimate is unsupported in the literature. Estimate was assigned a low survival improvement because of the high degree of uncertainty about its potential to improve salmonid survival. Currently, beneficial uses are most often associated with nearshore erosion management, and little is known about potential benefits to salmonids in the nearshore.
CRE-7: Reduce entrainment/ habitat effects of dredging and ballast.	Estimate is unsupported in the literature. Estimate is relatively low because of the uncertainty and lack of mortality documentation associated with entrainment.
CRE-8: Remove or modify pilings and pile dikes	Estimate is unsupported in the literature. Estimate is relatively high because of the number of pile dikes in the estuary and the suspected predation effects that result from the threat, including predation by cormorants, pikeminnow, bass, walleye, and catfish. Altered flow circulation and reduced juvenile access to low-velocity habitats may also be a threat.
CRE-9: Protect/restore high-quality off-channel habitat.	Estimate is unsupported in the literature. This is a protection action that is intended to reduce the potential for increased threat. The high estimate reflects the magnitude of importance that off-channel habitats represent to juveniles, especially ocean types. Because restoration activities are highly constrained, it is vital not to lose additional functioning habitats. Protection alone will only help preserve the status quo.
CRE-10: Breach, lower, or relocate dikes and levees.	Estimate is unsupported in the literature. Estimate is intended to demonstrate that dike or levee breaching is one of the top few actions that will increase ocean-type survival in the estuary. If substantial improvements for ocean-type life histories in the estuary are to occur, this is one of a handful of actions that must be implemented. Estimate assumes a significantly higher level of implementation than what is currently occurring.
CRE-11: Reduce over-water structures.	Estimate is unsupported in the literature. Estimate is relatively high because of the number of over-water structures in the estuary and the suspected predation effects that result from the threat, including predation by cormorants, pikeminnow, bass, walleye, and catfish. Other effects, such as decreased light penetration, are not well understood.

CRE-12: Reduce vessel wake stranding.	Mortality estimates for test sites have demonstrated a wide range of confirmed mortality. In Bauersfeld (1977), an assessment of five test sites estimated approximately 150,000 stranded juveniles (on those sites). No estuary-wide estimates have been developed. The emerging availability of LIDAR imagery for the estuary may provide for analysis to extrapolate confirmed site-specific information to estuary-wide predictions. Estimate is relatively high within the range of study estimates.
CRE-13: Manage pikeminnow and other piscivorous fish.	Estimate is unsupported in the literature. Some information exists about predation rates. The threat does not currently appear to be on the increase. Estimate is relatively high based upon conjecture by the NMFS Northwest Fisheries Science Center regarding pikeminnow predation rates, but the threat should be studied further and monitored over time.
CRE-14: Reduce predation by pinnipeds.	An estuary-wide mortality estimate is unsupported in the literature. Estimates are for adults only. Annual counts at Bonneville Dam indicate between 0.4 percent and 3.4 percent mortality of spring Chinook and winter steelhead. A 500-pound Stellar sea lion consumes about 40 to 60 pounds of fish each day. An unsubstantiated estimate of all pinniped predation in the estuary of approximately 10 percent of spring Chinook and winter steelhead is probably reasonable.
CRE-15: Reduce invasive plants.	Estimate is unsupported in the literature. Noxious weeds alter food webs and habitat and work at the ecosystem scale. Very little is understood about the connection between noxious weeds and juvenile salmonid survival. Estimate is relatively high for noxious weeds compared to other ecosystem-scale threats because, although associated actions are difficult, they have a greater likelihood of success than do actions to address other similar threats, such as invertebrate infestations.
CRE-16: Redistribute Caspian terns.	Estimate is supported by the literature. Recent successes in relocating terns have been documented. Efforts to implement the action are under consideration. Estimated mortality attributed to Caspian tern predation is approximately 3.6 million juveniles in 2005. Current planning calls for a two-thirds reduction in the East Sand Island nesting.

CRE-17: Redistribute cormorants.	Estimate is supported by the literature. Efforts to manage cormorants are not nearly as mature as efforts to manage terns. There is less certainty about implementation potential because cormorants have not responded to management efforts to the degree that terns have. Estimated mortality attributable to predation by double-crested cormorants is considered to be comparable to that of predation by terns. Assignment of the target survival improvement was lower than for terns because cormorants may be harder to manage than terns.
CRE-18: Reduce shad abundance.	Estimate is unsupported in literature. Estimate is low because of the high degree of uncertainty about the relationship between shad, salmonids, and ecosystem health. Estimate is also low because the literature does not identify potential actions to reduce shad abundance levels.
CRE-19: Prevent aquatic invertebrate introductions.	Estimate is unsupported in the literature. Extent of the threat is well-documented; however, invertebrate infestations occur at the ecosystem scale, and the degree of mortality that occurs because of food web changes at this scale is unknown. Estimate is relatively low because of the uncertainty of the threat and the inherent challenges of reducing the threat.
CRE-20: Implement pesticide/fertilizer BMPs.	Emerging literature (Loge et al. 2005) hypothesizes that mortality resulting from estuary contamination ranges from 1.5 percent to 9 percent, depending on the amount of time juveniles spend in the estuary. Estimates for CRE-21, CRE-22, and CRE-23 form the basis for survival improvements (using estimates from Loge et al. 2005).
CRE-21: Identify and reduce sources of pollutants.	Emerging literature (Loge et al. 2005) hypothesizes that mortality resulting from estuary contamination ranges from 1.5 percent to 9 percent. Estimates for CRE-20, CRE-22, and CRE-23 form the basis for survival improvements (using estimates from Loge et al. 2005).
CRE-22: Restore or mitigate contaminated sites.	Emerging literature (Loge et al. 2005) hypothesizes that mortality resulting from estuary contamination ranges from 1.5 percent to 9 percent. Estimates for actions CRE-20, CRE-21, and CRE-23 form the basis for survival improvements (using estimates from Loge et al. 2005).
CRE-23: Implement stormwater BMPs.	Estimate is unsupported in the literature. This is a protection action that is intended to reduce the potential for increased threat. This action does not assume retrofitting of existing stormwater function.

Recovery Plan Module
Mainstem Columbia River Hydropower Projects

1.0 Purpose

This module summarizes the general effects of Columbia River mainstem hydropower projects on all 13 Endangered Species Act (ESA)-listed anadromous salmonids in the Columbia basin, including the limiting factors and threats and expected actions (including site-specific management actions), or strategy options, to address those threats. The area to be addressed by the module includes the accessible mainstem habitat in the upper Columbia (i.e., to the tailrace of Chief Joseph Dam) and Snake (i.e., to the tailrace of Hells Canyon Dam) rivers, respectively, downstream to the tailrace of Bonneville Dam.[1] This module supports plans for the Snake River, Upper Columbia, Middle Columbia, Lower Columbia, and Upper Willamette River species, replacing the previous version provided as guidance to regional recovery planners, dated September 25, 2006. The material that follows is a synthesis of information that has undergone public processes for review, including, but not limited to, the Federal Columbia River Power System (FCRPS) 2008 Biological Opinion, Federal Energy Regulatory Commission (FERC) licensing proceedings, and Habitat Conservation Plans (HCPs). This module may, however, be updated as additional information becomes available.

1.1 How Salmon and Steelhead Use the Mainstem

All 13 ESA-listed species of salmon *(Oncorhynchus spp.)* and steelhead *(O. mykiss)* in the Columbia basin use the mainstem Columbia River (and Snake River for Snake River species) for migration to and from freshwater natal areas to the Pacific Ocean, where they grow from juveniles to mature adults. Most of the ESA-listed species spawn and incubate in tributaries, but Snake River (SR) fall Chinook, some populations of Lower Columbia River (LCR) fall Chinook, and Columbia River (CR) chum salmon spawn and incubate redds in the mainstem itself. Historically, the peak period for migration to the ocean has been spring and early summer, corresponding with snowmelt in the upper basin and high seasonal flows. However, individual juveniles from one species/population or another can be found in the system throughout the year.

Downstream travel has been shown to be active rather than passive; in addition to water velocity, the rate of travel is affected by date, temperature, the location where the fish begin their migration, fish size, and the extent of the parr-smolt transformation. Survival through the migration corridor declines with distance traveled, whether due to natural hazards (including predation), mortality due to passage at hydroelectric projects, or other factors associated with

[1] A separate module (the Mainstem Columbia River Estuary Recovery Plan Module) provides the same types of information for the lower river below Bonneville, in the estuary and the ocean plume.

development (exotic predators, habitat conditions that make native predators more efficient, water quality, etc.).

Based on emigration and rearing strategies, Connor et al. (2005) described two juvenile life history types for Snake River fall Chinook. At the time of the ESA listing (June 28, 2005; NMFS 2005), it was assumed that all juveniles of this species were ocean-type fish, characterized by entering saltwater at age 0 and spending their first winter in the ocean. However, some of the smaller, later-migrating fall Chinook salmon from the Snake River basin delay seaward movement, wintering in the lower Snake River reservoirs before resuming their seaward movement the following spring at age 1. According to Connor et al. (2005), although the condition of reservoir-type juveniles decreased over winter compared with ocean-type juveniles, the mean condition factor of the former always exceeded 1.0 in the single year of study.

After growth and maturation, whether in freshwater or the ocean, adult salmonids and steelhead generally return to their natal spawning areas for reproduction, though some straying into other basins is natural. As described in ISG (1996), the timing of adult entry and movement in rivers and tributary streams, and even the size, shape, and strength of adult fish represent adaptations to the physical and biological challenges presented by the upstream route to a specific spawning area. For example, waterfalls and similar physical barriers may be passable only at the range of flows that typically occurs during one month of the year, and then only by fish that have the physical ability to jump over or otherwise ascend the barrier. For fall-spawning fish, warm water conditions in late summer often present thermal barriers to movement and there may be little suitable habitat for resting (Berman and Quinn 1991, cited in ISG 1996). Therefore, at the adult life stage, population-specific behavioral patterns, closely attuned to the available habitats, appear to be critical for survival and successful reproduction.

Preferred spawning habitat is determined by the incubation needs of embryos, i.e., high flow of oxygenated water through the interstitial spaces in the streambed (Quinn 2005). Salmon usually avoid both the slowest water (where fine sand and silt accumulate) and the fastest water. Salmon lay their eggs in nests called redds. In areas where winter freezing can destroy embryos, salmon often build redds at sites with upwelling groundwater, which is warmer than river water. In the Columbia basin, two of the listed species, Snake River fall Chinook and Columbia River chum salmon, spawn both in tributaries and in the mainstem. In the vicinity of Ives Island (downstream of Bonneville Dam), chum spawn in shallow areas where it appears that river water is warmed by its transit through the gravel (Geist et al. 2002). At both Ives Island and in the Hanford Reach, fall Chinook salmon select upwelling sites in preference to non-upwelling sites (Geist 2000; Arntzen et al. 2005), but in other locations, fall Chinook prefer to spawn in downwelling areas at the heads of riffles (Healey 1991). At both Ives Island and the Hanford Reach, fall Chinook salmon select redd sites containing the highest dissolved oxygen concentrations in the river and riverbed, which is consistent with the requirements for incubating relatively large eggs (Healy 1991).

2.0 Habitat Limiting Factors and Threats Related to Mainstem Hydropower Projects and Operations

This section identifies the past and continuing effects of dams and reservoirs located in the mainstem Columbia and Snake River migratory corridors on listed species of salmon and steelhead and their designated critical habitat. The mainstem migratory corridor extends from the base of Hells Canyon Dam on the Snake River, and from Chief Joseph Dam on the Columbia River, to the tailrace of Bonneville Dam on the Columbia River.

Columbia River Basin anadromous salmon and steelhead have been affected by the development and operation of dams. Mainstem dams have extirpated anadromous fish from their pre-development spawning and rearing habitats. Dams and reservoirs, within the currently accessible migratory corridor, have altered the river environment and have affected fish passage and survival. The operation of water storage projects has altered the natural hydrograph of the Snake and Columbia Rivers. Water impoundment and dam operations also affect downstream water quality characteristics, including water temperatures, which are important to the survival of anadromous fish. Detailed descriptions of these effects are provided in Williams et al. 2005 and Ferguson et al. 2005 (NOAA Technical Memoranda NMFS-NWFSC-63 and 64) and summarized in NMFS 2008a (Supplemental Comprehensive Analysis of the Federal Columbia River Power System and Mainstem Effects of the Upper Snake and other Tributary Actions – Section 5.1).

2.1 Blocked and Inundated Habitat

The construction of Grand Coulee Dam in 1939 – River Mile 597 (and later Chief Joseph Dam in 1961 – RM 545) blocked access to important historical production areas for Upper Columbia River (UCR) spring Chinook salmon and steelhead (NRC 1996; ICTRT 2003) upstream of River Mile 597 (and RM 545). In addition to mainstem production areas, the Sanpoil, Spokane, Colville, Kettle, Pend Oreille, and Kootenai rivers each may have supported one or more populations of Chinook and/or steelhead.

In the Snake River, the construction of Swan Falls Dam in 1901 blocked access to important historical production areas of salmon and steelhead in the Snake River basin upstream of RM 424.[2] The construction of the Hells Canyon Dam complex (1958–1967) cut off access to the remaining historical habitat upstream of river RM 248, including seven major tributaries that had historically been important for spring/summer Chinook salmon and steelhead (and to sockeye

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[2] The area downstream of RM 578 (near the present location of Upper Salmon Falls Dam) was especially important to Snake River fall Chinook salmon, which Evermann (1896) identified as the "... largest and most important salmon spawning ground of which we know in Snake River."

salmon in the Payette River system): Boise, Burnt, Malheur, Owyhee, Payette, Powder, and Weiser rivers (Fulton 1968; Fulton 1970; Gustafson et al. 1997).

Between 1938 and 1971, the construction of Bonneville, The Dalles, John Day, and McNary dams inundated mainstem habitat in the lower Columbia River between Bonneville Dam (RM 146) and the confluence of the Snake River (RM 324). Between 1933 and 1967, the construction of Priest Rapids, Wanapum, Rock Island, Rocky Reach, and Wells dams inundated mainstem habitat in the middle Columbia River between the Snake River confluence (RM 324) and Chief Joseph Dam (545). Another 147 miles (RM 0 to RM 147) of mainstem habitat was inundated in the Snake River with the construction of Ice Harbor, Lower Monumental, Little Goose, and Lower Granite dams between 1962 and 1975 (Groves and Chandler 1999). Upstream from Bonneville Dam, the 41-mile stretch of the Columbia River known as the Hanford Reach between the head of Lake Wallula (McNary Dam pool – RM 356) and the tailrace of Priest Rapids Dam (RM 397), and the approximately 101-mile stretch of the Snake River, often referred to as the Hells Canyon reach (RM 147 to 248), provide the longest remaining unregulated reach of the mainstem ecosystem between Bonneville Dam and Chief Joseph Dam on the Columbia River and Hells Canyon Dam on the Snake River.

2.2 Mainstem Habitats & the Migratory Corridor

The Columbia and Snake Rivers (mainstem habitat) serve as corridors for migrating salmon and steelhead between the Pacific Ocean and their freshwater spawning and rearing habitats. Features of migration habitat important to these fish generally include: substrate, water quality, water quantity, water temperature, water velocity, cover/shelter, food (prey), riparian vegetation, space, and safe passage. For fall Chinook salmon, and to a lesser extent chum salmon, mainstem habitat also serves as important spawning and rearing habitat. Features of spawning and rearing habitat that are important to these fish generally include: spawning gravel, water quality, water quantity, water temperature, food, riparian vegetation, and access to spawning and rearing areas.

Current conditions within much of the mainstem Columbia and Snake Rivers are altered compared to historical conditions. The development of mainstem hydropower projects have resulted in the inundation of many mainstem spawning and shallow-water rearing areas (loss of spawning gravels and access to spawning and rearing areas); altered water quality (reduced spring turbidity levels), water quantity (seasonal changes in flows and consumptive losses resulting from use of stored water for agricultural, industrial, or municipal purposes), water temperature (including generally warmer minimum winter temperatures and cooler maximum summer temperatures), water velocity (reduced spring flows and increased cross-sectional areas of the river channel), food (alteration of food webs, including the type and availability of prey species), and safe passage (increased mortality rates of migrating juveniles) (Williams et. al 2005; Ferguson et. al 2005).

Within the migratory corridor, both dams and their associated reservoirs influence the current status of Columbia Basin salmon. To a greater or lesser extent specific to each dam, the dams present fish passage hazards, causing passage delays and varying rates of injury and mortality.

2.2.1 Adult Passage

Unlike downstream migrating juveniles, there is no indication that reservoirs substantially delay adult upstream migration (Ferguson et al. 2005). While the upstream migration of adults can be slowed as fish search for fishway entrances and navigate through the fishways themselves, they migrate more quickly through the relatively slow reservoirs.

Adult fish passage, in the form of fish ladders, is provided at the eight mainstem projects in the lower Snake and lower Columbia rivers and the five mainstem FERC-licensed projects in the middle Columbia reach. In general, adult passage facilities are highly effective. Nonetheless, salmon may have difficulty finding ladder entrances, and fish also may fall back over the dam, either voluntarily (e.g., adults that "overshoot" their natal stream and migrate downstream through a dam on their own volition), or involuntarily (entrained in spillway flow after exiting a fish ladder). Some adults that fall back or migrate downstream pass through project turbines and juvenile bypass systems. Adult mortality rates have been estimated at between 22% and 59%, depending on the species and size of the individual fish (larger fish are more likely to contact a turbine blade, etc.) (Ferguson et al. 2005). There is even less data on the survival of adults through juvenile bypass systems. It seems logical to assume that survival rates would be much higher through these systems than through turbine units, and indeed, with the possible exception of passage through the 14 to 16" gatewell orifices, conditions within these systems should be easily navigable by adults.

However, in spite of these potential hazards, average survival estimates using known origin PIT-tagged fish indicate that, after adjusting for known harvest and "natural" straying, survival through the mainstem Snake and Columbia River projects is relatively high (see Table 1 and discussion in Section 4 below).

Steelhead Kelts

Unlike other Pacific salmonids, a large fraction of the adult steelhead does not die after spawning and instead attempts to migrate back to the Pacific Ocean. Termed kelts, very few post-spawn adult steelhead survive downstream passage through the hydrosystem and so do not return and spawn again. Estimates of FCRPS passage survival ranged from 4.1 to 6.0% in the low flow year 2001 to 15.6% in 2002 and 34% in 2003 (Boggs and Peery 2004; Wertheimer and Evans 2005). At present, juvenile collection and bypass systems are not designed to safely pass adult fish including kelts. In addition to injury and mortality, kelt downstream migrations are delayed by the mainstem projects (Wertheimer and Evans 2005) in a manner similar to that previously described for juveniles.

The fraction of repeat spawning kelts in steelhead populations varies widely, from 1 to 51% (Wertheimer and Evans 2005). Boggs and Peery (2004) cite an estimated 2% kelt rate for the Clearwater River in 1954. It is estimated that 17 to 25% of the steelhead that pass Lower Granite Dam return downstream as kelts (Boggs and Peery 2004; Wertheimer and Evans 2005). Thus, while there is a relatively large number of kelts present, their relatively poor survival through the FCRPS (and potentially through the Middle Columbia PUD projects) may limit the contribution that they can make to steelhead populations.

Predation

Additionally, at Bonneville Dam, marine mammals (both the more common California sea lion and ESA-listed Stellar sea lion) are increasingly using the Bonneville Dam tailrace as a foraging area, presumably because the adult Chinook, steelhead, and lamprey upon which they feed are concentrated and delayed in this area as they seek entrance to the dam's adult fishways.

