UPPER WILLAMETTE RIVER CONSERVATION AND RECOVERY PLAN FOR CHINOOK SALMON AND STEELHEAD

Prepared by
Oregon Department of Fish and Wildlife (ODFW) and
the National Marine Fisheries Service (NMFS) Northwest Region

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Disclaimer

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Acronym and Abbreviation List

α	Alpha parameter
A	Abundance
A/P	Abundance/productivity
AHSWG	Ad Hoc Supplementation Monitoring and Evaluation Workgroup
AICs	Akaike information criterion
B	Beta parameter
BC	British Columbia
B-H	Beverton-holt function
BiOp	Biological opinion
BMPs	Best management practices
BOR	Bureau of Reclamation
BPA	Bonneville Power Administration
CA	Calapooia
CAPM	Conservation Assessment and Planning Model
CATAS	Conservation Assessment Tool for Anadromous Salmonids
CBFWA	Columbia Basin Fish and Wildlife Authority
C&S	Ceremonial and subsistence
CEP	Oregon State Police Coordinated Enforcement Program
CFS	Cubic feet per second
CHS	Spring Chinook
CIG	Climate Impacts Group
CM	Clackamas
CR	Columbia River
CRE	Columbia River estuary
CREP	Conservation Reserve Enhancement Program
CRF	Mean Columbia River Flow
CRFMP	Columbia River Fish Management Plan
CRITFC	Columbia River Inter-tribal Fish Commission
CRT	**C**ritical risk threshold
CSMEP	Collaborative Systemwide Monitoring and Evaluation Project
CSP	Conservation Supplementation Hatchery Program
CWA	Clean Water Act
CWT	**C**oded-wire tag
D	Diversity
DDT	Dichlorodiphenyltrichloroethane
DIDSON	Duel-Frequency Identification Sonar
DPS	Distinct population segment
EDT	Ecosystem Diagnosis and Treatment
EHM	Mortality associated with estuary habitat conditions
EIS	Environmental impact statement
EMAP	Environmental monitoring and assessment protocol
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
EWEB	Eugene Water and Electric Board
Ex Com	Willamette-Lower Columbia ESA Executive Committee
FCRPS	Federal Columbia River Power System
FEIS	Final environmental impact statement
FERC	Federal Energy Regulatory Commission

FMEP	Fisheries Management and Evaluation Plan
FPDO	Fall Pacific Decadal Oscillation
FR	Federal Register
FRAM	Fishery Regulation Assessment Model
FSA	Farm Service Bureau
FW	Freshwater
FWHM	Mortality associated with freshwater habitat conditions (non hydro)
γ	Gamma parameter
GNRO	Oregon Governor's Natural Resources Office
GRTS	Generalized Randomized-Tessellation Stratified technique
H	High extinction risk
HAAT	High Annual Air Temperature
HCP	Habitat Conservation Plan
HFM	Mortality associated with hatchery fish
HGMP	Hatchery Genetic Management Plan
HIP	High Intrinsic Potential
HM	Mortality associated with harvest
HMP	Harvest Mitigation Hatchery Program
HOR	Hatchery Origin Fish
HSRG	Columbia River Hatchery Scientific Review Group
HTT	WATER Habitat Technical Team
IC	Implementation Coordinator
ICTRT	Interior Columbia Technical Recovery Team
ID	Identify
IMST	Independent Multidisciplinary Science Team
IP	Intrinsic Potential
ISAB	Independent Scientific Advisory Board
JCM	Mortality associated with juvenile competition
JHM	Mortality associated with juvenile habitat conditions due to hydro/flood control
L	Low extinction risk
LAAT	Low Average Air Temperature
LCFRB	Lower Columbia Fish Recovery Board
LCR	Lower Columbia River
LCREP	Lower Columbia River Estuary Partnership
LFT	Limiting factor or threat
LWD	Large wood debris
M	Moderate extinction risk
MAT	Minimum abundance threshold
MF	Middle Fork Willamette
MK	McKenzie
MO	Molalla
MOP	Minimum operating pool
MPG	Major population group
MS	Mainstem Willamette
MSCLR	Maximum Snow at Crater Lake and Rainier
MSD	mean square deviation
MU	Management Unit
NEPA	National Environmental Policy Act
NFCP	Native Fish Conservation Policy
NFH	National Fish Hatchery
NGO	Non-government agency

NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration-Fisheries
NOR	Natural Origin Fish
NPCC	Northwest Power and Conservation Council
NRCS	Natural Resources Conservation Service
NS	North Santiam
nSPDO	Negative Spring Pacific Decadal Oscillation index
OAR	Oregon State Administrative Rule
ODEQ	Oregon Department of Environmental Quality
ODF	Oregon Department of Forestry
ODFW	Oregon Department of Fish and Wildlife
ODOT	Oregon Department of Transportation
OPI	Oregon Production Index
OPRD	Oregon Parks and Recreation District
OPSW	Oregon Plan for Salmon and Watersheds
OR	Oregon
OrLCR	Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and steelhead
OSM	Mortality associated with other species
OSP	Oregon State Police
OSU	Oregon State University
OWEB	Oregon Watershed Enhancement Board
OWRD	Oregon Water Resources Department
P	Productivity
PACFISH	Pacific Anadromous Fish Strategy
PAH	Polycyclic aromatic hydrocarbons
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyls
PCEs	Primary constituent elements
PCR	Polymerase chain reaction
PCSRF	Pacific Coastal Salmon Recovery Fund
PDO	Pacific Decal Oscillation
PFMC	Pacific Fishery Management Council
PGE	Portland General Electric
pHOS	Proportion Hatchery Origin Spawners
PIT	Passive integrated transponders
PNAMP	Pacific Northwest Aquatic Monitoring Partnership
PNI	Pacific Northwest Index
PNOB	Proportion Natural Origin Spawners in Broodstock
pNOS	Proportion Natural Origin Spawners
PNW	Pacific Northwest
PVA	Population viability assessment
QET	Quasi extinction threshold
Rkm	river kilometer
RM	River-mile
RME	Research, monitoring and evaluation
RPA	Reasonable and prudent alternative
SAM	Mortality associated with spawner access
SB	Senate Bill
SHM	Mortality associated with spawner habitat conditions
SLAM	Species Life-cycle Analysis Modules

SMU	Species Management Units
SNPs	Single nucleotide polymorphisms
SS	Spatial Structure
SSA	South Santiam
SSB	Substitute Senate Bill
SS/D	Spatial structure/Diversity
SPDO	Spring Pacific Decadal Oscillation
SRBP	Sandy River Basin Partners
STEP	Salmon and Trout Enhancement Programs
STS	Summer Steelhead
STW	Winter Steelhead
SURPH	Survival under proportional hazards
SVB	Sides, vertices, and boundaries
SWCD	Soil and water conservation district
SWW	Selective water withdrawal
TBD	to be determined
TCM	Total Cumulative Mortality
TDG	Total dissolved gas
TMDL	Total maximum daily loads
TRT	Technical Recovery Team
USACE	U. S. Army Corps of Engineers
USBLM	U. S. Bureau of Land Management
USDA	U. S. Department of Agriculture
USEPA	U. S. Environmental Protection Agency
USFS	U. S. Forest Service
USFWS	U. S. Fish and Wildlife Service
UWR	Upper Willamette River
VH	Very high extinction risk
VL	Very low extinction risk
VSP	Viable salmonid population
WATER	Willamette Action Team for Ecosystem Restoration
WDFW	Washington Department of Fish and Wildlife
WLC	Washington and Lower Columbia
WLC-TRT	Willamette/Lower Columbia Technical Recovery Team
WOE	Weight of Evidence
WQ	Water Quality
WQMP	Water Quality Management Plan
WP BiOp	Willamette Project Biological Opinion (NMFS 2008)
WR	Willamette River Keeper
WRI	Willamette Restoration Initiative
WSC	Watershed Council

Glossary

abundance: In the context of salmon recovery, unless otherwise qualified, abundance refers to the number of adult fish returning to spawn, measured over a time series.

adaptive management: Adaptive management in salmon recovery planning is a method of decision making in the face of uncertainty. A plan for monitoring, evaluation, and feedback is incorporated into an overall implementation plan so that the results of actions can become feedback on design and implementation of future actions.

anadromous fish: Species that are hatched in freshwater, migrate to and mature in salt water,and return to freshwater to spawn.

baseline monitoring: In the context of recovery planning, baseline monitoring is done before implementation, in order to establish historical and/or current conditions against which progress (or lack of progress) can be measured.

biogeographical region: an area defined in terms of physical and habitat features, including topography and ecological variations, where groups of organisms (in this case, salmonids) have evolved in common.

broad sense recovery goals: Goals defined in the recovery planning process, generally by local recovery planning groups, that go beyond the requirements for delisting, to address, for example, other legislative mandates or social, economic, and ecological values.