2.2.2 Juvenile Passage

Delay

Prior to the development of mainstem dams (c. 1938–1975), the mainstem migratory corridor was free-flowing with high velocities and a broad complex of habitats including rapids, short chutes, falls, riffles, and pools. It is not known how long it took juvenile salmon and steelhead to traverse the free-flowing river. Today, median travel times for yearling Chinook from the Lower Granite Dam on the Snake River to Bonneville Dam range from 14 days to 31 days depending on flow conditions, an increase of 40 to 50% over travel times measured in 1966 (Raymond 1968 and 1979), when fish encountered only the four mainstem dams (Williams et al. 2005).

This increased travel time (migration delay) presents an array of potential survival hazards to migrating juvenile salmon and steelhead: increasing their exposure to potential mortality vectors in the reservoirs (e.g. predation, disease, thermals stress), disrupting arrival timing to the estuary (which likely affects predator/prey relationships),[3] depleting energy reserves, potentially causing metabolic problems associated with smoltification (smoltification is the process of metabolic changes required to allow juvenile fish to convert from freshwater to saltwater environments), and for some steelhead and all Chinook salmon, contributing to residualism (a loss of migratory behavior).

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[3] During the spring and summer a series of changes occur in the composition of biotic communities the estuary and near-shore ocean environment. The assemblages of species change through time and disrupting arrival timing may increase the exposure of juvenile salmon to predators and/or diminish the availability of prey species to which the fish are adapted.

Migration delays and biological effects of a similar magnitude have likely also occurred in the middle Columbia River as a result of the construction of the middle Columbia PUD projects.

Dam Passage

A substantial proportion of juvenile salmon and steelhead can be killed while migrating through dams, both directly through collisions with structures and abrupt pressure changes during passage through turbines and spillways, and indirectly, through non-fatal injury and disorientation, which leave fish more susceptible to predation and disease and result in delayed mortality. Some juvenile mortality and injury is associated with any route of dam passage, but turbine passage generally has the highest direct mortality rate—8 to 19 percent. Juveniles passing through project spillways, sluiceways and other surface routes generally suffer the lowest direct mortality rates, 2% or less. However, substantially higher mortality rates have been measured through spillways at several mainstem FCRPS projects (Ferguson et al. 2005, NOAA Technical Memoranda NMFS-NWFSC-64).[4]

Additionally, a significant rate of juvenile mortality (approximately 3 to 5%) can occur in project forebays, just upstream of the dams (Axel et al. 2003; Ferguson et al. 2005; Hockersmith 2007), if fish are substantially delayed (median of 15-20 hours) before passing through the dam (Perry et al. 2007).[5] Forebay delay increases the exposure of juveniles to fish and avian predators and increases their exposure time to adverse water quality conditions (e.g. elevated total dissolved gas levels and high water temperatures), where present. (See discussion in NMFS 2008a—Supplemental Comprehensive Analysis, Section 5.1.2.1 for additional information regarding improvements made at the mainstem hydroelectric dams to improve passage since the mid-1990s, including some discussion of how the newly developed surface passage routes are proving effective at reducing forebay delay.)

Predation

The altered habitats in project reservoirs reduce smolt migration rates and create more favorable habitat conditions (increased growth rates, increased consumption rates, and enhanced foraging opportunities) for fish predators (see Dam Passage), including northern pikeminnow (*Ptychocheilus oregonensis*), and non-native walleye (*Sander vitreus*) and smallmouth bass (*Micropterus dolomieu*).

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[4] The route-specific mortality rate values given here are averages across several investigations. Higher and lower moralities have been observed and measured route-specific mortality is influenced by an array of factors ranging from the health and species of the test fish to study methods, the performance characteristics and working condition of the system being studied, and environmental conditions.

[5] This study was conducted at McNary Dam; estimates of delay for individual fish ranged from 0 to 172 hours in this study.

Dams also enhance conditions for avian predators - primarily Caspian terns, double-crested cormorants, and several gull species – because these species can more effectively forage in the forebays and tailraces of the mainstem projects than in a more riverine system.

Transportation Program

Following a decade of research that led to the conclusion that in most cases, the average adult return rates of predominantly stream-type salmonids (spring/summer Chinook and steelhead) that were transported as juveniles exceeded the return rates of fish that migrated inriver, the Corps began large-scale juvenile transportation as a management measure in 1975 (Ebel 1980; Ebel et al. 1973; Mighetto and Ebel 1994). Currently, fish collection and transportation systems are operated seasonally at Lower Granite Dam, Little Goose Dam, and Lower Monumental Dam (and at McNary Dam for summer migrating fall Chinook salmon). Most transported fish are barged to release points downstream from Bonneville Dam. When collection numbers become too small for barging to be cost-effective, collected fish are transported via truck. Approximately 60 to 90% of spring migrating smolts (spring/summer Chinook and steelhead) in the Snake River basin have been transported annually (Williams et al. 2005). Higher proportions (>95%) of Snake River migrants are likely to be transported during low water year conditions (defined as years in which spring flows are expected to be less than 65,000 cubic feet per second at Lower Granite Dam). With the addition of surface passage routes at the Snake River dams, far fewer fish may be transported – especially early in the migration season when adult returns from Chinook salmon smolts left to migrate inriver are relatively high (compared to transported fish) [see discussion below] – than has been possible in the past. For example, in 2007 transport rates were estimated to be much lower than previously estimated (approximately 25% for wild and hatchery yearling Chinook salmon and about 41% for wild and hatchery steelhead) (Smith 2008).

Recent data show that the effectiveness of transportation, in terms of the ratio of returning adults to transported juveniles (termed smolt-to-adult return ratio or SAR) from the Snake River, varies among species, season, and collection location (Williams et al. 2005; Scheuerell and Zabel 2007). In general, the SARs of both transported and inriver migrating Snake River spring/summer Chinook salmon and steelhead tend to decrease once the day of arrival below Bonneville Dam passes early May. For steelhead, SARs of transported fish are typically equal to or higher than those of the surviving inriver migrants arriving downstream of Bonneville Dam (transport-to-in-river SAR ratios > 1.0). For spring/summer Chinook salmon, SARs of surviving inriver migrating fish often are substantially higher in early to mid May than those of transported migrants (transport-to-in-river SAR ratios < 1.0). However, in late May and June, the differences are generally diminished such that SARs are nearly equal (transport-to-in-river ratios ≈1.0).[6]

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[6] The ISAB (2008) recently reviewed this information and generally agreed with NOAA Fisheries' assessment of the currently available data regarding the relative returns of adult Chinook and steelhead that were either transported or left inriver to migrate as juveniles. However, they advised NOAA Fisheries, the federal Action Agencies, and other regional managers to continue a "spread the risk" approach to spill and transport management to determine if

2.3 Mainstem Hydrologic Conditions

Flow regulation, water withdrawal, and climate change have reduced the Columbia River's average flow, altered its seasonality, and reduced sediment discharge and turbidity (NRC 1996; Sherwood et al. 1990; Simenstad et al. 1982 and 1990; Weitkamp 1994). Annual spring freshet flows through the Columbia River estuary are about one-half of the pre-development levels that flushed the estuary and carried smolts to sea (Figure 1).

Flow affects juvenile travel time and the distribution of individuals among the various routes of dam passage. In general, the lower the flow through the FCRPS reservoirs, the longer the travel time of juveniles that migrate inriver.[7] The longer juveniles remain in project reservoirs, the greater their exposure to predation, elevated temperatures, disease, and other sources of mortality and injury.

Combined with the influence of reservoirs in the migration corridor, reductions in spring and early summer flows slow juvenile fish emigration, increase their exposure to injury and mortality factors within the reservoirs (e.g. predation, temperature stress, disease, and others), and change the timing of ocean entry.

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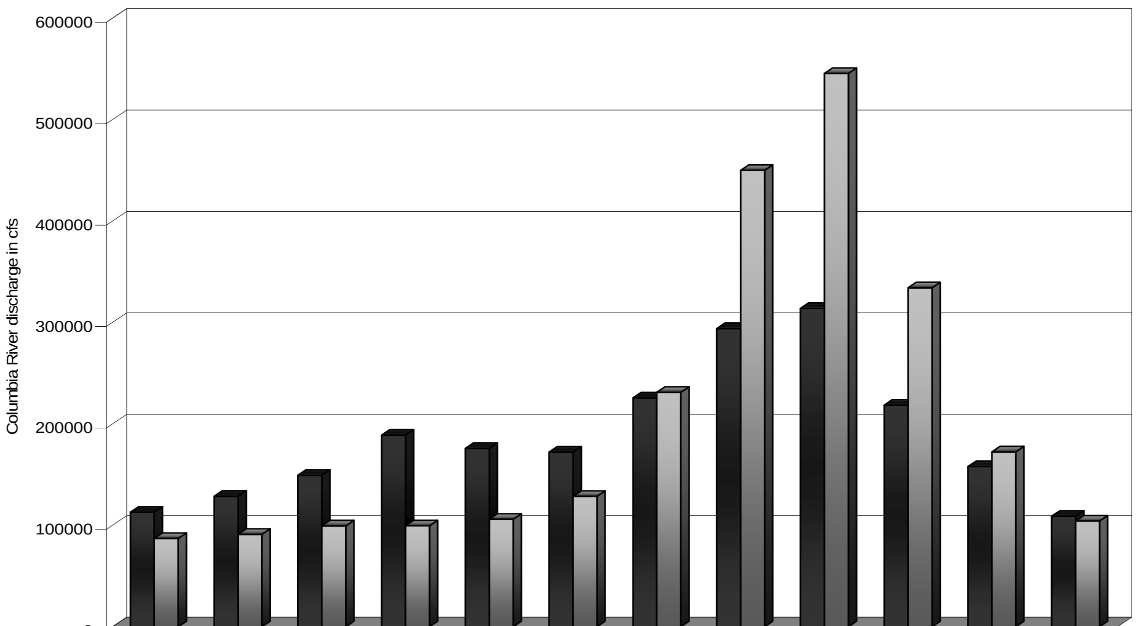
these patterns have been altered by recent structural improvements and operations at the mainstem dams and out of concern for potential effects of spring spill and transport operations [proposed in the 2008 FCRPS biop (NMFS 2008b)] on sockeye and lamprey.

[7] At lower river flows a higher proportion of individuals is collected and transported for some ESUs, thereby avoiding the delay associated with inriver hydrosystem passage.

Figure 1. Simulated mean monthly Columbia River flows at Bonneville Dam under current conditions (black columns) versus flows that would have occurred without reservoir management (gray) (water years 1929 –1978. Source: Current Condition Flows – Bonneville Power Administration, HYDSIM model run FRIII_07rerun2004biop.xls; Pre-Development Flows – USBR (1999) Cumulative Hydrologic Effects of Water Use: An Estimate of the Hydrologic Impacts of Water Resource Development in the Columbia River Basin. (In NMFS' (2008a) Supplemental Comprehensive Analysis, Section 5.1.3.)



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Current	113017	128641	149403	189076	175921	172150	225689	293948	313930	218523	157935	109020
Natural	87115	91029	99387	99496	106033	128580	231047	450040	545561	334238	172430	104310

2.4 Mainstem Water Quality

Water quality characteristics of the mainstem Snake and Columbia Rivers are affected by an array of land and water use developments. Water quality characteristics of particular concern are: water temperature, turbidity, total dissolved gas, and chemical pollutants.

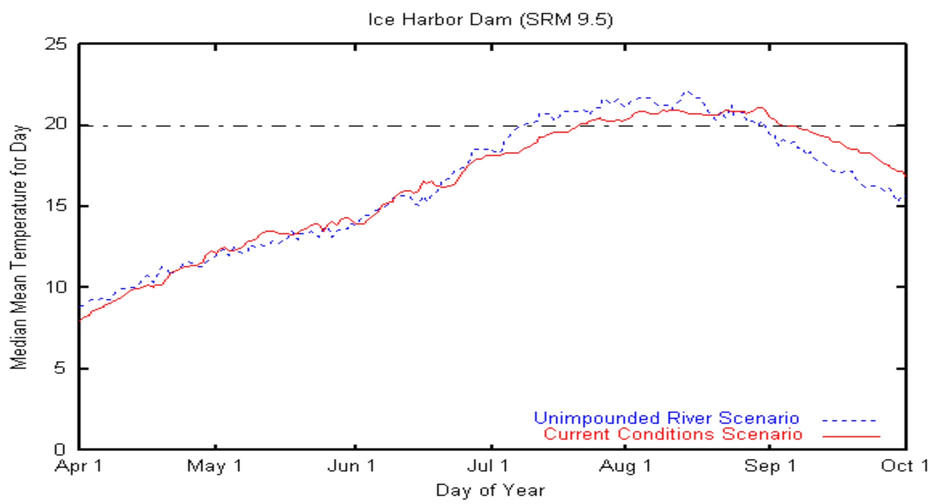
2.4.1 Water Temperature

Changes in water temperatures can have significant implications for anadromous fish survival. Dams and reservoirs influence water temperatures through storage, diversion, and irrigation return flows. Comparisons of long-term temperature monitoring in the migration corridor before and after impoundment reveal a fundamental change in the thermal regime of the Snake and

Columbia rivers. As shown in Figure 2, there are three notable differences between the current and the unimpounded river:[8]

- the maximum summer water temperature has been slightly reduced,
- water temperature variability has decreased, and
- post-impoundment water temperatures stay cooler longer into the spring and warmer later into the fall. The latter phenomenon is termed thermal inertia.

Figure 2. Median daily Snake River water temperatures (°C) at Ice Harbor Dam before and after development of the four lower Snake River projects (20°C denotes Washington Department of Ecology standard). Source: Perkins and Richmond 2001 in NMFS 2008a.



High water temperatures stress all life stages of anadromous fish, increase the risk of disease and mortality, affect toxicological responses to pollutants, and can cause migrating adult salmon to stop or delay their migrations and juvenile steelhead to residualize. Warm water temperatures also increase the foraging rate of predatory fish thereby increasing the consumption of smolts.

Though the duration and magnitude of high water temperatures in the migratory corridor is generally less under current, developed conditions than prior to water development, some juvenile fish are exposed to these conditions for a longer period of time due to the adoption of

[8] NOTE: Significant land use practices, including the development of a large number of water storage and diversion projects had already occurred by the 1960s. Therefore, the unimpounded river scenario in this graphic does not be equate to the pre-development condition.

alternative life histories (i.e, juvenile fall Chinook that over-summer in the mainstem reservoirs) or increases in migration travel time.

Coincident with and possibly due to climate change, average annual Columbia Basin air temperatures have increased by about 1 degree C over the past century and water temperatures in the mainstem Snake and Columbia rivers have been affected similarly (ISAB 2007). The influence of this and other large-scale environmental variations are discussed in NMFS 2008a – Supplemental Comprehensive Analysis, Section 5.7.

Also, due to the thermal inertia of the reservoirs (both mainstem and upstream storage projects), atmospheric cooling of water temperatures is delayed in the fall and warming is delayed in the early spring. This can affect Snake River fall Chinook by increasing the exposure of adults to elevated temperatures prior to spawning, resulting in an increased potential of pre-spawning mortality, reduced gamete viability, and subsequent impacts to the development and survival of fish through the egg to fry life stages.

2.4.2 Turbidity

Flow regulation and reservoirs reduces turbidity in the Columbia and Snake rivers. Reduced turbidity can increase predator success through improved prey detection, increasing the susceptibility of smolts to predation. Predation is a substantial contributor to juvenile salmon mortality in reservoirs throughout the Columbia and Snake River migratory corridors.

2.4.3 Total Dissolved Gas

Spill at mainstem dams (either as a means to pass fish or involuntarily in response to over-generational flows) can cause downstream waters to become supersaturated with dissolved atmospheric gasses. Supersaturated total dissolved gas (TDG) conditions can cause gas bubble trauma (GBT) in adult and juvenile salmonids resulting in injury or death. Biological monitoring shows that the incidence of GBT in both migrating smolts and adults remains between 1-2% when TDG concentrations in the upper water column do not exceed 120% of saturation in FCRPS project tailraces and 115% in project forebays. When those levels are exceeded, there is a corresponding increase in the incidence of GBT symptoms.

However, the effects of total dissolved gas (TDG) supersaturation on aquatic organisms are moderated by depth due to hydrostatic pressure. Each meter of depth compensates for about 10% of gas supersaturation as measured at the water surface. Thus, if the dissolved gas concentration is 120% of supersaturation at the surface, then the condition that the aquatic organism actually experiences at a depth of 2.0 meters is reduced to about 100% (i.e., the fishes tissues will be in equilibrium with the surrounding water and it will not develop gas bubble disease or trauma; Weitkamp 2003).

2.4.4 Pollutants

Background or ambient levels of pollutants in inflows from upstream areas are variable and generally unquantified. Growing population centers throughout the Columbia and Snake River basins and numerous smaller communities contribute municipal and industrial waste to the rivers. Mining areas scattered around the basin deliver higher background concentrations of metals. Highly developed agricultural areas of the basin also deliver fertilizer, herbicide, and pesticide residues to the river. While these pollutants are not caused by the mainstem Snake and Columbia rivers projects, they are transported through them to the estuary.

Current environmental conditions in the Columbia River estuary indicate the presence of contaminants in the food chain of juvenile salmonids including DDT, PCBs, and polyaromatic hydrocarbons (PAH) (NMFS 2001). This data also indicates that juvenile salmonids in the Columbia River estuary have contaminant body burdens in the range where sublethal effects can occur. The sources of exposure are not clear, but may be widespread. Several pesticides and heavy metal contaminants have been detected in Columbia River sediments (ODEQ 2007). In field studies, juvenile salmon from sites in the Pacific Northwest have demonstrated immunosuppression, reduced disease resistance, and reduced growth rates associated with contaminant exposure during their period of estuarine residence (Arkoosh et al. 1991, 1994, 1998; Varanasi et al. 1993; Casillas et al. 1995a, 1995b, and 1998). Some impacts may be occurring within the mainstem Columbia and Snake Rivers, to the extent that juvenile fish are rearing in areas that are contaminated to similar levels as in the estuary.

3.0 Current Recovery Strategies and Actions

Current hydropower programs and operations are the result of completed or ongoing ESA section 7 consultations, Habitat Conservation Plans (HCPs) pursuant to section 10 of the ESA; FERC relicensing proceedings and other regulatory processes. In most cases, hydropower programs and operations are intended to avoid jeopardy and contribute to recovery. There is no distinction between the hydropower actions intended to meet ESA regulatory requirements and those intended purely for recovery.[9]

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[9] Recovery cost estimates do not include costs for implementing mainstem actions, first, because of their basinwide scope and applicability to all 13 Columbia Basin salmonid species listed as threatened or endangered, and second, because they are considered "baseline actions," a term that NMFS' NWR ESA recovery plans use for actions already incorporated into other processes, such as section 7 consultations, FERC licensing agreements, and Habitat Conservation Plans, and these costs would occur regardless of the recovery plans.

3.1 Federally Owned and Operated Projects in the Columbia Basin

3.1.1 Federal Columbia River Power System

The Federal Columbia River Power System (FCRPS) consists of 14 projects, each composed of dams, powerhouses, and reservoirs, that are operated as a coordinated system for power production and flood control (while also effectuating other project purposes) on behalf of the Federal government under various Congressional authorities. These projects are: Dworshak, Lower Granite, Little Goose, Lower Monumental, and Ice Harbor dams, power plants, and reservoirs in the Snake River basin; Albeni Falls, Hungry Horse, Libby, Grand Coulee and Banks Lake (features of the Columbia Basin Project), and Chief Joseph dams, power plants, and reservoirs in the upper Columbia River basin; and McNary, John Day, The Dalles, and Bonneville dams, power plants, and reservoirs in the lower Columbia River basin.

The plan for operation of the FCRPS through 2018 is described in U.S. Army Corps of Engineers (USACE) et al.'s Comprehensive Analysis Document (USACE et al. 2007a) and Biological Assessment (USACE et al. 2007b) and in NMFS' Supplemental Comprehensive Analysis Document (NMFS 2008a) and Biological Opinion (NMFS 2008b). The following is a general summary of the performance standards, metrics, and targets required in the 2008 Biological Opinion to maintain or improve salmon and steelhead survival in the mainstem migration and rearing corridor and the strategies that will be pursued to achieve these metrics (see RPA 51 in NOAA Fisheries' Reasonable and Prudent Alternative Table of Actions – NMFS 2008b). These actions are intended to address the needs for survival and recovery of all 13 species of ESA-listed salmon and steelhead in the Columbia basin.

- **Adult Passage Performance Standards.** The Actions Agencies must track and confirm that the relatively high levels of adult survival currently observed are maintained or increased through 2018 (see Table 7 of NOAA Fisheries' Reasonable and Prudent Alternatives Table of Actions – NMFS 2008b). These survival rates, which are based on known-origin fish PIT tagged as juveniles, after accounting for known harvest and "natural" rates of straying, range from 81.2% for Snake River fall Chinook salmon up to 91.0% for Snake River spring/summer Chinook salmon (BON to LGR); and from 84.5% for Upper Columbia River steelhead up to 90.1% for Upper Columbia River spring Chinook (BON to MCN).[10]
- **Juvenile Dam Passage Performance Standards.** The Action Agencies must achieve an average Juvenile Dam Passage Performance Standards of 96% survival across Snake

[10] The discrepancy between adult survivals for Upper Columbia River versus Snake River species in the lower Columbia River is recognized and is the subject of directed research, monitoring, and evaluation programs. The objectives of these programs are to determine why the differences exist and what actions might be effective at increasing the survival of the Upper Columbia River species in the lower Columbia River.

River and Lower Columbia River dams for spring Chinook and steelhead and an average of 93% survival across Snake River and Lower Columbia River dams for Snake River sub-yearling fall Chinook.

- **Achieve Juvenile Inriver Survival Performance Metrics.** The Action Agencies must annually measure the survival of inriver migrating fish and compare these numbers with COMPASS model estimates, which will be based on the conditions actually experienced and the expected benefits of completed hydro actions, to assure that survival improvements are occurring as expected.
- **Juvenile System Survival Performance Targets.** The Action Agencies must achieve the expected increase in juvenile fish survival through the hydrosystem (survival to below Bonneville Dam of both transported and inriver migrating fish) that are associated with the proposed hydrosystem actions.

To achieve these metrics, the Action Agencies will pursue the following general objectives and strategies (see NOAA Fisheries' Reasonable and Prudent Alternatives Table of Actions, NMFS 2008b, for specific details):

- Continue collaboration with States and Tribes in the implementation of RPA actions, progress reporting, and adaptive management using fora such as the Regional Implementation Oversight Group.
- Operate the FCRPS to provide flows and water quality to improve juvenile and adult fish survival.[11]
- Modify Columbia and Snake river dams to maximize juvenile and adult fish survival.[12]
- Implement spill and juvenile transportation improvements at Columbia and Snake River dams.
- Operate and maintain facilities at Corps mainstem projects to maintain biological performance.
- Implement piscivorous predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia rivers.

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[11] This includes the operation of storage reservoirs to increase the likelihood of achieving seasonal flow objectives: Spring \ 85 – 100 kcfs at Lower Granite dam, 135 kcfs at Priest Rapids dam, and 220 – 260 kcfs at McNary dam; Summer \ 50-55 kcfs at Lower Granite dam and 200 at McNary. It also includes the continued release of cool water from Dworshak dam during the summer to reduce and maintain temperatures in the lower Snake River.

[12] This includes the design, construction, and testing of structures and operations to provide surface oriented routes of passage which should be beneficial to juvenile migrants and downstream migrating adults (overshoots, fallbacks, or steelhead kelts).

- Implement avian predation control measures to increase survival of juvenile salmonids in the lower Snake and Columbia rivers.
- Implement marine mammal control measures to increase survival of adult salmonids at Bonneville Dam.
- Provide information needed to support planning and adaptive management and demonstrate accountability related to the implementation of FCRPS ESA hydropower actions for all ESUs (i.e., implement research, monitoring, and evaluation programs for hydropower actions and predator control actions).

In addition to these objectives, the 2008 FCRPS Reasonable and Prudent Alternative Action Table articulates site-specific management actions that will benefit interior Columbia species (see NOAA Fisheries' Reasonable and Prudent Alternatives Table of Actions, NMFS 2008b, for specific details).

3.1.2 U.S. Bureau of Reclamation Projects in the Upper Snake Basin above Brownlee Reservoir

The USBR's proposed actions in its August 2007 Biological Assessment (USBR 2007) addressed operations at 12 projects in the upper Snake River basin: Baker, Boise, Burnt River, Little Wood River, Lucky Peak, Mann Creek, Michaud Flats, Minidoka, Owyhee, Palisades, Ririe, and Vale (collectively, the Upper Snake Project). The proposed actions encompassed USBR's future operations and routine maintenance, including storage and delivery of water, hydropower generation, and releasing water to augment flows for migrating salmonids. NMFS (2008c) prepared a biological opinion on this proposal and concluded that the action would not jeopardize the listed species nor result in the destruction or adverse modification of their designated critical habitat.

The site-specific action of providing salmon flow augmentation is intended to address the needs for survival and recovery of all 13 species of ESA-listed salmon and steelhead in the Columbia basin. Although the physical project operations take place upstream of the migration barrier at Idaho Power Company's Hells Canyon Complex, water released from the upper Snake River project reaches the lower Snake and Columbia rivers where it benefits juvenile salmon and steelhead migrants.

The USBR provides salmon flow augmentation by acquiring water through rental pools and leasing or acquiring natural flow rights. The Nez Perce Water Rights Settlement and the Idaho law that implemented the settlement provide that up to 487,000 acre-feet may be provided for flow augmentation.

3.2 Federal Energy Regulatory Commission-licensed Projects

The Federal Energy Regulatory Commission (FERC) licenses five hydroelectric dams in the middle Columbia reach (i.e., between Chief Joseph Dam and the confluence of the Snake and Columbia rivers): Wells (owned and operated by Douglas County Public Utility District (PUD)), Rocky Reach and Rock Island (Chelan County PUD), and Wanapum and Priest Rapids (Grant County PUD). FERC also licenses Idaho Power Company's (IPC) Hells Canyon Complex in the Snake River basin.

3.2.1 Hydropower Projects Owned and Operated by Chelan and Douglas PUDs

NMFS (2002) entered into three site-specific 50-year anadromous fish agreements and habitat conservation plans (HCPs), one for each of the three mainstem Columbia River hydroelectric projects owned by Chelan (Rocky Reach and Rock Island) and Douglas (Wells) County PUDs, pursuant to section 10 of the Endangered Species Act. The HCPs were developed to protect the five species of Columbia River steelhead and salmon (spring-run Chinook salmon; summer/fall-run Chinook salmon; sockeye salmon, steelhead, and coho salmon, two of which (Upper Columbia River spring-run Chinook salmon and steelhead) were listed as endangered at that time.[13] They satisfied the PUDs' regulatory obligations with respect to anadromous salmonid species under the Federal Power Act, Fish and Wildlife Coordination Act, Pacific Northwest Electric Power Planning and Conservation Act, the essential fish habitat provisions of the Magnuson-Stevens Fishery Conservation and Management Act, and Title 77 RCW, as well as the ESA. The agreements set a "no net impact" standard to protect salmon and steelhead at the Wells, Rocky Reach, and Rock Island projects, and provide some degree of certainty for the long-term operation of these projects.[14]

Each of the three HCPs established a standard of 91% combined adult and juvenile passage survival at each project (Wells, Rocky Reach, and Rock Island) (NMFS 2002).[15] The combined survival standard is composed of 93% juvenile and 98% adult project passage survival for all anadromous salmonids. At the time the Incidental Take Permits were issued (August 20, 2003), NMFS estimated that the HCPs represented a 22 to 45% survival improvement potential over the survival levels observed under the historical operations at these projects.

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[13] NMFS (2006) revised its listing of Upper Columbia River steelhead from "endangered" to "threatened" on January 5, 2006.
[14] The HCPs are intended to help prevent conditions that would lead to the need to list additional species of Upper Columbia River salmon and steelhead in the future.
[15] The HCPs allowed the PUDs to compensate for up to 9% project passage mortality through up to 7% hatchery production and up to 2% funding of tributary habitat enhancement projects. That is, the mitigation is intended to match the level of impact.

3.2.2 Hydropower Projects Owned and Operated by Grant County PUD

Grant County PUD's new FERC license includes survival standards required in NMFS (2004) for the Priest Rapids Project (Priest Rapids and Wanapum dams and reservoirs) that are identical to those described above for the HCPs. Furthermore, the following site-specific measures are also included in the new FERC license and are being implemented to ensure that the standards are met:

- Downstream passage measures, including spill through existing and top spill through future units; turbine operations and the installation of advanced turbines; total dissolved gas abatement; avian predator control; and a northern pikeminnow *(Ptychocheilus oregonensis)* removal program

- Continued operation and maintenance, and where needed, improvements to adult fishways at both Priest Rapids and Wanapum dams

- Design and construction of an off-ladder trap and fish-handling facilities at Priest Rapids Dam

- Sluiceway operations for steelhead fallbacks (kelts)

The FERC has completed consultation with NMFS on the terms of a new, 44-year license for the Priest Rapids Project. With respect to site-specific actions for mainstem facilities and operations, FERC adopted the hydro actions in the Reasonable and Prudent Alternative in NMFS' Biological Opinion on Grant County PUD's Interim Protection Plan (NMFS 2004) and in NMFS' February 1, 2008, Biological Opinion (NMFS 2008d) for listed salmon and steelhead, described above.

3.3 Idaho Power Company's Hells Canyon Project

The relicensing of the Hells Canyon Hydroelectric Project is the subject of ongoing administrative proceedings before FERC involving its owner, IPC; Federal, state, and tribal agencies; and other stakeholders. At present, IPC voluntarily operates the project to protect habitat used by fall Chinook salmon for spawning (i.e., by eliminating flow fluctuations), and incubation (i.e., by providing enough flow to prevent the dewatering of redds downstream of the project). As part of an interim settlement agreement in the license proceedings, IPC has agreed to release about 237 thousand acre-feet (kaf) of water – primarily during July - to improve downstream migration conditions (flow) for juvenile fall Chinook salmon (Tucker 2005).

4.0 Survival Rates at Mainstem Federal and Non-Federal Hydro Projects

4.1 Adult Survival

Adult survival estimates presented in this document are based primarily on a simple, straight-forward "conversion rate" method which relies upon the detection and subsequent re-detection of PIT-tagged "known-origin" adults[16] as they migrate upstream through the fishways (some fitted with PIT tag detectors) at the mainstem hydro projects. Detection rates are typically $\geq$ 99% for an individual PIT tag detector and, because there are typically two or three detectors in series within each of the key fishways –virtually every PIT-tagged adult fish migrating upstream through a mainstem fishways is detected.[17]

Minimum adult survival estimates (or conversion rates) can be calculated as the number of fish re-detected at an upstream project divided by the number of fish initially detected at the downstream project of interest. Estimates of "natural" straying rates and of known harvest are also factored in and the resulting number is the proportion of fish that survived between the two projects. For details regarding this method and how "natural" stray rates and harvest rates were used in these analyses, the reader is advised to read the Adult Survival Estimate Appendix of NOAA's Supplemental Comprehensive Analysis (NMFS 2008a). Otherwise, these estimates capture all sources of mortality manifested within the identified reaches, including those resulting from the existence and operation of the FCRPS, as well as unquantifiable levels of mortality from other potential sources (e.g., unreported or delayed mortality caused by fisheries, marine mammal predator attacks, etc.) and unquantifiable levels of "natural" mortality (i.e., levels of mortality in the migratory corridor that would have occurred "naturally" without human influence).

Adult Survival – Federal Projects

Under the 2008 FCRPS Biological Opinion (NMFS 2008b), the federal action agencies are responsible for ensuring that the relatively high rates of survival currently observed in the Bonneville Dam to Lower Granite Dam (7 dams) reach for Snake River species and Bonneville Dam to McNary Dam (3 dam) reach for Upper Columbia River spring Chinook and steelhead is maintained or increased through 2018. Snake River species, for which the most information is available, were used as surrogates for Middle Columbia River steelhead, and Lower Columbia River species. The average survival estimates, annual estimates (ranges), and additional

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[16] "Known-origin" means that the release locations for all PIT tagged juvenile fish are available in the PITAGIS data base – and the general area to which these fish are attempting to migrate as adults is also known.
[17] It should be noted that some adults may avoid detection by migrating past the dams via the locks at the federal projects. This is evidenced by individuals not being detected at a particular dam, but being detected at another dam upstream.

information are provided in Table 1 (Column 3 titled "Adult Surv. – FCRPS") and the information for Snake River and Upper Columbia River species is also summarized in the text below.

The average survival estimate for Snake River fall Chinook salmon between Bonneville Dam and Lower Granite Dam was 81% for those that migrated inriver as juveniles and approximately 75% for those that were transported as juveniles, equating to a per project survival (7 dams) of 97% and 96%, respectively.[18]

The average survival estimate for Snake River spring/summer Chinook salmon between Bonneville Dam and Lower Granite Dam was 91% for those that migrated inriver as juveniles and about 84% for those that were transported as juveniles, equating to a per project survival (7 dams) of 99% and 98%, respectively.

The estimated average survival of Snake River sockeye salmon between Bonneville Dam and Lower Granite Dam was 81% equating to a per project survival (7 dams) of about 97%. No estimate can be made with the available data for those fish transported as juveniles (see Table 1, footnote 3).

The average survival estimate for Snake River steelhead between Bonneville Dam and Lower Granite Dam was 90% for those that migrated inriver as juveniles and approximately 83% for those that were transported as juveniles, equating to a per project survival (7 dams) of 99% and 97%, respectively.

The average survival estimate for Upper Columbia River spring Chinook salmon between Bonneville Dam and McNary Dam was 90% (all of these fish migrate inriver as juveniles), equating to a per project survival (3 dams) of approximately 97%.

The average survival estimate for Upper Columbia River steelhead between Bonneville Dam and McNary Dam was 85% (all of these fish migrate inriver as juveniles), equating to a per project survival (3 dams) of 95%.[19]

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[18] Average per project survival estimates are calculated as Average Survival Estimate ^ 1/n. Average per project survival estimates are useful because they allow for a comparison between species that migrate past different numbers of dams.

[19] Note: The apparent discrepancy between the survival rates of Upper Columbia River spring Chinook salmon and steelhead through a 3 dam reach and Snake River spring/summer Chinook salmon and steelhead through a 7 dam reach is noted in the 2008 FCRPS biological opinion. Reasonable and Prudent Alternative Action 52 requires an investigation into the possible causes of this apparent discrepancy (NMFS 2008b). Once a likely cause is identified, the Action Agencies, NOAA Fisheries and co-managing agencies will develop appropriate corrective actions and a monitoring plan to ensure that the differential survival is minimized or eliminated.

Adult Survival – Non-Federal Projects

Under the terms of the Middle Columbia Habitat Conservation Plans for the Wells, Rocky Reach, and Rock Island projects; and under the 2008 biological opinion for the Priest Rapids Project (Wanapum and Priest Rapids dams, NMFS 2008d), the Public Utility Districts must meet or exceed a per project survival of 98% for all adult migrants. At this time, it appears that the average per project survival between Priest Rapids and Wells Dam is 98.7% and 98.2% for Upper Columbia River spring Chinook salmon and steelhead, respectively. The average survival estimates, annual estimates (ranges), and additional information for Upper Columbia River species are provided in Table 1 (Column 4 titled "Adult Surv. – Mid-Columbia" and Column 5 titled "Adult Surv. - Total) and also summarized in the text below.

The average survival estimate for Upper Columbia River spring Chinook salmon migrating between Priest Rapids and the Wenatchee, Entiat, and Methow rivers is approximately 95%, 96%, and 97%, respectively. This survival multiplied by the Bonneville to McNary survival estimate[20] yields a Bonneville to Wenatchee, Entiat, and Methow river survival estimate of about 85%, 87%, and 88%.

The average survival estimate for Upper Columbia River steelhead migrating between Priest Rapids and the Wenatchee, Entiat, and Methow rivers is approximately 93%, 95%, and 96%, respectively. This survival multiplied by the Bonneville to McNary survival estimate[19] yields a Bonneville to Wenatchee, Entiat, and Methow river survival estimate of about 79%, 80%, and 82%.

4.2 Juvenile Survival

Juvenile survival levels are estimated for two periods (See Tables 2 and 3). The "Current" scenario generally translates to survivals recently observed or estimated (modeled using COMPASS) to have occurred due to operational and configuration changes at the mainstem hydroelectric projects through about 2006. The "Prospective" scenario generally translates to attaining survival levels (if not already attained or exceeded) that are required by the Habitat Conservation Plans for the Wells, Rocky Reach, and Rock Island projects; the 2008 biological opinion for the Priest Rapids project (Wanapum and Priest Rapids Dam) (NMFS 2008d); or modeled using COMASS for the 2008 FCRPS biological opinion (NMFS 2008b). Full attainment of these standards is expected when the FCRPS biological opinion is fully implemented from 2015 to 2018.

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[20] A McNary to Priest Rapids (Hanford Reach) survival estimate has not yet been calculated, but is likely less than 100%.

Juvenile survival through the federal projects under both the “Current” and “Prospective” cases was estimated using NOAA Fisheries’ COMPASS model. The COMPASS model was populated with the best empirically derived estimates of route-specific passage and survival rates available for juvenile Chinook or steelhead to reflect the “Current” configuration of the hydrosystem. The Federal Action Agencies assessed the likely benefits (specific survival improvements) that should result from additional dam configuration actions required in the 2008 FCRPS biological opinion and these improvements were included in the modeling runs of the “Prospective” scenario. Both the “Current” and “Prospective” configurations and operations were modeled across a 70-year (1928 through 2000) historical water record.

The model provides estimates of survival to below Bonneville Dam for inriver (and transported, if applicable) migrants, proportion of the migrants that would likely be transported (if applicable), and the arrival timing of migrants to the Bonneville dam tailrace for ESA-listed spring and summer Chinook salmon and steelhead from the Snake River, Upper Columbia River, and Middle Columbia River populations.[21] For the purpose of this module, the most relevant pieces of information are likely the survival estimates.

4.2.1 Juvenile Survival – Current

Estimates of “Current” juvenile survival through the federal projects, ranges of expected survival, and proportion of juveniles expected to be transported are provided in Table 2 (Column 3 - Juv. Survival – FCRPS). These results are broken into two categories (expected average flows at Lower Granite Dam of less than 65 kcfs or greater than >65 kcfs) for Snake River populations to display the likely effect of the “full transport” operation that would occur in the low flow years – which occurs in about 19% (13 of 70) of the years modeled. Estimates of survival for juveniles migrating from the Methow, Entiat and Wenatchee rivers are provided in Column 4 – Juv. Survival – Mid-Columbia; and combined survival estimates are provide in Column 5 – Juv. Survival – Total. A brief summary of this information is provided for spring migrating Snake River and Upper Columbia River Chinook salmon and steelhead populations in the text below.

The average juvenile survival estimate for Snake River spring/summer Chinook salmon is 56% in the LGR > 65 kcfs years and 37% in the LGR < 65 kcfs years. Estimates of the proportion transported are about 64% and 95% in these flow conditions, respectively.

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[21] Insufficient data, primarily resulting from the multiple life-history strategies exhibited by Snake River fall Chinook salmon, was available to populate the COMPASS model to estimate juvenile fall Chinook survival through the FCRPS projects. Instead, NOAA Fisheries derived survival estimates from Fish Passage Center data (see NMFS 2008a and 2008b).

The average juvenile survival estimate for Snake River steelhead is 39% in the LGR > 65 kcfs years and 8% in the LGR < 65 kcfs years. Estimates of the proportion transported are about 79% and 94% in these flow conditions, respectively.