compliance monitoring: Monitoring to determine whether a specific performance standard, environmental standard, regulation, or law is met.

delisting criteria: Criteria incorporated into ESA recovery plans that define both biological viability (biological criteria) and alleviation of the causes for decline (threats criteria based on the five listing factors in ESA section 4[a][1]), and that, when met, would result in a determination that a species is no longer threatened or endangered and can be proposed for removal from the Federal list of threatened and endangered species. These criteria are a NMFS determination and may include both technical and policy considerations and constitute our best estimate of what would be needed for delisting at this time. New information or analyses could lead us to delist before we reach the delisting criteria.

distinct population segment (DPS): A listable entity under the ESA that meets tests of discreteness and significance according to USFWS and NMFS policy. A population is considered distinct (and hence a "species" for purposes of conservation under the ESA) if it is discrete from and significant to the remainder of its species based on factors such as physical, behavioral, or genetic characteristics, it occupies an unusual or unique ecological setting, or its loss would represent a significant gap in the species' range.

diversity: All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population. Variations could include anadromy vs. lifelong residence in freshwater, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology, molecular genetic characteristics, etc.

endangered species: A species in danger of extinction throughout all or a significant portion of its range.

effectiveness monitoring: Monitoring set up to test cause-and-effect hypotheses about recovery actions: Did the management actions achieve their direct effect or goal? For example, did fencing a riparian area to exclude livestock result in recovery of riparian vegetation?

ESA recovery plan: A plan to recover a species listed as threatened or endangered under the U.S. Endangered Species Act (ESA). The ESA requires that recovery plans, to the extent practicable, incorporate (1) objective, measurable criteria that, when met, would result in a determination that the species is no longer threatened or endangered; (2) site-specific management actions that may be necessary to achieve the plan's goals; and (3) estimates of the time required and costs to implement recovery actions.

evolutionarily significant unit (ESU): A group of Pacific salmon or steelhead trout that is (1) substantially reproductively isolated from other conspecific units and (2) represents an important component of the evolutionary legacy of the species.

extinct: No longer in existence. No individuals of this species can be found.

extirpated: Locally extinct. Other populations of this species exist elsewhere. Functionally extirpated populations are those of which there are so few remaining numbers that there are not enough fish or habitat in suitable condition to support a fully functional population.

factors for decline: Five general categories of causes for decline of a species, listed in the Endangered Species Act section 4(a)(1)(b): (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or human-made factors affecting its continued existence.

functionally extirpated: Describes a species that has been extirpated from an area; although a few individuals may occasionally be found, there are not enough fish or habitat in suitable condition to support a fully functional population.

hyporheic zone: Area of saturated gravel and other sediment beneath and beside streams and rivers where groundwater and surface water mix.

implementation monitoring: Monitoring to determine whether an activity was performed and/or completed as planned.

independent population: Any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations.

indicator: A variable used to forecast the value or change in the value of another variable.

interim regional recovery plan: A recovery plan that is intended to lead to an ESA recovery plan but that is not yet complete. These plans might address only a portion of an ESU or lack other key components of an ESA recovery plan.

intrinsic potential: The estimated relative suitability of a habitat for spawning and rearing of anadromous salmonid species under historical conditions inferred from stream characteristics including channel size, gradient, and valley width.

intrinsic productivity: The expected ratio of natural-origin offspring to parent spawners at levels of abundance below carrying capacity.

kelts: Steelhead that are returning to the ocean after spawning and have the potential to spawn again in subsequent years (unlike most salmon, steelhead do not necessarily die shortly after spawning).

large woody debris (LWD): A general term for wood naturally occurring or artificially placed in streams, including branches, stumps, logs, and logjams. Streams with adequate LWD tend to have greater habitat diversity, a natural meandering shape, and greater resistance to flooding.

legacy effects: Impacts from past activities that continue to affect a stream or watershed in the present day.

limiting factor: Physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, insufficient prey resources) experienced by the fish that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity). Key limiting factors are those with the greatest impacts on a population's ability to reach a desired status.

locally developed recovery plan: A plan developed by State, tribal, regional, or local planning entities to address recovery of a species. These plans are being developed by a number of entities throughout the region to address ESA as well as State, tribal, and local mandates and recovery needs.

maintained status: Population status in which the population does not meet the criteria for a viable population but does support ecological functions and preserve options for ESU/DPS recovery.

management unit: A geographic area defined for recovery planning purposes on the basis of State, tribal or local jurisdictional boundaries that encompass all or a portion of the range of a listed species, ESU, or DPS.

metrics: A metric is something that quantifies a characteristic of a situation or process; for example, the number of natural-origin salmon returning to spawn to a specific location is a metric for population abundance.

morphology: The form and structure of an organism, with special emphasis on external features.

natural-origin fish: Fish that were spawned and reared in the wild, regardless of parental origin.

parr: The stage in anadromous salmonid development between absorption of the yolk sac and transformation to smolt before migration seaward.