The average juvenile survival estimate for Upper Columbia River spring Chinook salmon is 67% through the four FCRPS dams in the lower Columbia River, and 68%, 71%, and 77% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five Middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 45%, 47%, and 51%, respectively.

The average juvenile survival estimate for Upper Columbia River steelhead is 48% through the four FCRPS dams in the lower Columbia River, and 69%, 72%, and 75% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five Middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 33%, 34%, and 36%, respectively.

4.2.2 Juvenile Survival – Prospective

Estimates of "Prospective" juvenile survival through the federal projects, ranges of expected survival, and proportion of juveniles expected to be transported are provided in Table 3 (Column 3 - Juv. Survival – FCRPS). These results are broken into two categories (expected average flows at Lower Granite Dam (LGR) of less than 65 kcfs or greater than >65 kcfs) to display the likely effect of the "full transport" operation that would occur in the low flow years – which occurs in about 19% (13 of 70) of the years modeled. Estimates of survival for juveniles migrating from the Methow, Entiat and Wenatchee rivers are provided in Column 4 – Juv. Survival – Mid-Columbia; and combined survival estimates are provide in Column 5 – Juv. Survival – Total. A brief summary of this information is provided for spring migrating Snake River and Upper Columbia River populations in the text below.

The average juvenile survival estimate for Snake River spring/summer Chinook salmon is 63% in the LGR > 65 kcfs years and 52% in the LGR < 65 kcfs years. Estimates of the proportion transported are about 64% and 95% in these flow conditions, respectively.

The average juvenile survival estimate for Snake River steelhead is 45% in the LGR > 65 kcfs years and 9% in the LGR < 65 kcfs years. Estimates of the proportion transported are about 74% and 89% in these flow conditions, respectively.

The average juvenile survival estimate for Upper Columbia River spring Chinook salmon is 73% through the four FCRPS dams in the lower Columbia River, and 72%, 75%, and 81% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five Middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 53%, 55%, and 59%, respectively.

The average juvenile survival estimate for Upper Columbia River steelhead is 53% through the four FCRPS dams in the lower Columbia River, and 75%, 78%, and 81% for juveniles migrating from the Methow, Entiat, and Wenatchee rivers through the three to five Middle Columbia projects. The total survival estimate for these populations to below Bonneville Dam is 40%, 41%, and 43%, respectively.

Table 1: Recent Adult Survival Estimates for ESA-listed Columbia River Basin Salmon and Steelhead Populations Migrating Past Mainstem Hydroelectric Projects Based on PIT-tagged, Known-Origin Adults.[1]

Species	**Population**	**Adult Surv.**[2] **– FCRPS** ***Reach*** **Average** Range *Special Info.*	**Adult Surv. – Mid-Columbia**[5] ***Reach*** **Average** Range *Special Info.*	**Adult Surv.**[2] **– Total** **Average** Range *Special Info.*
SR fall Chinook[3]	Single Pop.	***BON – LGR*** **Inriver:** **81.0** (58.8 – 98.6) **Transported:** **74.9** (62.4 – 94.7)		***BON – LGR*** **Inriver:** **81.0** (58.8 – 98.6) **Transported:** **74.9** (62.4 – 94.7)
SR spr/sum Chinook[3]	All Pops.	***BON – LGR*** **Inriver:** **91.0** 81.6 – 97.9 **Transported:** **84.1** *73.7 – 88.0*		***BON – LGR*** **Inriver:** **91.0** 81.6 – 97.9 **Transported:** **84.1** *73.7 – 88.0*
SR sockeye[3]	Single Pop.	***BON – LGR*** **Inriver:** **81.1** 79.1 – 83.2 **Transported:** **(No Est. Available)**		***BON – LGR*** **Inriver:** **81.1** 79.1 – 83.2 **Transported:** **(No Est. Available)**
SR steelhead[3]	All Pops.	***BON – LGR*** **Inriver:** **90.1** 85.6 – 93.8 **Transported:** **83.3** *78.2 – 89.8* (BON – LGR)		***BON – LGR*** **Inriver:** **90.1** 85.6 – 93.8 **Transported:** **83.3** *78.2 – 89.8* (BON – LGR)

Species	Population	Adult Surv.[2] – FCRPS *Reach* Average Range *Special Info.*	Adult Surv. – Mid-Columbia[5] *Reach* Average Range *Special Info.*	Adult Surv.[2] – Total Average Range *Special Info.*
UCR spring Chinook[6]	Methow Entiat Wenatchee	***BON - MCN*** **Inriver:** **90.1** 86.1 – 96.1	***PRD - WEL*** **94.7** ***PRD - RRE*** **96.2** ***PRD – RIS*** **97.4**	***BON – WEL*** **85.3** ***BON – RRE*** **86.7** ***BON – RIS*** **87.8**
UCR steelhead[6]	Methow / Okanogan Entiat Wenatchee	***BON - MCN*** **Inriver:** **84.5** 77.6 – 90.7	***PRD - WEL*** **93.0** ***PRD - RRE*** **94.7** ***PRD – RIS*** **96.4**	***BON - WEL*** **78.6** ***BON - RRE*** **80.0** ***BON – RIS*** **81.5**
MCR steelhead[4,7]	Yakima / Walla Walla Umatilla / John Day Deschutes and BON pool	***BON - (MCN, JDA, and TDA)*** **Inriver:** **95.6** 93.5 – 97.3 **97.0** 95.6 – 98.2 **98.5** 97.8 - 99.1		***BON-(MCN, JDA, and TDA)*** **Inriver:** **95.6** 93.5 – 97.3 **97.0** 95.6 – 98.2 **98.5** 97.8 - 99.1
LCR Chinook[4]	Spring-run adults Fall-run adults	***BON Pool*** **Inriver:** **98.6** 97.1 – 99.7 **96.9** 92.7 – 99.8		***BON Pool*** **Inriver:** **98.6** 97.1 – 99.7 **96.9** 92.7 – 99.8
LCR steelhead[4,8]	BON pool	***BON Pool*** **>98.5** >97.8 - >99.1		***BON Pool*** **>98.5** >97.8 - >99.1
CR coho[4]	BON pool	***BON Pool*** **96.9** 92.7 – 99.8		***BON Pool*** **96.9** 92.7 – 99.8
CR chum[4]	BON pool	***BON Pool*** **96.9** 92.7 – 99.8		***BON Pool*** **96.9** 92.7 – 99.8

Sources: NMFS' 1) Supplemental Comprehensive Analysis Document (May 5, 2008a); and 2) Biological Opinion – Consultation on Remand for Operation of the Federal Columbia River Power System, 11 bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (May 5, 2008b).

[1] Key to Dams: BON = Bonneville Dam, TDA = The Dalles Dam, JDA = John Day Dam, MCN = McNary Dam, PRD = Priest Rapids Dam, WAN = Wanapum Dam, RIS = Rock Island Dam, RRE = Rocky Reach Dam, WEL = Wells Dam, IHR = Ice Harbor Dam, LMN = Lower Monumental Dam, LGS = Little Goose Dam, and LGR = Lower Granite Dam.

[2] These estimates are based on detections of known origin fish returning to the Columbia River, detected passing Bonneville Dam, and redetected at upstream locations. These estimates have been adjusted to account for estimated harvest and "natural" straying rates of adults within the FCRPS migration corridor, but otherwise capture all other sources of mortality manifested within the identified reaches, including those resulting from the existence and operation of the FCRPS, unquantifiable levels of mortality from other potential sources (e.g., unreported or delayed mortality caused by fisheries, marine mammal predator attacks, etc.), and unquantifiable levels of "natural" mortality (i.e. levels of mortality in the migratory corridor that would have occurred "naturally" without human influence).

[3] Adult survival rates for SR fall Chinook, SR spr/sum Chinook, and SR steelhead are reported separately as either inriver or transported (via barge or truck) to properly reflect their migration history as juveniles. Survival estimates for adult SR sockeye are primarily based on unknown origin (though likely from the Lake Wenatchee or Okanogan River sockeye populations) adults PIT tagged at Bonneville Dam and detected at McNary Dam. The average per dam survival is expanded to a seven dam reach (Bonneville Dam to Lower Granite Dam).

[4] The estimates for these ESUs only apply to those adults migrating to tributaries entering the reservoir upstream of Bonneville Dam, or in the case of MCR steelhead, the adult populations migrating to tributaries entering the Columbia River between Bonneville Dam and McNary Reservoir.

[5] Recent adult survival estimates from Priest Rapids to Wells dam are reported in Anchor Env. and Douglas PUD (2008): 93.0% and 94.7% for summer steelhead (2004-2007) and spring Chinook salmon (2003-2007), respectively. The average per project survival estimates (1/4th root of the reach survival estimate) are 98.2% for steelhead and 98.7% for spring Chinook.

[6] NOTE: A separate estimate for the McNary Dam to Priest Rapids Dam reach has not yet been generated. This will be addressed in the next update of the Recovery Planning Hydro Module.

[7] Within the Bonneville pool, Klickitat River and 15 Mile Creek populations of steelhead are part of the Mid Columbia River steelhead Distinct Population Segment.

[8] Within the Bonneville pool, Hood River and Wind River populations of steelhead are part of the Lower Columbia River steelhead Distinct Population Segment.

Table 2. "Current" (2002-2009) Juvenile Survival Estimates for ESA-listed Columbia River Basin Salmon and Steelhead Populations Migrating Inriver Past Mainstem Hydroelectric Projects.[1]

Species	**Population**	**Juv. Survival - FCRPS *Reach*** **Average** (Range) *Special Info.*	**Juv. Survival**[3] **– Mid-Columbia *Reach*** **Average (**Range) *Special Info.*	**Juv. Survival – Total** **Average (**Range) *Special Info.*
SR fall Chinook	Single Pop.	***LGR - BON*** **18.7 - 55.4** (12.4 – 71.7) *≈ 52% of the juveniles would be transported*		***LGR - BON*** **18.7 - 55.4** (12.4 – 71.7) *≈ 52% of the juveniles would be transported*
SR spr/sum Chinook	All Pops.	***LGR – BON*** **LGR >65 kcfs** **56.3** (47.5 – 60.8) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **37.3** (33.8 – 51.3) *≈ 95% of the juveniles would be transported*		***LGR – BON*** **LGR >65 kcfs** **56.3** (47.5 – 60.8) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **37.3** (33.8 – 51.3) *≈ 95% of the juveniles would be transported*
SR sockeye[4]	Single Pop.	***LGR - BON*** **LGR >65 kcfs** **36.4** (19.9 – 57.0) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **8.2** (Unknown) *≈ 95% of the juveniles would be transported*		***LGR - BON*** **LGR >65 kcfs** **36.4** (19.9 – 57.0) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **8.2** (Unknown) *≈ 95% of the juveniles would be transported*
SR steelhead	All Pops.	***LGR – BON*** **LGR >65 kcfs** **38.9** (20.3 – 56.9) *≈ 79% of the juveniles would be transported* **LGR <65 kcfs** **7.5** (3.3 – 23.1) *≈ 94% of the juveniles would be transported*		***LGR – BON*** **LGR >65 kcfs** **38.9** (20.3 – 56.9) *≈ 79% of the juveniles would be transported* **LGR <65 kcfs** **7.5** (3.3 – 23.1) *≈ 94% of the juveniles would be transported*

Species	Population	Juv. Survival - FCRPS *Reach* **Average** (Range) *Special Info.*	Juv. Survival[3] – Mid-Columbia *Reach* **Average** (Range) *Special Info.*	Juv. Survival – Total **Average** (Range) *Special Info.*
UCR spring Chinook	Methow Entiat Wentachee	***MCN – BON*** **66.7** (60.9 – 72.9)	***WEL – PRD*** **67.9** ***RRE – PRD*** **70.6** ***RIS – PRD*** **76.7**	***WEL – BON*** **45.3** ***RRE – BON*** **47.1** ***RIS – BON*** **51.2**
UCR steelhead	Methow / Okanogan Entiat Wentachee	***MCN – BON*** **47.9** (16.8 – 67.4)	***WEL – PRD*** **68.9** ***RRE – PRD*** **71.7** ***RIS – PRD*** **74.8**	***WEL – BON*** **33.0** ***RRE – BON*** **34.3** ***RIS – BON*** **35.8**
MCR steelhead[2,5]	Yakima / Walla Walla Umatilla / John Day Deschutes BON pool	***(MCN, JDA, TDA) – BON*** **47.6** (17.2 – 67.1) **53.6** (23.2 – 72.1) **73.0** (61.5 – 77.6) **90.0** (80.6 – 93.0)		***(MCN, JDA, TDA, BON Pool) – BON*** **47.6** (17.2 – 67.1) **53.6** (23.2 – 72.1) **73.0** (61.5 – 77.6) **90.0** (80.6 – 93.0)
LCR Chinook[2]	BON pool	***BON Pool*** **95.1** (94.4 – 95.9)		***BON Pool*** **95.1** (94.4 – 95.9)
LCR steelhead[2,6]	BON pool	***BON Pool*** **90.6** (80.3 – 94.7)		***BON Pool*** **90.6** (80.3 – 94.7)
CR coho[2]	BON pool	***BON Pool*** **95.1** (94.4 – 95.9)		***BON Pool*** **95.1** (94.4 – 95.9)
CR chum[2]	BON pool	***BON Pool*** **95.1** (94.4 – 95.9)		***BON Pool*** **95.1** (94.4 – 95.9)

Sources: NMFS' 1) Supplemental Comprehensive Analysis Document (May 5, 2008a); and 2) Biological Opinion – Consultation on Remand for Operation of the Federal Columbia River Power System, 11 bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (May 5, 2008b).

[1] Key to Dams: BON = Bonneville Dam, TDA = The Dalles Dam, JDA = John Day Dam, MCN = McNary Dam, PRD = Priest Rapids Dam, WAN = Wanapum Dam, RIS = Rock Island Dam, RRE = Rocky Reach Dam, WEL = Wells Dam, IHR = Ice Harbor Dam, LMN = Lower Monumental Dam, LGS = Little Goose Dam, and LGR = Lower Granite Dam.

[2] The estimates for these ESUs only apply to those juveniles migrating from tributaries entering the reservoir upstream of Bonneville Dam, or in the case of MCR steelhead, the juvenile populations migrating from tributaries entering the Columbia River between Bonneville Dam and McNary Reservoir.

[3] Current reach survival estimates for the Mid-Columbia projects are based on the following:

- ***Wells (96.2% for spring Chinook and steelhead)*** - average of the 1998 (99.7%) Chinook study, and 1999 (94.3%) and 2000 (94.6%) steelhead studies as reported in NMFS 2002;

- ***Rocky Reach (92.1% for spring Chinook)*** – average of 2004-2005 studies (93.0% and 91.1%, respectively) as reported in Skalski et al (2006), and ***(95.8% for steelhead)*** - average of 2004-2006 studies (98.3%, 93.0%, and 96.0%, respectively) as reported in Anchor Env. and Chelan PUD (2007) and Skalski et al (2006);

- ***Rock Island (93.4% for spring Chinook)*** – average of 2002-2004 studies (95.6%, 93.4%, and 91.4%, respectively) as reported in Anchor Env. and Chelan PUD (2004) and Skalski et al (2006), and ***(94.1% for steelhead)*** – average of 2004-2006 studies (96.6%, 91.6%, and 94.0%, respectively) as reported in Anchor Env. and Chelan PUD (2007) and Skalski et al (2006);

- ***Wanapum and Priest Rapids (82.0% for spring Chinook)*** – estimated using data from PIT tag studies conducted by Chelan PUD in 1998, 2001, 2002, and 2003 as reported in NMFS 2004 – Table A-2 (90.5% per project); and ***(79.5% for steelhead)*** - estimated using data from PIT tag studies conducted by Chelan PUD in 1999 and 2000 as estimated in NMFS 2004 – Table A-2 (89.1% per project).

[4] Williams et al. 2005 provided estimated survival rates ranging for PIT tagged SR sockeye migrating from Lower Granite to McNary Dams in 2000 to 2003. Of these years, 2001, is most representative of the <65 kcfs flow condition – though still conservative because little spill was provided at the mainstem dams for passage in that year. Survival in this year was estimated at 23.9 percent. The remaining years are representative of the >65 kcfs flow condition. Survival rates ranged from 39.7% to 72.5% (average of 56.1%) in these years. An average per project survival was estimated for this reach (LGR to MCN survival ^ (1/4) = 86.5% per project) and then expanded to a Lower Granite to Bonneville Dam (7 project) reach survival estimate (LGR to BON (per project survival estimate ^ 7 = 36.4%).

[5] Within the Bonneville pool, Klickitat River and 15 Mile Creek populations of steelhead are part of the Mid Columbia River steelhead Distinct Population Segment.

[6] Within the Bonneville pool, Hood River and Wind River populations of steelhead are part of the Lower Columbia River steelhead Distinct Population Segment.

Table 3: "Prospective" (approximately 2014 and beyond) Juvenile Survival Estimates for ESA-listed Columbia River Basin Salmon and Steelhead Populations Migrating Inriver Past Mainstem Hydroelectric Projects.[1]

Species	**Population**	**Juv. Survival - FCRPS *Reach*** **Average** (Range) *Special Info.*	**Juv. Survival[3] – Mid-Columbia *Reach*** **Average (**Range) *Special Info.*	**Juv. Survival – Total** **Average (**Range) *Special Info.*
SR fall Chinook	Single Pop.	***LGR - BON*** **18.7 - 55.4** (12.4 – 71.7) *≈ 52% of the juveniles would be transported*		***LGR - BON*** **18.7 - 55.4** (12.4 – 71.7) *≈ 52% of the juveniles would be transported*
SR spr/sum Chinook	All Pops.	***LGR – BON*** **LGR >65 kcfs** **62.8** (58.0 – 67.8) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **51.9** (46.7 – 57.2) *≈ 95% of the juveniles would be transported*		***LGR – BON*** **LGR >65 kcfs** **62.8** (58.0 – 67.8) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **51.9** (46.7 – 57.2) *≈ 95% of the juveniles would be transported*
SR sockeye[4]	Single Pop.	***LGR - BON*** **LGR >65 kcfs** **42.8** (23.5 – 64.6) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **9.8** (Unknown) *≈ 88% of the juveniles would be transported*		***LGR - BON*** **LGR >65 kcfs** **42.8** (23.5 – 64.6) *≈ 64% of the juveniles would be transported* **LGR <65 kcfs** **9.8** (Unknown) *≈ 88% of the juveniles would be transported*
SR steelhead	All Pops.	***LGR – BON*** **LGR >65 kcfs** **45.3** (23.9 – 64.5) *≈ 74% of the juveniles would be transported* **LGR <65 kcfs** **9.1** (4.0 – 20.7) *≈ 89% of the juveniles would be transported*		***LGR – BON*** **LGR >65 kcfs** **45.3** (23.9 – 64.5) *≈ 74% of the juveniles would be transported* **LGR <65 kcfs** **9.1** (4.0 – 20.7) *≈ 89% of the juveniles would be transported*

Species	Population	Juv. Survival - FCRPS *Reach* Average (Range) *Special Info.*	Juv. Survival[3] – Mid-Columbia *Reach* Average (Range) *Special Info.*	Juv. Survival – Total Average (Range) *Special Info.*
UCR spring Chinook	Methow Entiat Wentachee	***MCN – BON*** **72.6** (65.4 – 79.6)	***WEL – PRD*** **72.3** ***RRE – PRD*** **75.1** ***RIS – PRD*** **80.8**	***WEL – BON*** **52.5** ***RRE – BON*** **54.5** ***RIS – BON*** **58.7**
UCR steelhead	Methow / Okanogan Entiat Wenatchee	***MCN – BON*** **52.8** (17.3 – 73.8)	***WEL – PRD*** **75.0** ***RRE – PRD*** **78.0** ***RIS – PRD*** **81.4**	***WEL – BON*** **39.6** ***RRE – BON*** **41.2** ***RIS – BON*** **43.0**
MCR steelhead[2,5]	Yakima / Walla Walla Umatilla / John Day Deschutes BON pool	***(MCN, JDA, TDA) – BON*** **52.4** (17.9 – 73.3) **57.9** (23.9 – 77.7) **76.8** (64.5 – 82.2) **90.3** (80.3 – 93.2)		***(MCN, JDA, TDA, BON Pool) – BON*** **52.4** (17.9 – 73.3) **57.9** (23.9 – 77.7) **76.8** (64.5 – 82.2) **90.3** (80.3 – 93.2)
LCR Chinook[2]	BON pool	***BON Pool*** **95.5** (94.6 – 96.2)		***BON Pool*** **95.5** (94.6 – 96.2)
LCR steelhead[2,6]	BON pool	***BON Pool*** **90.8** (79.9 – 94.8)		***BON Pool*** **90.8** (79.9 – 94.8)
CR coho[2]	BON pool	***BON Pool*** **95.5** (94.6 – 96.2)		***BON Pool*** **95.5** (94.6 – 96.2)
CR chum[2]	BON pool	***BON Pool*** **95.5** (94.6 – 96.2)		***BON Pool*** **95.5** (94.6 – 96.2)

Sources: NMFS' 1) Supplemental Comprehensive Analysis Document (May 5, 2008a); and 2) Biological Opinion – Consultation on Remand for Operation of the Federal Columbia River Power System, 11 bureau of Reclamation Projects in the Columbia Basin and ESA Section 10(a)(1)(A) Permit for Juvenile Fish Transportation Program (May 5, 2008b).

[1] Key to Dams: BON = Bonneville Dam, TDA = The Dalles Dam, JDA = John Day Dam, MCN = McNary Dam, PRD = Priest Rapids Dam, WAN = Wanapum Dam, RIS = Rock Island Dam, RRE = Rocky Reach Dam, WEL = Wells Dam, IHR = Ice Harbor Dam, LMN = Lower Monumental Dam, LGS = Little Goose Dam, and LGR = Lower Granite Dam.

[2] The estimates for these ESUs only apply to those juveniles migrating from tributaries entering the reservoir upstream of Bonneville Dam, or in the case of MCR steelhead, the juvenile populations migrating from tributaries entering the Columbia River between Bonneville Dam and McNary Reservoir.

[3] Prospective reach survival estimates for the Mid-Columbia projects are based on the following:

- ***Wells (96.2% for spring Chinook and steelhead)*** - average of the 1998 (99.7%) Chinook study, and 1999 (94.3%) and 2000 (94.6%) steelhead studies as reported in NMFS 2002;

- ***Rocky Reach (93.0% for spring Chinook)*** – assumes that the minimum survival requirement of the Rocky Reach Habitat Conservation Plan will be met (NMFS 2002), and ***(95.8% for steelhead)*** - average of 2004-2006 studies (98.3%, 93.0%, and 96.0%, respectively) as reported in Anchor Env. and Chelan PUD (2007) and Skalski et al (2006);

- ***Rock Island (93.4% for spring Chinook)*** – average of 2002-2004 studies (95.6%, 93.4%, and 91.4%, respectively) as reported in Anchor Env. and Chelan PUD (2004) and Skalski et al (2006), and ***(94.1% for steelhead)*** – average of 2004-2006 studies (96.6%, 91.6%, and 94.0%, respectively) as reported in Anchor Env. and Chelan PUD (2007) and Skalski et al (2006);

- ***Wanapum and Priest Rapids (86.5% for spring Chinook and steelhead)*** – assumes the minimum survival standard (93.0% per project) for these species will be achieved (NOAA 2004).

[4] Williams et al. 2005 provided estimated survival rates ranging for PIT tagged SR sockeye migrating from Lower Granite to McNary Dams in 2000 to 2003. Of these years, 2001, is most representative of the <65 kcfs flow condition – though still conservative because little spill was provided at the mainstem dams for passage in that year. Survival in this year was estimated at 23.9 percent. The remaining years are representative of the >65 kcfs flow condition. Survival rates ranged from 39.7% to 72.5% (average of 56.1%) in these years. An average per project survival was estimated for this reach (LGR to MCN survival ^ (1/4) = 86.5% per project) and then expanded to a Lower Granite to Bonneville Dam (7 project) reach survival estimate (LGR to BON (per project survival estimate ^ 7 = 36.4%). To estimate the expected increase in survival between the “current” and “prospective” conditions, these estimates were adjusted by the estimated survival improvement of SR steelhead in the >65 kcfs flow year condition (45.3% [Prospective] - 38.9% [Current] = 6.4%) resulting in an estimate of 42.8% (36.4% + 6.4%). This was also done for the <65 kcfs flow year condition (9.1% [Prospective] – 7.5% [Current] = 1.6%) resulting in an estimate of 9.8% (8.2% + 1.6%).

[5] Within the Bonneville pool, Klickitat River and 15 Mile Creek populations of steelhead are part of the Mid Columbia River steelhead Distinct Population Segment.

[6] Within the Bonneville pool, Hood River and Wind River populations of steelhead are part of the Lower Columbia River steelhead Distinct Population Segment.

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DRAFT

Supplemental Recovery Plan Module for Snake River Salmon and Steelhead Mainstem Columbia River Hydropower Projects

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1. Introduction

This document incorporates by reference and supplements NMFS' *Recovery Plan Module, Mainstem Columbia River Hydropower Projects* (Hydro Module, dated September 24, 2008) for Snake River anadromous fish species listed under the Federal Endangered Species Act (ESA): Snake River spring/summer and Chinook and Snake River fall Chinook salmon, Snake River steelhead, and Snake River sockeye salmon (NMFS 2008a).[1] NMFS prepared this module to assist in recovery planning for listed Columbia basin species. The 2008 Hydro Module overviews limiting factors and threats, summarizes current recovery strategies, and provides estimates of juvenile and adult survival rates associated with the Columbia and Snake River hydropower and water storage projects. This 2014 Supplemental Module (hereafter "Supplemental Module") updates the scientific and technical information relevant to the four Snake River species, including an updated discussion of "latent" and "differential delayed" mortality. The geographic area addressed in the Hydro Module and the Supplemental Module extends from the accessible mainstem habitat in the Snake River (i.e., to the tailrace of Hells Canyon Dam) downstream to the tailrace of Bonneville Dam (see Figure 1 below).[2]

This Supplemental Module, together with the 2008 Hydro Module, will comprise the "Hydro Module," an appendix to the ESA Snake River "roll-up" Recovery Plan. The Hydro Module provides consistent information on the general effects of Columbia River mainstem hydropower and water storage projects.

This Supplemental Module incorporates new scientific data that assesses the implementation of the Reasonable and Prudent Alternative (RPA) described in the 2008 Federal Columbia River Power System (FCRPS) Biological Opinion (NMFS 2008a) and the 2009 Adaptive Management Implementation Plan, which we incorporated into the 2010 and 2014 FCRPS Supplemental Biological Opinions (NMFS 2010, 2014). This new information includes:

- Post-2008 configuration changes at FCRPS mainstem dams;
- Recent (2008-2013) data on juvenile survival following the installation of surface bypass structures;
- Recent (2008-2013) information on juvenile fish transportation;
- Recent (2008-2010) data on latent mortality.

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[1] This module is a supplement to the September 24, 2008 Hydro Module (*Recovery Plan Module, Mainstem Columbia River Hydropower Projects*; NMFS 2008b) in the sense that it updates the information in the 2008 module. The 2008 module and this supplement together serve as guidance for the recovery of the four Snake River salmon and steelhead species and the remaining nine listed salmonid species in the Columbia River.

[2] The *Columbia River Estuary ESA Recovery Plan Module for Salmon and Steelhead* (NMFS 2011) provides guidance for the recovery of all 13 listed species of salmon and steelhead in the Columbia basin based on limiting factors and threats in the lower Columbia River below Bonneville Dam.

We will continue to update this module in the future as emerging monitoring and research findings change our understanding of the ways that hydropower facilities in the Columbia basin affect the recovery of ESA-listed salmon and steelhead.

The new and updated information in this Supplemental Module is arranged in the following order:

- Hydropower System Overview
    - Limiting Factors & Threats
    - Recent Hydrosystem Improvements
- Adult and Juvenile Management Actions & Survival Rates
    - Adult Passage Management Actions & Conversion Rates
    - Kelt Management Actions & Survival Rates
    - Juvenile Passage Management Actions & Survival Rates
- Smolt to Adult Returns
- Key Uncertainties

2. Hydropower System Overview

Historically, the Snake River species traveled through a free-flowing river system as they migrated from their freshwater natal streams to the Pacific Ocean, and again as they returned as adults to spawn. Many dams were constructed by the Corps of Engineers, Bureau of Reclamation, and Idaho Power Company in the Snake River basin during the 20th century beginning with the construction of Swan Falls Dam and its hydroelectric plant in 1901. The reservoirs behind these dams inundated habitat, blocked access to upstream spawning and rearing areas, altered the natural hydrograph, and affected water quality (temperature, turbidity, etc.) and sediment transport processes. The construction of these water storage and hydro generating projects affected the ecological functions necessary for fish growth and survival. In the following paragraphs we describe the past and continuing effects of these dams and their operations on the four listed Snake River species and their designated critical habitat.

2.1 Limiting Factors & Threats

The reasons for a species' decline are generally described in terms of limiting factors and threats. Limiting factors are the biological, physical or chemical conditions and associated ecological processes and interactions that limit a species' viability. Threats are human activities or natural events, such as floodplain development or drought that cause or contribute to limiting factors.[3] The most dramatic effect of dams is blocked access to important historical production areas for salmon and steelhead. For example, prior to dam development the great majority of Snake River fall Chinook spawned primarily in the Thousand Springs and Marsing reaches of the Snake River, near Hagerman and Marsing, Idaho. Today, fall Chinook occupy the area downstream of the tailrace of Hells Canyon Dam, which represents approximately 18 percent of the historical range of this ESU (Groves and Chandler 2005, Williams et al. 2007). Those projects on the mainstem Snake and Columbia Rivers where fish passage has been provided affect salmonids in the following ways (Williams et al. 2005; Ferguson et al. 2005):

- Inundated mainstem spawning and shallow-water rearing areas (loss of spawning gravels and access to spawning and rearing habitat);
- Altered riparian vegetation;
- Altered water quality (reduced spring turbidity levels);
- Altered water quantity (seasonal changes in flows and consumptive losses resulting from use of stored water for agricultural, industrial, or municipal purposes);
- Influenced natural regulation of water temperature (including generally warmer minimum winter temperatures, cooler maximum summer temperatures, and delayed fall cooling);

[3] The term "threats" carries a negative connotation; however, they are often legitimate and necessary activities that at times may have unintended negative consequences on fish populations. These activities can be managed to minimize or eliminate the negative impacts.

- Altered water velocity (reduced spring flows, decreased channel gradient, and increased cross-sectional areas of the river channel);
- Altered habitat for predators in the reservoirs and in the tailrace of each mainstem dam
- Changed food webs (including the type and abundance of prey species [both native and non-native]); and
- Reduced or delayed safe fish passage.

Together these factors affect all Snake River species as they migrate through the Columbia and Snake River systems. The effects on fall Chinook salmon include changes in their spawning and rearing habitat because they use the mainstem river environment for these functions as well. In addition to access, important features of spawning and rearing habitat include spawning gravel, water quality, water quantity, water temperature, food, and riparian vegetation.

Detailed descriptions of the effects of the Columbia basin hydropower system on salmon and steelhead are provided in Williams et al. (2005) and Ferguson et al. (2005) and summarized in the 2008 Hydro Module and in Section 5.1 of NMFS (2008a).

In the following sections we provide new information on configuration and operational changes at the eight mainstem FCRPS projects; the five FCRPS reservoir storage projects; and Idaho Power Company's three-project Hells Canyon Complex on the Snake River.

2.2 Federal Columbia River Power System

The FCRPS has been the subject of two supplemental biological opinions since 2008:

- 2010 FCRPS Supplemental Biological Opinion (NMFS 2010), which amended the RPA to incorporate the 2009 Adaptive Management Implementation Plan (BPA et al. 2009)
- 2014 FCRPS Supplemental Biological Opinion (NMFS 2014), which made some modifications to the RPA

The following descriptions of recent hydrosystem improvements (and monitoring data on juvenile and adult survival rates) include the measures described in the 2008 RPA and in these two supplemental biological opinions.

2.2.1 Recent Changes to FCRPS Project Configurations and Operations

Most of the mainstem project configuration and operational improvements required by the 2008 FCRPS RPA (as amended in the 2010 Supplemental BiOp) were in place by 2012. All eight run-of-river dams on the lower Snake and lower Columbia rivers now have a surface oriented passage route (spillway weirs at six dams, a corner collector at Bonneville Dam, and an ice and trash sluiceway at The Dalles Dam). These facilities were designed to improve passage conditions for juvenile and adult salmon and steelhead. The most significant changes made during 2008 to 2013 were:

- In 2008, the U.S. Army Corps of Engineers (Corps) installed a spillway weir at Lower Monumental Dam and two spillway weirs at John Day Dam to provide surface oriented passage routes for downstream migrants.
- In 2009, the Corps installed a spillway weir at Little Goose Dam and increased summer spill levels at McNary Dam to 50 percent of total river flow, following several years of testing alternative operations.[4]
- In 2010, the Corps rebuilt the John Day Dam north adult fish ladder's flow control section, installing redesigned weirs to improve passage conditions for adult salmon and steelhead.
- In 2010, the Corps completed construction of a spillway wall at The Dalles Dam. This structure, along with improved avian predator deterrents (wire arrays), has substantially increased the survival of juvenile salmon passing the dam by about 2 to 4 percent. Wire arrays were also installed in the tailrace of John Day Dam. The Corps discontinued the use of the temporary spillway weirs (TSW) at McNary Dam during the summer migration period because survival rates for subyearling fall Chinook were lower than through standard spillbays at this dam.

[4] Before 2005, no spill was provided after June 30. A determination of when to begin transporting juvenile fish reaching this project was made by the Technical Management Team based on their assessment of in-river migration conditions. Spring migrants have not been transported from McNary Dam since 1994.

- In 2012, the Corps relocated the juvenile bypass outfalls at Lower Monumental and McNary dams. In both cases, the old outfalls released fish into the slower-moving water close to the shoreline, exposing them to concentrations of predatory fish and birds. The new outfalls are further downstream and further from shore, where higher velocities prevent predatory fishes from maintaining their positions. This has increased the survival of juvenile salmon and steelhead passing each dam via the turbine bypass system.
- In 2013, the Corps installed adult PIT tag detectors in the ladders at The Dalles Dam, which will help fisheries managers identify adult losses or passage delays in the lower Columbia River.
- The Corps is planning to install adult PIT tag detectors in the ladders at Lower Monumental and Little Goose dams in 2014, which will help fisheries managers identify adult losses or passage delays in the lower Snake River.

2.2.2 Adult Management Actions & Conversion Rate (Minimum Survival) Estimates

The duration of the upstream migration of adults through the mainstem FCRPS projects is relatively unchanged compared to an undammed river. While adults are delayed as they search for fishway entrances and navigate through the fishways themselves, they migrate faster through the relatively low velocity reservoir environments. Water management operations at large upstream flood control storage projects in the United States and Canada, mainstem run-of-river reservoirs, and changing climate patterns have altered the thermal regime of the Snake and Columbia Rivers compared to the predevelopment period. In general, the mainstem Snake and Columbia Rivers now have higher minimum winter temperatures and lower maximum summer temperatures, and are cooler later in the spring and warmer later in the fall. The combined effects of these alterations could benefit adults that migrate during the spring and much of the summer (spring and summer Chinook salmon and early migrating sockeye salmon and steelhead), but could increase the exposure of fall Chinook salmon and later migrating sockeye and steelhead (which migrate in the late summer and fall) to elevated temperatures. The Corps operates Dworshak Dam, on the North Fork Clearwater River, during July, August, and September to maintain cooler summer temperatures in the lower Snake River to benefit summer migrating adult salmon and steelhead and juvenile fall Chinook salmon.

Adult salmon and steelhead can pass each of the eight mainstem dams in the lower Snake and Columbia rivers volitionally at fish ladders. In general, we consider these adult passage facilities to be highly effective. For example, the current estimate of average adult Snake River spring/summer Chinook salmon survival (conversion rate estimates using known-origin adult fish after accounting for "natural straying" and mainstem harvest) between Bonneville and Lower Granite dams (2008-2012) is approximately 82.4 percent (Table 1).[5,6] Prior to 2010 there

[5] These adult survival estimates capture all sources of mortality within the Bonneville to Lower Granite dam reach, including those resulting from the existence and operation of the FCRPS, unquantified levels of mortality from other potential sources (e.g., unreported or delayed mortality caused by fisheries, marine mammal attacks, etc.), and unquantified levels of "natural' mortality (i.e., levels that would have occurred without the influence of human activities).

were not enough detections of PIT tagged adult SR sockeye in the system for assessing conversion rates. We therefore used PIT tag detections from upper Columbia River sockeye stocks as surrogates to assess survival rates in the lower Columbia River reach and extrapolated these to assess likely survival rates for the entire Bonneville to Lower Granite dam migration corridor. As the captive broodstock program is beginning to increase the number of adults returning to Bonneville Dam, we are now able to make direct estimates of survival to Lower Granite Dam. The average for the 2010 to 2012 migration years was 70.4 percent (Table 1).

Table 1. Adult salmon and steelhead survival estimates (adjusted for reported harvest and natural rates of straying) based on PIT tag conversion rate analysis for SR salmon ESUs and the steelhead DPS from Bonneville (BON) to McNary (MCN) dams, McNary to Lower Granite (LGR) dams, and Bonneville to Lower Granite dams. Sources: http://www.PTAGIS.org; WDFW and ODFW 2013, 2014; Appendix A in NMFS 2008c.

Species	Years	BON to MCN	MCN to LGR	BON to LGR
SR Fall Chinook	2008-2012 Avg	93.5%	96.9%	90.5%
SR Spr/Sum Chinook	2008-2012 Avg	87.6%	94.1%	82.4%
SR Sockeye	2010-2012 Avg[1]	75.7%	93.0%	70.4%
SR Steelhead	2008-2012 Avg	91.7%	88.7%	81.1%

[1] Only known origin SR sockeye salmon were used to assess adult reach survival from 2010 to 2012.

2.2.2.1 Adult passage blockages at Lower Granite Dam in 2013

Low summer flows, combined with high air temperatures and a period of little or no wind, created thermally stratified conditions in Lower Granite reservoir during late July 2013 such that the lens of warm surface water entered the adult ladder which disrupted fish passage for more than a week. The Corps pumped cooler water from deeper in the forebay into the ladder to enhance fishway entrance conditions. Modified operations, combined with cooler weather, allowed fish to resume passing the dam. Unadjusted PIT tag based conversion rates from Ice Harbor to Lower Granite Dam indicated that about 30 percent of the migrating sockeye salmon failed to pass Lower Granite Dam and most likely died without spawning. Fewer summer-run Chinook were affected (about 15 percent), but this is still a substantial effect.

A similar event occurred in September, blocking passage for fall Chinook salmon and for steelhead for about a week. The same combination of pumping cooler water from deeper in the forebay and modifying operations combined with more favorable weather conditions allowed adults to resume their migration, However, this event resulted in an estimated 7 percent of fall Chinook salmon and 12 percent of steelhead failed to pass Lower Granite Dam.

[6] Although NMFS believes this method provides the best scientific data available, it is possible that the harvest estimates – which were not generated specifically for PIT tagged fish – may be inaccurate for this purpose or biased in some other way. Further work is being done to assess this potential issue.

The Corps of Engineers is evaluating options to deliver cooler water into the ladder entrance and adult trap with the intent of designing and constructing the needed structures in time for the 2015 migration. In the event of this situation recurs in 2014, the Corps plans to employ the measures that were developed in 2013 and use pumps to draw additional cool water into the ladder entrances and adult trap to minimize the temperature effects and provide passage.

2.2.3 Snake River Steelhead Kelt Survival Rates

Unlike other Pacific salmonids, a large fraction of the adult steelhead do not die after spawning. Instead, these fish, termed “kelts,” migrate back to the ocean and then return in subsequent years as repeat spawners. Estimates of FCRPS kelt passage survival in the FCRPS have ranged from 4.1 to 6.0 percent in the low flow year 2001 to 15.6 percent in 2002 and 34 percent in 2003 (Boggs and Peery 2004; Wertheimer and Evans 2005). Although some portion of the implied mortality would occur in a free-flowing river, fisheries managers expect that survival is low because turbine bypass systems were not designed to safely pass adult fish. In addition to causing injury and mortality, the mainstem hydro projects delay kelt downstream migrations (Wertheimer and Evans 2005). Boggs and Peery (2004) and Wertheimer and Evans (2005) estimated that 17 to 25 percent of the steelhead that pass Lower Granite Dam return downstream as kelts. Thus, while there may be a relatively large number of kelts in Snake River, survival through the FCRPS may limit their contribution to the productivity of their respective populations.

BPA and the Corps have developed a Kelt Management Plan (BPA and USACE 2012) to improve the productivity of B-run Snake River steelhead populations by about 6 percent as required by the 2008 FCRPS BiOp (RPA 33). BPA and the Corps is pursuing three strategies for attaining the remaining survival improvements necessary to achieve this goal: implement measures to improve inriver survival of migrating kelts, collect and transport kelts to areas below Bonneville Dam to improve adult return rates, and long-term reconditioning to increase the number of viable females on the spawning grounds.

The Kelt Management Plan includes using surface passage routes at lower Columbia dams outside of the juvenile migration season to increase the survival of kelts moving back downstream. These include expanded operations at the ice and trash sluiceway at The Dalles Dam. Researchers are evaluating the behavior of adult steelhead at McNary Dam during winter 2012 and 2013 for modifications that could protect downstream migrants.

The installation of spill weirs and other surface passage routes at each of the mainstem FCRPS dams to improve juvenile passage has also benefited kelts. In 2012, Coleto et. al. (2013) estimated that about 40% of the kelts released at or above Lower Granite Dam survived to river kilometer 156 (downstream of Bonneville Dam); compared to estimated survival rates of about 4 to 16% in 2001 and 2002. The median travel time from Lower Granite to Bonneville Dam in 2012 was nine days compared with 27 days in 2001 (BPA and USACE 2013) and 19 days in 2002 (Wertheimer and Evans 2005). Although average Snake River flows were much higher in 2012 than in 2001 or 2002, which would be expected to reduce travel time, the scale of the improvement strongly suggests that improved surface passage routes are also a factor. Shorter travel times are likely to indirectly affect survival through the lower estuary and nearshore ocean environment by reducing stress and the amount of energy expended during the downstream migration.

The returns of transported kelts averaged 1.17%, compared to 0.68% for inriver migrating kelts over a 5-year period (BPA and USACE 2013b). However, until more good condition kelts are available, transportation will occur only after the capacity of the rehabilitation research facility at Dworshak Hatchery is exceeded.

Long-term reconditioning at the Dworshak Hatchery rehabilitation research facility continues to have potential for increasing kelt survival in the short term. To date, success rates have been somewhat inconsistent, but recent improvements to the facility should substantially increase the success rate of this program. (BPA and USACE 2013b) About 38% (10-year average) of the kelts in a similarYakima Basin program are being rehabilitated and released to spawn again (Hatch et al. 2013).

2.2.4 Juvenile Dam Passage Survival

Snake River juvenile migrants pass eight federal mainstem dams on their way to the ocean. They pass these mainstem dams via three potential routes: through turbines, by way of the spillway, or through the juvenile bypass system. Empirical studies indicate survival typically is highest through spillways, followed by bypass systems and then turbines (Muir et al. 2001). These studies have shown that juvenile salmon experience abut an 11 percent mortality rate per mainstem dam when they pass by way of turbines (Whitney et al. 1997). Mortality can be caused by striking the turbine runners, exposure to rapid and severe pressure changes that occur in the turbine environment, predation of fish emerging from the turbine tube into the project tailrace in a disoriented state, or other factors. The Corps has constructed juvenile bypass systems at the mainstem FCRPS dams to reduce the number of fish that pass through turbines. Large underwater screens partially cover the turbine intakes, creating a hydraulic field that guides the juvenile migrants into the bypass system. The juvenile fish then pass horizontally through the dam's interior through a series of galleries then through an outfall pipe to the tailrace. At some dams (Lower Granite, Little Goose, Lower Monumental, and McNary dams) the bypassed fish can be collected for barge or truck transport to below Bonneville Dam, but at the other four facilities they can only be discharged downstream into the river.

Fish can also pass the mainstem dams via spillways. All of the mainstem dams are equipped with spillways, which were designed to allow the controlled release of water from behind the dam when flow in the river would exceed the power house capacity or when there is no market for the energy that would otherwise be produced. Flow over the spillway is controlled by large gates, which must be raised to allow water to pass at a depth of 40 feet or more. Water spilled to provide a safer passage route for juvenile fish even when flows are below powerhouse capacity (rather than running the water through turbines to produce electricity) is called “voluntary” spill. Whether or not it is voluntary, as spill levels increase, the proportion of smolts passing through turbines (and bypass systems) generally decreases. The Corps has voluntarily spilled water as a means to increase the survival of smolts passing dams on the Snake and Columbia rivers since 1994, although the proportion of flow spilled for fish has increased over time.

Although spillways generally provide the highest survival rates for migrating juveniles, spillways were not designed for this purpose. Most yearling Chinook salmon migrate in the upper 10 to 20 feet of the water column (and steelhead are even shallower) and must dive 40 to 60 feet to take advantage of the spillway passage route. In addition, water plunging over the spillway increases the amount of total dissolved gas (TDG) in the water below the dams to levels that can injure or even kill fish. At present, spill levels that result in TDG levels in excess of the national water quality standard of 110% of saturation are allowed during the juvenile fish migration period (April through August) through “waivers” issued by the Oregon Department of Environmental Quality and Washington Department of Ecology. Because the effects of total dissolved gas on aquatic organisms are moderated by hydrostatic pressure—each meter of depth compensates for 10% of gas supersaturation as measured at the water surface—NOAA Fisheries has determined that as long as the water is deep enough for fish to migrate 2 meters below the surface, they will not be harmed. Thus, the waivers allow managers the ability to increase spill levels (beyond those that could occur without a waiver) to provide effective passage for juvenile migrants at the mainstem Columbia and Snake River dams.

During the early 2000s, hydrosystem biologists and engineers designed surface spillway weirs to capitalize on the natural tendency of juvenile salmonids to migrate at shallow depths (Beeman et al. 2006). Each spillway weir design is based on the concept of providing an overflow weir with a depth similar to the natural migration depths of juvenile Chinook and steelhead (Beeman et al. 2010). Empirical studies have shown that surface spillway weirs have guided enough fish away from the turbine and bypass system passage routes that total dam passage survival rates (for all routes combined) have increased (Beeman et al. 2010).

Fish passage operations including voluntary spill levels at lower Snake and Columbia River dams have been relatively stable since 2010 and the Corps of Engineers have made substantial progress during the past five years in implementing the structural improvements anticipated in the 2008 BiOp. Survival studies show that with few exceptions, these measures are performing as expected and are very close to achieving, or are already achieving, the juvenile dam passage survival objectives of 96 percent for yearling Chinook salmon and steelhead and 93 percent for subyearling Chinook salmon (in NMFS 2014). We expect the Action Agencies (U.S. Army Corps of Engineers, Bonneville Power Administration, and U.S. Bureau of Reclamation) to complete the remaining configuration and operational improvements and the associated juvenile performance standard testing by 2018.

2.2.4.1 Juvenile Inriver Reach Survival Estimates

Inriver reach survival estimates allow us to assess the combined effects of background environmental conditions, actions at the run-of-river projects within the lower Snake and Columbia River migration corridor, and water management operations at upstream storage projects on juvenile migrants. Because they estimate survival over distances of hundreds of miles and time periods of days to weeks, they are influenced by factors such as the condition and health of these fish when they first reach the mainstem and interactions between run timing and environmental conditions. To derive these estimates, thousands of juvenile salmon and steelhead are PIT tagged at or above Lower Granite Dam each year. Detections at mainstem dams (in juvenile bypass systems or the corner collector at Bonneville Dam) and in the estuary allow NMFS to estimate survival rates through the Lower Granite to Bonneville reach. We reported estimates of expected average annual juvenile survival rates in the 2008 Hydro Module derived from the COMPASS model, calibrated with the empirical data from wild (natural origin) migrants available at the time. We presented two scenarios, "Current" (survival through the hydrosystem under the operational and configuration changes at the mainstem hydroelectric projects through 2006) and "Prospective" (expected survival by 2014-2018, following implementation of key actions in the 2008 RPA). The 2008 to 2010 reach survival estimates for yearling Chinook salmon obtained from empirical PIT tag detections (Figure 1) were within the ranges of the "Current" survival rates considered in the 2008 BiOp (range = 33.9 to 60.8 percent, mean of 52.8 percent; see Appendix F, Inriver Juvenile Survival in NMFS 2008c). More recent (2011 to 2013) empirical estimates are consistent with, or slightly higher than, the "Prospective" survival rates (range = 46.7 to 67.8 percent, mean of 60.8 percent) expected in the 2008 BiOp.

Similar empirical (PIT tag) estimates for wild yearling SR steelhead ranged from about 42 to 57 percent during 2008-2013, about double the average survival rates estimated for the Base Period (26.5 percent) and higher than both the average Current survival rates (range = 3.3 to 56.9 percent, mean = 33.1 percent) and the Prospective survival rates (range = 4.0 to 64.4 percent, mean = 38.5 percent) in the 2008 BiOp (Figure 2). We do not report an empirical estimate for juvenile steelhead in 2012 because so few of the PIT tagged fish were detected at both Bonneville Dam and the estuary that the standard error was greater than 15%.

Increased smolt production from the SR sockeye captive broodstock program and the ability to tag and release larger groups for reach survival studies has substantially improved the accuracy of the empirical estimates for the Lower Granite to Bonneville Dam reach since 2008: 40.4 to 57.3 percent. These are higher than the average Current estimate derived from COMPASS modeling in the 2008 BiOp, and four of the five empirical estimates are higher than the average Prospective estimate in the 2008 BiOp (Figure 3). We do not present a survival estimate for SR sockeye salmon in 2011 because too few PIT-tagged fish were detected at both Bonneville dam and the downstream pair-trawl detector for adequate precision.

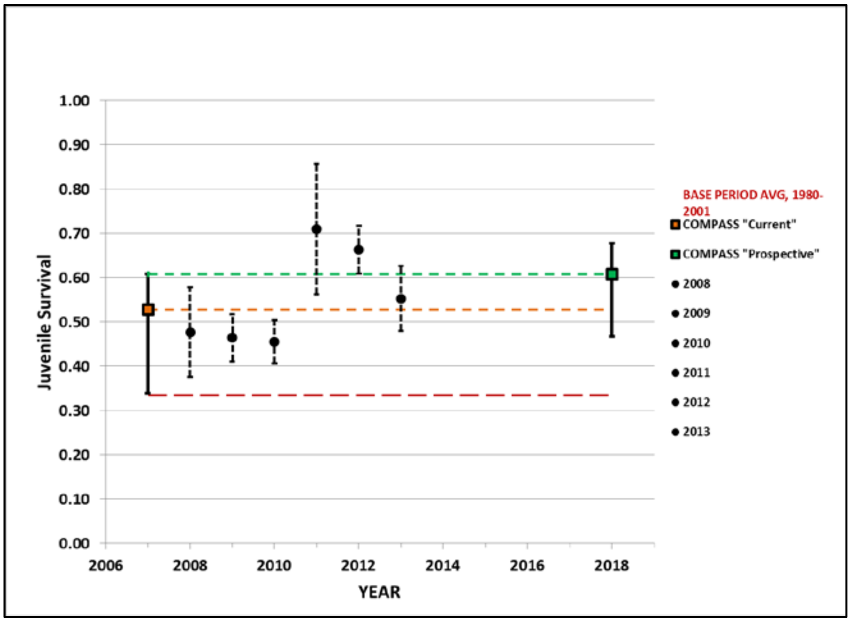


Figure 1. Lower Granite to Bonneville dam survival estimates (standard error) for wild SR spring/summer Chinook salmon (2008–2012) compared to Base Period (bottom horizontal dashed line), Current (middle horizontal dashed line), and Prospective (top horizontal dashed line) average estimates (ranges are indicated by vertical bars) in the 2008 BiOp.

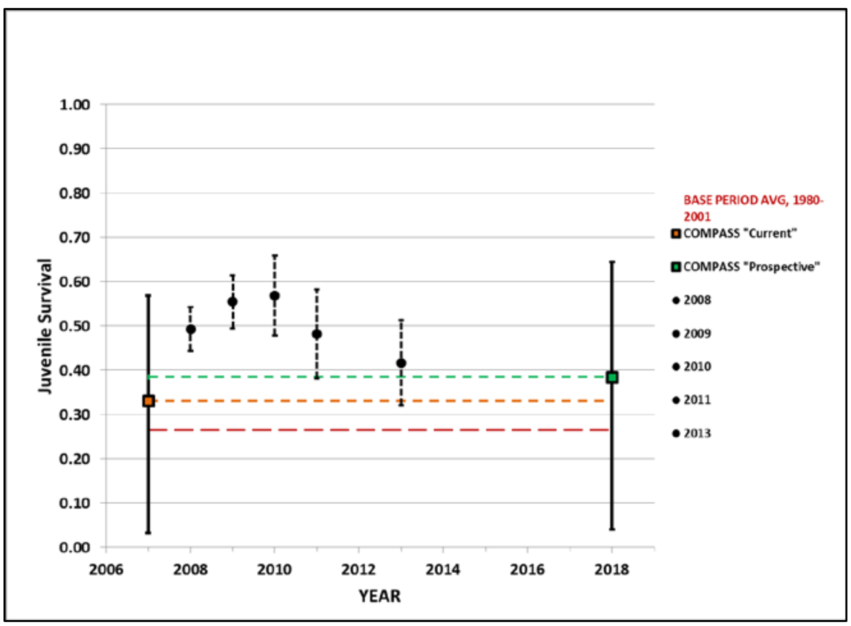


Figure 2. Lower Granite to Bonneville dam survival estimates (standard error) for wild SR steelhead (2008–2012) compared to Base Period (bottom horizontal dashed line), Current (middle horizontal dashed line), and Prospective (top horizontal dashed line) average estimates (ranges are indicated by vertical bars) in the 2008 BiOp.

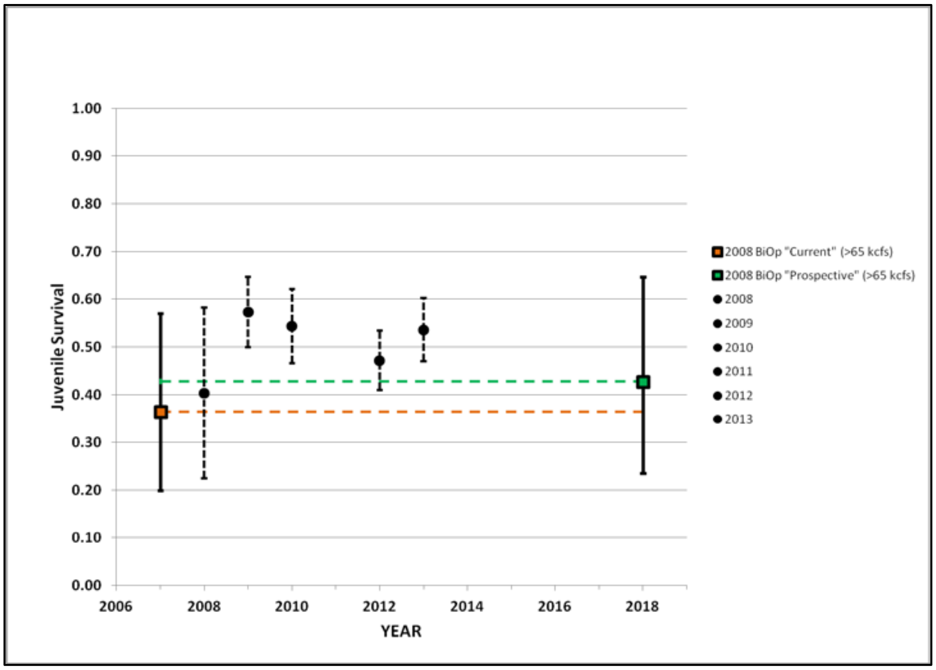


Figure 3. Lower Granite to Bonneville dam survival estimates (standard error) for wild SR sockeye salmon (2008–2012) compared to Current (bottom horizontal dashed line) and Prospective (top horizontal dashed line) average estimates (ranges are indicated by vertical bars) in the 2008 BiOp.

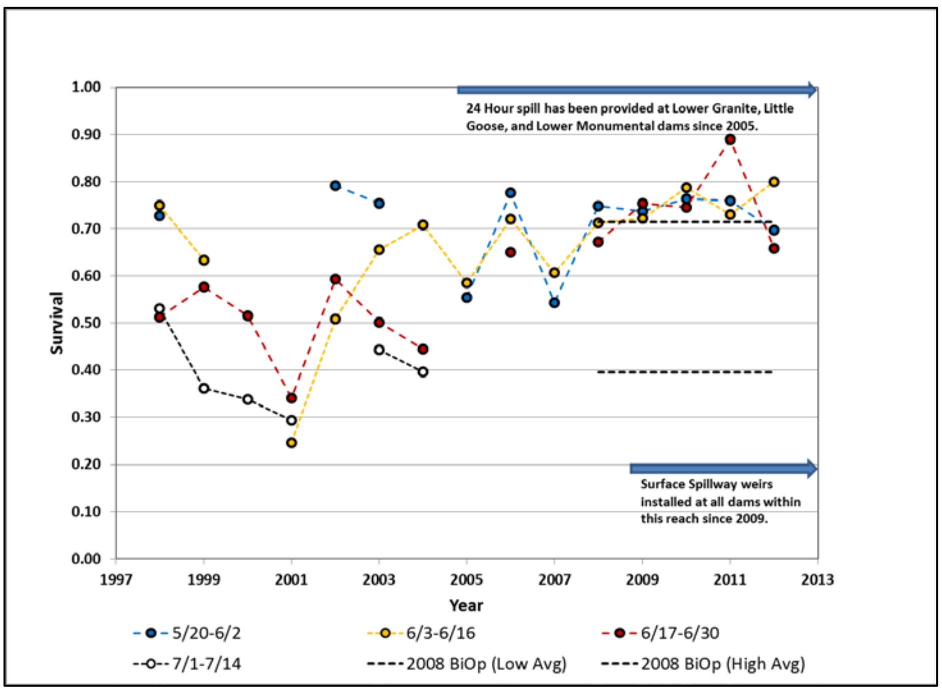


Figure 4. Estimated survival rates from two-week cohorts of juvenile subyearling SR fall Chinook salmon between Lower Granite and McNary Dams from 1998 to 2012. Black horizontal dashed lines denote Prospective minimum and maximum average survival rates estimated in the 2008 BiOp; blue arrows denote years in which Court Ordered summer spill occurred at the three Snake River transport projects (top) and years in which all dams in this reach were configured with surface passage routes (bottom).

The Action Agencies began providing summer spill at the three Snake River collector projects in 2005 in response to an order from a District Court.[7] Survival rates during the years affected by summer spill, prior to and including the installation of surface passage routes such as weirs at each of the five projects in the Lower Granite to McNary reach, are shown in Figure 4. Prior to 2005, survival estimates for subyearling SR fall Chinook between Lower Granite and McNary dams ranged from about 25 to nearly 80 percent, trending lower as the season progressed (i.e., groups passing later in the season typically had lower survival rates than those passing earlier). Between 2005 and 2008 (the last year before all of the new surface passage routes were installed), fish migrated earlier (i.e., there are now too few smolts passing Lower Granite Dam in the July 1 to July 14 period to make up a cohort for estimating survival) and survival rates were substantially higher, ranging from about 56 to 78 percent for individual cohorts.[8] From 2009-2012, years when both summer spill and surface passage routes were in effect, survival rates ranged from 66 to 89 percent for individual cohorts and all but two cohorts of fish tracked during this period exceeded the highest average survival rate expected (as a result of fully implementing the RPA) in the 2008 BiOp (71 percent).

In summary, reach survival estimates for subyearling SR fall Chinook salmon and yearling spring/summer Chinook salmon, sockeye salmon, steelhead, all appear to be meeting or, in the case of fall Chinook salmon, sockeye, and steelhead, substantially exceeding both Current and Prospective 2008 BiOp expectations for migrating smolts. As noted in the 2010 Supplemental BiOp (see Section 2.2.2.2), on a per-kilometer basis, these survival rates are approaching those estimated for several free-flowing river systems. In general, we expect these increased average survival rates for inriver migrating juveniles to result in increased adult returns.

Direct survival

Many juvenile salmon and steelhead do not survival their journey through the Columbia River to the ocean. Direct estimates of survival can be measured at a dam, through a reservoir, or past a series of dams and reservoirs using either passive (e.g., passive integrated transponder or "PIT") or active (e.g., radio or acoustic) tags. In most studies, direct survival is measured from an upstream point to a location immediately below a dam or below a series of dams. The mortality rate can be calculated as 1 minus the observed survival rate (e.g., 1.00 – 0.98 survival rate = 0.02 or 2 percent mortality).

Latent Mortality

More complex is the concept of latent, or indirect, mortality. In terms of the Columbia River hydrosystem, it is defined as the mortality that occurs after a juvenile fish passes Bonneville Dam that would not occur in a free-flowing system of equal length (Williams et al. 2005). The concept assumes that juveniles passing through the FCRPS experience a certain degree of harm, which reduces the likelihood of that some proportion will survive to return as spawning adults. Potential causes of latent mortality include:

[7] NOAA Fisheries has since incorporated summer spill at these projects into the RPA.

[8] Researchers group the data for all juvenile migrants entering the hydrosystem within each 2-week block of time into a "cohort" in order to estimate any changes in survival rates across the season (i.e., within a migration year).

- Delayed arrival timing in the estuary and ocean (the series of dams and reservoirs increases juvenile travel time through the migration corridor);
- Sublethal injuries or stress incurred during migration through juvenile bypass systems, turbines, or spillways;
- Disease transmission or stress resulting from the artificial concentration of fish in bypass systems;
- Depletion of energy reserves from prolonged migrations;
- Altered conditions in the estuary and plume as a result of water management operations; and
- Disrupted homing ability in fish transported as juveniles.

Most researchers agree that some level of latent mortality exists. However, there are many opinions regarding what mechanisms are important and by extension, what managers can do to minimize or mitigate for these effects in the future. For example, Williams et al. (2005) posited that a major component of latent mortality was the disrupted migration timing of transported fish and inriver migrants and that the effect of interactions between latent mortality and ocean conditions was likely to vary seasonally. Schaller and Petrosky (2007) found that Snake River Chinook salmon adult return rates were substantially lower after construction of the four lower Snake River dams than during the years preceding their existence. More recently, the DeHart (2010) conducted a literature review and concluded that passage through turbines and bypass systems at the mainstem dams results in significant latent and differential delayed mortality of juvenile salmonids, which in turn reduces adult returns. Similarly, Buchanan et al. (2011) reviewed the effects of juvenile bypass systems and found that for some species, adult return rates were consistently lower for individuals that experienced bypass systems than for smolts that used turbines or spillways. They further noted that some pairs of dams had synergistic effects – where the experience of using two or more bypasses had a greater statistical effect on adult returns than the sum of the effect of each bypass individually.

The Independent Scientific Advisory Board (ISAB) reviewed a number of hypotheses relating causative factors for latent mortality. The panel noted that researchers have made estimates of latent mortality that range from 0.01 to 64 percent (ISAB 2007). The management implications of these vastly different estimates are substantial. If the 64 percent figure is accurate, then the adverse effects of FCRPS passage would be greater than currently known requiring consideration of commensurate reconfiguration actions to support recovery objectives. Conversely, if the 0.01 percent estimate is correct, mainstem passage would not play a significant role in post-Bonneville survival rates. The ISAB (2007) strongly advised against continuing efforts to measure absolute latent mortality because it requires a reference condition that does not exist: the Columbia and Snake River system with no dams. Instead, "the focus should be on the total mortality [direct and indirect] of in-river migrants and transported fish, which is the critical issue for recovery of listed salmonids," and "research and monitoring [should] be used to further quantify biological factors[9] that contribute to variability in estimated post-Bonneville mortality" (ISAB 2007).

More recently, the ISAB (2011, 2012) was asked to review several Fish Passage Center documents relating to latent mortality of in-river migrants due to route of dam passage (spill passed fish versus bypassed fish). They concluded that "[b]ased, on our review, the studies and analyses cited in these technical memos do not provide an adequate base of reliable information to support a 'weight of evidence' conclusion on the strength of a relationship between multiple bypass passage and latent mortality of juvenile Chinook and steelhead. That is, the relationships observed between latent mortality and bypass passage are confounded with other factors that obscure unambiguous interpretation."

In summary, the experience of hydrosystem passage in the lower Snake and Columbia Rivers is likely to result in some latent mortality, but the specific mechanisms (e.g., altered migration timing, passage through bypass systems, etc.) and how these factors might interact with factors such as ocean productivity are poorly understood. Hopefully, continued monitoring of Smolt to Adult returns relating to hydrosystem improvements (juvenile bypass system outfall relocations, reduced travel times due to increased access to surface passage routes) and other ongoing research will shed additional light on this issue.

2.2.4.2 Juvenile Transportation

The Action Agencies, in cooperation with NMFS and other regional fish management agencies, developed the juvenile fish transportation system to mitigate for juvenile mortality incurred when passing through the mainstem Federal dams. Fish are collected at the uppermost mainstem dams and transported in barges (or trucks when numbers are very low) to a release point below Bonneville Dam. This is intended to eliminate the mortality juveniles would otherwise experience by passing multiple dams. Three of the four lower Snake River dams plus McNary Dam on the Columbia River are equipped with juvenile fish collection and transportation facilities that obtain fish from the bypass system discussed above.

The value of transportation as a strategy to improve juvenile survival is continuously evaluated. Studies have consistently shown that transportation results in a higher adult return rate for steelhead compared to in-river migrants (Marsh et al. 2005, 2006, 2007; Williams et al. 2005; Schaller et al. 2007). However, this is not true for wild (i.e., natural-origin) spring Chinook when measured as an annual average rate of return (Schaller et al. 2007). Williams et al. (2005) and Marmorek et al. (2004) have demonstrated a seasonal benefit from transport, generally beginning in early May. In addition, adult steelhead and to a lesser extent spring Chinook that were

[9] Identifiable factors that contribute to variability in post-Bonneville mortality may include: predation by birds; predation by fishes; increased vulnerability to predators because of size, stress, or disease; timing of ocean entry; ocean conditions; ocean interceptions and harvest of returning adults; and in-river adult pre-spawn mortalities. Source: ISAB (2007)

transported as juveniles tend to stray into non-natal spawning areas at higher rates than adults that out-migrated inriver as juveniles (cite NMFS 2008c and ISAB 2008).

Seasonal trends in the effectiveness of juvenile transport were reflected in the COMPASS model, which was used to evaluate proposed spill and transport operations and their likely effect on steelhead and spring/summer Chinook adult returns for the 2008 BiOp. As a result of this modeling effort, the 2008 BiOp called for two transportation operations, depending on the runoff volume forecast. In years when the Snake River spring flow was forecast to average less than 65 kcfs, no spill was to be provided at the three Snake River collector dams and all fish collected were to be transported beginning April 3. In years when the Snake River spring flow was forecast to exceed 65 kcfs, spill was to be provided and juvenile fish would be collected for transportation beginning April 21. The 2008 BiOp specified a spill cessation period from May 7 to May 20, with spill resuming May 21, to maximize transportation and to spread the risk between transport and inriver migration routes. However, the ISAB (2008) did not endorse NMFS' proposal to maximize transport even for the discreet periods proposed, citing a list of uncertainties with respect to this action including:

- The effects of recent configuration improvements (e.g., surface spillway weirs) at the dams
- Effects of transport on lamprey and sockeye
- Relative amounts of adult straying, and potential effects on genetic and life history diversity, for transported versus inriver fish.

Based on the COMPASS model, the 2008 BiOp had anticipated that the percentage of spring Chinook transported would range from about 40 to 96 percent (averaging 64 percent over the range of flow conditions analyzed). We expected a somewhat higher percentage of steelhead to be transported – from about 50 to 98 percent (averaging 74 percent). However, the actual percentage of spring yearlings transported has generally been less than 50 percent since 2008 (roughly 23 to 40 percent for natural-origin spring/summer Chinook salmon and 28 to 46 percent for natural-origin steelhead) because, based on the ISAB's advice, spill has been throughout the migration season and across all flow conditions. In addition, with the advice of regional fisheries managers, the Action Agencies have delayed the start of collection for transport until May 1 each year at Lower Granite and until May 8 at Lower Monumental Dam. Reduced transport rates should substantially reduce straying by SR spring/summer Chinook and steelhead into other basins.

Juvenile SR fall Chinook pass Lower Granite Dam in late May and June. Transportation operations begin in late April or early May at the three Snake River collector dams and continue through October. In the 2008 BiOp, we estimated that 52 percent of subyearling juvenile SR fall Chinook would be transported; the actual average during 2008-2011 was 52.8 percent (DeHart 2012).

Differential Delayed Mortality

"D" or differential delayed mortality is a specific type of latent mortality that is used to measure the relative effectiveness of transporting juvenile fish past the FCRPS dams compared to inriver migration. The direct survival rate of transported juveniles to below Bonneville Dam is estimated to be about 98%. However, average adult return rates are usually lower for transported fish than for fish that migrated through the hydrosystem in-river. "D" is defined as the ratio of post-Bonneville Dam survival for transported fish to that of in-river migrants. [10] When D = 1, the post-BON survival rates for transported and inriver migrating juveniles is equivalent, and when D is not equal to 1, there is a difference. Whether D is greater than or less than 1 indicates which type of hydrosystem passage results in higher relative post-BON survival rates. When D is greater than 1, transported fish survive at a higher rate post-BON, and when D is less than 1 inriver migrants survive at a higher rate. Transportation is beneficial when D exceeds the inriver survival rate. Differential delayed mortality is a ratio and not an absolute measure of survival (Anderson et al. 2012). Although there is regional consensus on the need to track "D" for Snake River salmon and steelhead, the mechanisms that produce the relative differences in post-Bonneville mortality are uncertain at this time. Candidates include:

- Arrival timing in the hydrosystem (i.e., from the spawning and rearing areas)
- Travel time through the hydrosystem (to below Bonneville)
- Fish size, physiological condition, and health
- Dam operations
- Barging conditions
- Environmental conditions and predators in the lower Columbia River
- Environmental conditions and predators (especially terns and cormorants) below Bonneville Dam
- Straying
- Survival estimation techniques

Calculated values of "D" vary by species and between years. The authors of the Comparative Survival Study (CSS, which is a collaborative effort by the U.S. Fish and Wildlife Service; the states of Washington, Oregon, and Idaho; and the Columbia River Intertribal Fish Commission) report average "D" values for spring Chinook and steelhead each year (Table 2; Tuomikoski et al. 2013).

Annual estimates of "D" remain one of the metrics that regional managers consider in evaluating trends in the effectiveness of transportation and its appropriate use as a mitigation strategy.

[10] $D = (T: I) * S_{inriver}$ where D is differential delayed mortality, T is the SAR of transported juveniles and I is the SAR of inriver migrating juveniles (from Lower Granite Dam to the ocean and back to Lower Granite Dam for Snake River species), and $S_{inriver}$ is the estimated survival of inriver migrants from Lower Granite Dam to the Bonneville tailrace. Thus, unlike the TIR ratios discussed under "Effectiveness of Transport Operations," D takes into account the survival of inriver migrants to the tailrace of Bonneville Dam.

Table 2. Date at which transport started at Lower Granite Dam and D values reported by the CSS for natural origin SR spring Chinook and steelhead (Source: Tuomikoski et al. 2013).

Year	Transport Start Date at LGR	Spring Chinook D	Steelhead D
2006	April 20	0.47	0.52
2007	May 1	0.80	1.20
2008	May 1	0.82	0.60
2009	May 1	0.65	0.94
2010[1]	April 24	0.72[2]	0.93[1]
2011	May 1	0.41	

[1] Incomplete steelhead adult returns until 3-salt returns (if any) occur after June 27, 2013 at LGR.

[2] Incomplete adult return (only returning 2-salts as of July 18, 2013.

Note: "n-salt" refers to the number of years an adult has spent in the ocean prior to returning to freshwater to spawn. Most Chinook salmon return to freshwater after spending 1 to 3 years in the ocean (e.g., 1- to 3-salt returns).

Effectiveness of Transport Operations

We consider the smolt-to-adult return rates (SAR) of the juveniles that were transported (SAR_T), and the fish that migrated inriver (SAR_I) to assess the effectiveness of transportation. We use the ratio of SAR_T to SAR_I, referred to as the transport-to-inriver (TIR) ratio, to compare the two rates. A TIR greater than 1 indicates that transported fish survived to return as adults at a higher rate than inriver migrants. A TIR less than 1 indicates that inriver fish survived to return as adults at a higher rate than transported fish. The data used to calculate the inriver SARs are based on juveniles that were not detected at any of the Snake River collector projects (Tuomikoski et al. 2013). The TIRs for adults returning to Lower Granite Dam are available for the years 2006-2011for spring Chinook and 2006-2010 for steelhead (Table 3; Tuomikoski et al. 2013). The TIRs greater than 1 in Table 3.3-5 indicate that transport has returned more natural origin adult steelhead and spring Chinook for all years with the exception of 2006. The TIR for both steelhead and spring Chinook was less than 1 in 2006, which had an early transport start date at Lower Granite Dam (April 20) compared to April 24 to May 1 in subsequent years. The earlier transport start date in 2006 may explain the low TIR for that year.

Table 3. Initial date of transport for natural origin spring Chinook and steelhead at Lower Granite Dam. TIRs (Transport to Inriver ratios) from Tuomikoski et al. 2013.

Year	Transport Start Date at Lower Granite Dam	Spring Chinook TIR	Steelhead TIR
2006	April 20	0.78	0.85
2007	May 1	1.27	2.89
2008	May 1	1.19	1.16

2009	May 1	1.11	1.31
2010	April 24	1.21	1.47[1]
2011	May 1	0.64[2]	

[1]Incomplete adult returns for steelhead until 3-salt returns (if any) occur after June 27, 2013 at Lower Granite Dam.

[2]Incomplete adult return (only returning 2-salts as of July 18, 2013)

Note: "n-salt" refers to the number of years an adult has spent in the ocean prior to returning to freshwater to spawn. Most Chinook salmon return to freshwater after spending 1 to 3 years in the ocean (e.g., 1- to 3-salt returns).

As mentioned above, the NWFSC conducts a similar analysis of juvenile transportation effects, but focuses on within-season patterns in SARs relative to juvenile migration timing and changing environmental conditions. The metric used to report these results is the T:B ratio because the comparison is between transported (T) and bypassed (B) fish (i.e., bypassed, but returned to the river below the dam rather than transported). The average annual T:B ratios for juveniles that were PIT tagged upstream from Lower Granite Dam during 2006–2011 have ranged from 1.34 to 1.77 across the season for natural origin spring Chinook and 1.44 to 2.89 for steelhead (Smith et al. 2013). The seasonal benefit from transport is most prominent for natural origin spring Chinook; before May 1, there is almost no benefit from transport, but after May 1 transport is generally beneficial with the benefit increasing during the month of May (Williams et al. 2005; Smith et al. 2013). Steelhead typically show a benefit from transport during April and continuing through May.

To summarize, several different metrics have been developed to evaluate how juvenile fish transport affects adult returns: Transport to Inriver (TIR), Transport to Bypass (T:B), and Differential delayed mortality ("D"). "TIR" compares the relative success in terms of producing adult returns of juvenile fish that were transported versus those that migrated downstream "inriver" (i.e., fish that were never detected in a juvenile bypass system at any of the four dams on the Snake River or at McNary Dam on the Columbia River). Calculating this metric allows fish managers to assess of how the transport of juvenile fish affects adult returns in a given year. "T:B" compares the relative success in terms of adult returns of juveniles that were transported versus those that migrated inriver and were detected in one or more of the juvenile bypass systems on the Snake River or at McNary Dam. This metric, calculated daily, allows us to assess how transporting juveniles affects adult returns relative to juveniles that migrate inriver on the same day. "D" compares the relative success in terms of adult returns between fish that were either transported to below Bonneville Dam as juveniles or migrated inriver and survived to below Bonneville Dam.

2.2.5 Smolt-to-Adult Returns

Smolt-to-adult return ratios (SARs) represent the survival of salmon from the smolt stage at a particular location in the freshwater environment through adults returning to the same location (or to another useful location in the migration corridor). These estimates typically represent aggregate survival through a portion of the juvenile freshwater migration corridor, the estuary, the ocean, and a portion of the adult freshwater migration corridor. SARs therefore provide useful information to assess survival through the mainstem migration corridors and ocean-rearing environment. This section focuses on the SARs of all migrants (inriver and transported fish combined) rather than on the comparisons of these groups (see Section 2.2.4).

Estimated SARs (Lower Granite dam back to Lower Granite dam) for Snake River spring/summer Chinook and steelhead from the mid-1960s to mid-2000s are shown in Figures 5 and 6. The older (1960s to early 1990s) data were derived using run reconstruction techniques; the more recent data were generated using PIT tagged fish. In general, SARs for both Chinook salmon and steelhead have declined since the 1960s; but continue to be highly variable; ranging from about 0.5 to 4 percent in recent years. The exact causes are unknown, but several factors likely contributed including the construction of four dams in the late 1960s and early 1970s (John Day Dam on the Columbia River, and Lower Monumental, Little Goose, and Lower Granite dams on the Snake River); and a shift to generally less productive conditions in the northern Pacific Ocean (Mantua et al. 1997; Peterson and Schwing 2003; Scheuerell and Williams 2005; Petrosky and Schaller 2012; Haeseker et al. 2012; Burke et al. 2013). Other human factors, including increased hatchery production, and land use management activities (e.g., agriculture, forestry, and mining) could potentially affect the relative fitness (condition, size, or competiveness) of juvenile fish and so may also have contributed to a downward trend in SARs.

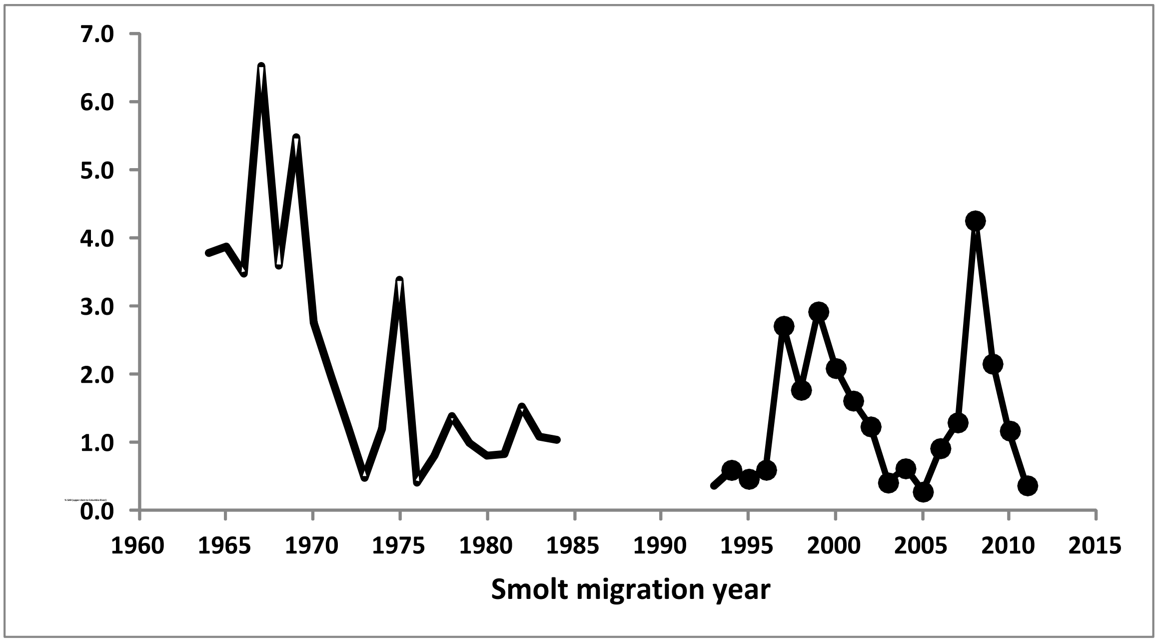


Figure 5. SARs from smolts at uppermost Snake River dam to Columbia River returns (including jacks) for wild Snake River spring/summer Chinook, 1964–2011. SARs based on run reconstruction (1964-1984 and 1993, solid line) and CSS PIT tags (1994-2001, dots and solid line). Smolt migration years are (brood year+2). The 2010 and 2011 estimates are derived from incomplete returns; SAR for 2011 is complete through 2-salt returns only. (Source: Figure 4.1 in Tuomikoski et al. 2013).

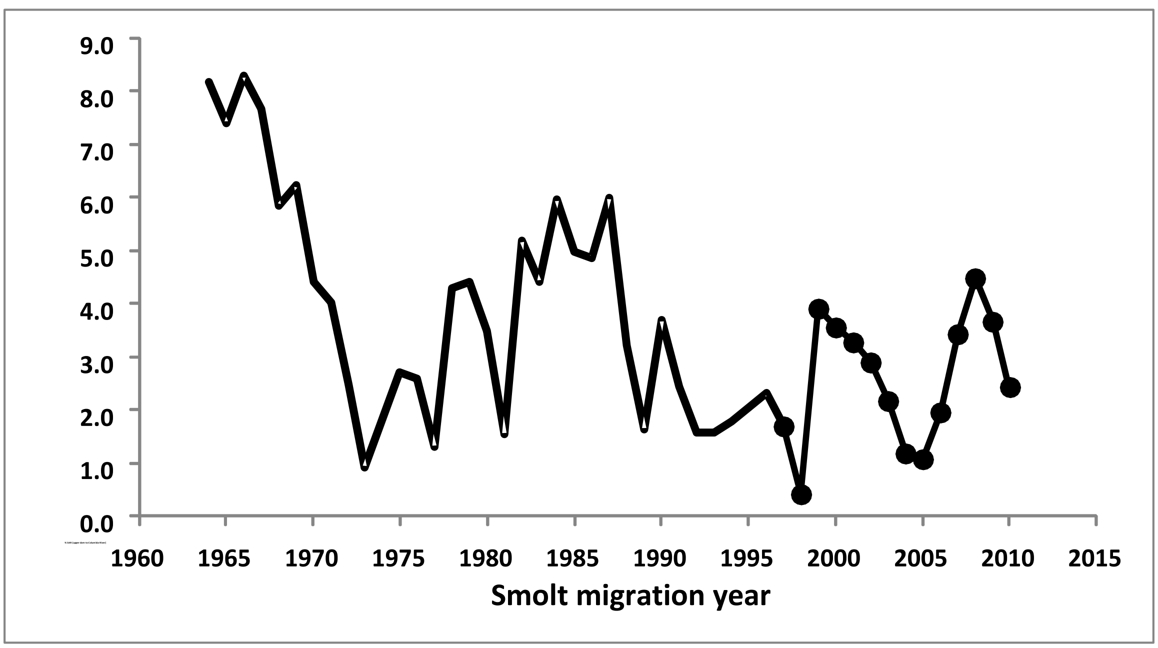
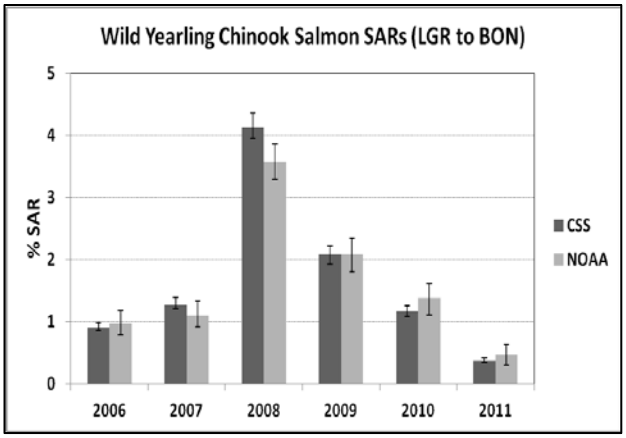


Figure 6. SARs from smolts at uppermost Snake River dam to Columbia River returns for wild Snake River steelhead, 1964-2010. SARs based on run reconstruction (1964-1996, solid line) and CSS PIT tags (1997-2010, dots and solid line). Smolt migration years are (brood year+2). The 2010 estimate is derived from incomplete returns. Source: Figure 4.5 in Tuomikoski et al. (2013).

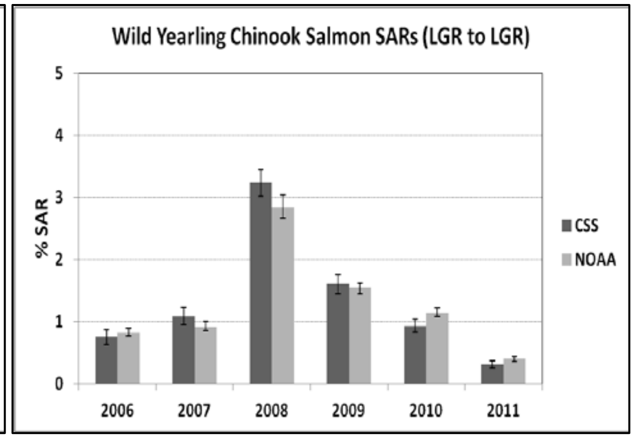
This remainder of this section summarizes recent SAR estimates for PIT tagged migrating smolts[11] that passed Lower Granite Dam from 2006 to 2011 (inriver and transported migrants combined). Figure 7 depicts SAR estimates (with 90% confidence intervals) for wild yearling Chinook salmon (including jacks) and steelhead smolts returning as adults to either Bonneville or Lower Granite Dam. Thus, the difference between these two estimates represents adult losses from Bonneville Dam to Lower Granite Dam from all sources (e.g., hydropower, harvest, injuries due to predation, natural mortalities, etc.). These graphics include estimates from the Comparative Survival Study (Tuomikoski et al. 2013) as well as the NOAA Fisheries' Northwest Fisheries Science Center (unpublished data) for juveniles tagged upstream of Lower Granite Dam.

There is substantial agreement in the SAR estimates made by CSS and NOAA. As expected, SAR estimates to Lower Granite Dam were consistently lower than SAR estimates to Bonneville Dam. Recent SARs peaked for both yearling Chinook salmon and steelhead smolts that outmigrated in 2008 with steelhead SARs exceeding 4 percent and yearling Chinook salmon SARs exceeding 3.5% back to Bonneville Dam. SARs estimates declined substantially to less than 0.5% in 2011 for spring/summer Chinook salmon (though relatively small numbers of 2-ocean and older fish have not returned and have not been included in this estimate).

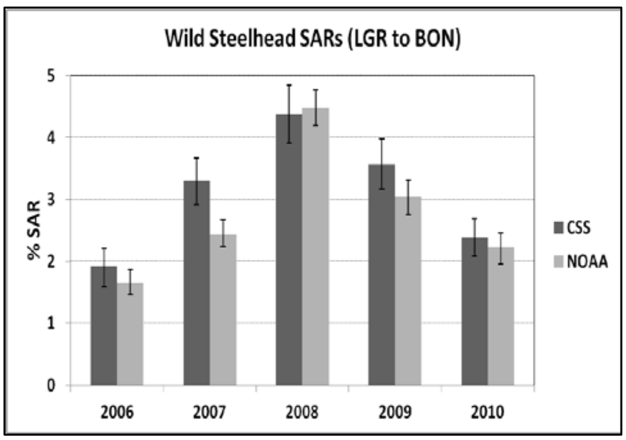
[11] There is evidence suggesting that PIT tagged juveniles return at lower rates (Knudsen et al. 2009) than untagged fish, although the magnitude and variability of this "handling effect" are poorly understood. Thus, PIT tag derived estimates should be interpreted as "minimum" SAR estimates for the run as a whole because they are likely lower (to an unknown degree) than those of untagged fish.



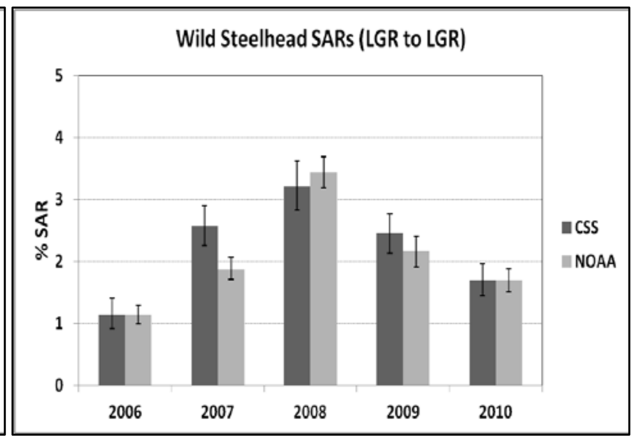
A.



B.



C.



D.

Figure 7. Smolt-to-Adult Return estimates (with 90% confidence intervals) for juvenile Chinook salmon and steelhead tagged upstream of Lower Granite Dam. A. Wild Yearling Chinook returning as adults to Bonneville Dam; B. Wild Yearling Chinook returning as adults to Lower Granite Dam; C. Wild steelhead returning as adults to Bonneville Dam; and D. Wild steelhead returning as adults to Lower Granite Dam. Sources: Tuomikoski et al. 2013 and NOAA Fisheries' Northwest Regional Science Center (Smith 2014, unpublished data).

2.2.6 Key Uncertainties

Direct survival rates of both juvenile and adult salmon and steelhead migrating through the mainstem Snake and Columbia Rivers are estimated annually and well documented (Faulkner et al 2013; Tuomikoski 2013; NMFS 2014). The degree to which mortality in the estuary and ocean is caused by the prior experience of juveniles passing through the FCRPS (i.e., delayed or latent mortality) is unknown and hypotheses regarding the magnitude of this effect vary greatly (ISAB 2007; ISAB 2012). The relative magnitude of delayed or latent effects, the specific mechanisms causing these effects, and the potential for interactions with other factors (ocean conditions, toxics, etc.) remain key uncertainties. Answering these key uncertainties would greatly enhance the ability of hydrosystem managers to improve survival (and SARs) through additional structural improvements or operational modifications at the mainstem dams in future years.

2.2.6.1 Latent Mortality of In-River Migrants Due to Route of Dam Passage

As previously discussed, juvenile migrants can pass through dams via spillways (either conventional or surface oriented), screened bypass systems, or turbine units. Although estimates of direct survival through spillways and bypass systems tend to be high (>98%), there is evidence that fish bypass systems are associated with some latent mortality. The ISAB (2012) summarized the two competing hypotheses explaining this association and noted that the hypotheses have very different implications for hydrosystem operations:

> "The significant association between fish bypass and latent mortality might only reflect a non-random sampling of smolts at the bypass collectors (the selection hypothesis) rather than injury or stress caused by the bypass event (the damage hypothesis)."

Simply put, if sick, distressed, or injured fish are substantially more likely to pass a dam through the screened bypass systems (selection hypothesis), then actions to move these fish to spillway routes of passage will have little bearing on the long-term survival of these already compromised fish or their likelihood of returning as adults. However, if the fish are randomly entering the screened bypass systems and being injured or otherwise impacted by these systems, then actions to move these fish to spillway routes would be expected to increase long-term survival and likelihood of returning as adults.

Some of the fish losses included in latent mortality estimates undoubtedly include mortalities stemming from fish being injured within the bypass systems or from predation in the vicinity of the bypass system outfall. Many modifications were made during the early 2000s to improve survival rates through these systems, i.e., screens and debris management improvements, use of "full flow" systems, and outfall relocations (USACE et al. 2007, Appendix A: Overhaul of the System; BPA et al. 2013; and BPA et al. 2014). Most recently, the outfalls of several juvenile bypass systems have been relocated to areas that better protect juvenile migrants from predators (Little Goose Dam in 2010, McNary Dam in 2011, and Lower Monumental Dam in 2012). Improvements are also planned for completion at Lower Granite Dam prior to 2018 (BPA et al. 2014).

Assuming that the "damage hypothesis" is correct, these improvements should result in some reduction in rates of latent mortality for bypassed juveniles. Detections of adult fish, that were both PIT tagged and bypassed as juveniles should provide evidence, over time, that supports or refutes this hypothesis.

The Corps of Engineers, with the assistance of NMFS and other regional parties, is designing a PIT tag detector to be installed in a spillway bay at Lower Granite Dam before 2018 (BPA et al. 2014). This system would, for the first time, allow a direct comparison of the survival rates and downstream detection probabilities of juveniles passing this dam via the spillway and bypass system. However, this tool, by itself, would not allow for a comparison of the condition and health of these fish, information that is needed to support either the "selection" or "damage" hypotheses. . This would require a study that either captured smolts in the forebay of a dam and compared their condition and health to that of juveniles collected from the bypass system on the same day or captured smolts passing through the spillways into the tailrace to compare with those taken from the bypass system.

2.2.6.2 Proposed Spill Experiment

Consistent with the "damage" hypothesis noted above, in recent annual reports for the Comparative Survival Study, Tuomikoski et al. (2011, 2012, 2013) hypothesized that substantially increasing spill levels (to reduce exposure of juveniles to juvenile bypass systems and turbines) would substantially increase both inriver smolt survival and SAR rates (inriver plus ocean survival). The CSS reports present prospective modeling results for four scenarios, ranging from current levels of spill at the eight mainstem dams to spill that creates total dissolved gas levels up to 125% of saturation in each tailrace. The CSS participants recommended that the region design and implement a large-scale operational study to evaluate this hypothesis (CSS Workgroup 2013).

NMFS considered the proposed spill test in the 2014 Supplemental FCRPS Biological Opinion (NMFS 2014):

> "NOAA will continue to monitor the effects of project operations on juvenile survival and adult returns as reported by CSS and the NWFSC. We note the adult returns from the year 2011, a year that had high levels of spill and flow, has produced below average adult return rates. Results such as this reinforce our current management approach to hydrosystem operations. Substantial progress has been made toward improving survival of juvenile anadromous fish in the hydrosystem. Models of the system effects will continue to improve through 2018 as more data from current operations is added, and NOAA Fisheries will continue to consider opportunities to make further improvements to hydrosystem operations or configurations."

NMFS also identified several technical issues and other factors to be addressed in consideration of a spill test and ultimately did not determine that such a test was necessary to avoid jeopardy within the time frame of the 2014 Supplemental Biological Opinion (i.e., through 2018). The proposed spill test was also reviewed by the Independent Scientific Advisory Board (ISAB 2014), which identified several weaknesses in the proposal and advised additional scrutiny of the available data. However, the ISAB also indicated that a spill test with appropriate controls and adequate monitoring would increase the region's base of knowledge "regarding spill, juvenile salmonid dam passage survival, impacts on adult fish passage and other species, and total dissolved gas effects."

Proposals for large, multi-year operational experiments must be based on the best available science, have a high potential to improve fish survival, and possess a sound study design. A study must also be consistent with state and federal laws, deemed operationally and economically feasible by the operating agencies and be subject to independent scientific reviews. Assuming these and other necessary conditions are met, such experiments could be used to inform future management decisions regarding configuration and operational improvements at mainstem dams.

2.2.6.3 Adult Survival Rates from the Estuary to Lower Granite Dam

Adult survival rates in the estuary (except in the Bonneville Dam tailrace, where passage may be delayed while adult salmon and steelhead find and enter adult fishway entrances) is likely not related to the Hydropower system. However, salmon and steelhead losses in the lower Columbia River estuary are important to consider in the context of recovery planning; and injuries resulting from sea lion attacks or from harvest activities (gillnets, recreational fishing, etc.) are likely affecting survival rate estimates in reaches upstream of Bonneville Dam.

After accounting for harvest, Rub et al. (2012a, 2012b) estimated survival rates from Rkm 45 in the estuary to Bonneville Dam for adult spring Chinook of 88% during 2010 and 85% in 2011. These estimates include losses to pinnipeds in the Bonneville tailrace. Direct annual estimates of survival in the lower Columbia River are not available for other salmonid species. The numbers of California sea lions and Steller sea lions are increasing (Scordino 2010; Carretta et al. 2013), and predation below Bonneville Dam is likely substantial, especially for spring migrating adults.

Average recent conversion rates for adult Snake River spring/summer Chinook salmon, sockeye salmon,[12] and steelhead (see Table 1) are about 6 to 10% than expected (see Section 3.3.3.1 in NMFS 2014). Most of these losses appear to occur between Bonneville and McNary dams for spring/summer Chinook and sockeye salmon and between McNary and Lower Granite dams for steelhead.

Factors that could potentially be affecting adult passage and observed conversion rates upstream of Bonneville Dam include: environmental factors (flows, spill operations, temperature, etc.), structural modifications, errors in the harvest or stray rate estimation methods, variability in stock run timing, or some combination of these factors. NOAA plans to evaluate these factors in relation to PIT tag based conversion rate estimates (Dygert and Graves 2013) in the coming years.

Annual estimates of adult survival allow managers a means of determining whether or not management actions are having the intended effect. Extended to the estuary and Columbia River below Bonneville Dam, annual survival estimates would allow managers to assess if predation from increasing numbers of pinnipeds was causing adult survival rates to decline.

NMFS is exploring systems to obtain PIT tag detections in the lower Columbia River annually. Beginning in 2014, PIT tag detectors will be present in the fish ladders at every mainstem dam except John Day in the lower Columbia River. PIT tag detection systems have similarly been installed in the lower reaches of many tributaries to the mainstem Snake and Columbia rivers upstream of Bonneville Dam, as well as in many locations in tributaries upstream of Lower Granite Dam. Recent and future improvements to the network of PIT tag detection systems,

[12] These estimates do not include effects of the adult passage blockages at Lower Granite Dam in 2013, which are discussed in Section 2.2.2 of this Hydro Module and in more detail in the 2014 Supplemental FCRPS Biological Opinion (NMFS 2014).

occasional adult radio-telemetry studies, and efforts to evaluate how environmental and management factors affect PIT tag based conversions rate estimates should substantially improve the ability of mangers to identify issues and implement corrective measures, if warranted.

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