Persistence probability: The persistence probability is the complement of the extinction risk (i.e., persistence probability = 1 – extinction probability).

phenotype: Any observable characteristic of an organism, such as its external appearance, development, biochemical or physiological properties, or behavior.

piscivorous: (Adj.) Describes fish that eat other fish.

productivity: The average number of surviving offspring per parent. Productivity is used as an indicator 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 an entire life cycle. Can be expressed as the number of recruits (adults) per spawner or the number of smolts per spawner.

recovery domain: An administrative unit for recovery planning defined by NMFS based on ESU boundaries, ecosystem boundaries, and existing local planning processes. Recovery domains may contain one or more listed ESUs.

recovery goals: Goals incorporated into a locally developed recovery plan, which may include delisting (i.e. no longer considered endangered or threatened), reclassification (e.g., from endangered to threatened), and/or other goals. Broad sense goals are a subset of recovery goals (see glossary entry above).

recovery scenarios: Scenarios that describe a target status for each population within an ESU, generally consistent with TRT recommendations for ESU viability.

redd: A nest constructed by female salmonids in streambed gravels where eggs are fertilized and deposited.

recovery strategy: Statements that identify the assumptions and logic – the rationale – for the species' recovery program.

riparian area: Area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland.

salmonid: Fish of the family *Salmonidae*, including salmon, trout, chars, grayling, and whitefish. In general usage, the term usually refers to salmon, trout, and chars.

smolt: A juvenile salmonid that is undergoing physiological and behavioral changes to adapt from freshwater to saltwater as it migrates toward the ocean.

spatial structure: Characteristics of a fish population's geographic distribution. Current spatial structure depends upon the presence of fish, not merely the potential for fish to occupy an area.

stakeholders: Agencies, groups, or private citizens with an interest in recovery planning, or those who will be affected by recovery planning and actions.

Technical Recovery Team (TRT): Teams convened by NMFS to develop technical products related to recovery planning. Planning forums unique to specific states, tribes, or regions may use TRT and other technical products to identify recovery actions.

threatened species: A species likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

threats: Human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, volcanoes) that cause or contribute to limiting factors. Threats may exist in the present or be likely to occur in the future.

viability criteria: Criteria defined by NMFS-appointed Technical Recovery Teams to describe a viable salmonid population, based on the biological parameters of abundance, productivity, spatial structure, and diversity. These criteria are used as technical input into the recovery planning process and provide a technical foundation for development of biological delisting criteria.

viability curve: A curve describing combinations of abundance and productivity that yield a particular risk of extinction at a given level of variation over a specified time frame.

viable salmonid population (VSP): an independent population of Pacific salmon or steelhead trout that has a negligible risk of extinction over a 100-year time frame.

VSP parameters: Abundance, productivity, spatial structure, and diversity. These describe characteristics of salmonid populations that are useful in evaluating population viability. See NOAA Technical Memorandum NMFS-NWFSC-42, *Viable salmonid populations and the recovery of evolutionarily significant units* (McElhany et al. 2000).

Executive Summary

(Separate document)

Separate Document

Chapter 1: Introduction

1.1 Scope of Recovery Plan

This Recovery Plan (Plan) serves as both a recovery plan under the Federal Endangered Species Act (ESA) and as a State of Oregon conservation Plan under Oregon's Native Fish Conservation Policy (NFCP). The Plan provides a framework and roadmap for the conservation and recovery of ESA listing units for Chinook salmon and steelhead species in the Willamette River system of Oregon. The listing units that are considered threatened under the ESA are:

- The Upper Willamette River (UWR) Chinook (Oncorhynchus tschawytscha) Evolutionarily Significant Unit (ESU)[1]. This ESU includes all naturally spawned populations of spring Chinook salmon in the Clackamas River and in the Willamette Basin upstream of Willamette Falls . Seven artificial propagation programs were considered to be part of the ESU: The McKenzie River Hatchery (Oregon Department of Fish and Wildlife (ODFW) stock #24[2]), Marion Forks/North Fork Santiam River (ODFW stock #21), South Santiam Hatchery (ODFW stock #23) in the South Fork Santiam River, South Santiam Hatchery (ODFW stock #23) in the Calapooia River, South Santiam Hatchery (ODFW stock #23) in the Mollala River, Willamette Hatchery (ODFW #22), and Clackamas Hatchery (ODFW #19) spring-run Chinook salmon hatchery programs. We have determined that these artificially propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (70 FR 37160; June 28, 2005). The only change in the UWR Chinook salmon hatchery membership since the listing is that the South Santiam (Calapooia) hatchery adult outplanting program was terminated in 2005. Currently the ESU includes the remaining six hatchery programs -- Clackamas, North Santiam, South Santiam (South Santiam River), South Santiam (Molalla River), McKenzie, and Middle Fork Willamette (Jones et al. 2011)..

- The UWR steelhead (Oncorhynchus mykiss) Distinct Population Segment (DPS).[3] The DPS includes all naturally spawned anadromous winter-run steelhead populations in the Willamette River and its tributaries upstream from Willamette Falls to the Calapooia River (inclusive).

Hereafter in this document we refer to the listing units as "UWR Chinook salmon and steelhead ESUs," unless otherwise specified.

The Plan contains the following major elements:

- A description of the context and process of Plan development (Chapter 1).
- Background information on the environmental characteristics of the Willamette River and biological structure of the UWR ESU/DPS (Chapter 2).
- Oregon's recommended criteria to achieve ESA delisting and further "broad sense" recovery, along with a description of the analyses and chapter relations in this Plan (Chapter 3).
- An evaluation of the conservation gaps between current status and different extinction risk levels for individual populations, as determined through a population viability model (Chapter 4).

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[1] Upper Willamette River Chinook listed as threatened in 1999 (64 FR 14208)[1] ; reaffirmed in 2005 (70 FR 37160)

[2] The stock numbers for the McKenzie River Hatchery and South Santiam Hatchery programs were mistakenly reversed in the regulatory description of this ESU.

[3] Upper Willamette River steelhead listed as threatened in 1999 (64 FR 14517)[3]; listing reaffirmed in 2006 (71 FR 834)

- A description of the life cycle and location-specific limiting factors and threats currently impacting each population (See Box 1 and Chapter 5).
- Details about the desired extinction risk status of populations and their threat scenarios chosen to meet delisting and broad sense recovery criteria (Chapter 6).
- A list of recovery strategies and management actions necessary to address limiting factors and threats and close gaps between the current and desired status of populations, or maintain current population status into the future (Chapter 7).
- A description of the research, monitoring, and evaluation, and associated measurable criteria, necessary to assess populations, make delisting decisions, understand uncertainties, and allow adaptive management in the future (Chapter 8).
- An adaptive management framework describing requirements for implementation, effectiveness evaluations, strategy and action modification, and reporting (Chapter 9).
- Details about goal and objectives for meeting broad sense recovery criteria (Chapter 10).

Box 1, A description of Limiting Factors and Threats.

Limiting Factors and Threats

The reasons for a species' decline generally have been described in terms of limiting factors and threats. NMFS has defined limiting factors as the biological and physical conditions that limit a species' viability – e.g., high water temperature – and defines threats as those human activities or natural processes that cause the limiting factors. For example, removing the vegetation along the banks of a stream (threat) can cause higher water temperatures (limiting factor), because the stream is no longer shaded.

In the context of experimental scientific investigation, it is often assumed that there is a single factor that limits a population of organisms. However, complexity and diversity in habitats, life cycle, and genetic adaptation give salmonid populations the resilience that has allowed them to survive over thousands of years. It is often impossible to obtain enough data to determine a single limiting factor in such a complex system, and because of the interrelationships of the elements of such a system, it is not even very useful to talk *as if* salmonid survival is controlled by a single factor (Bisson 1992).

Recently, to avoid the implications of "limiting factor" as it is used in the study of simpler systems, NMFS scientists have moved toward using "ecological concerns" as an umbrella term for the biological and physical conditions that limit a species' viability. However, the term "limiting factors" has been used extensively in Northwest salmon and steelhead recovery plans and in the Pacific Salmon Restoration Fund (PCSRF). For the sake of consistency, we have chosen to continue its use in this plan, while realizing that several limiting factors are implicated for most VSP parameters. Following through with research, monitoring, and evaluation to understand further the relative importance of these factors is also an essential part of the recovery plan.

1.2 Species Recovery under ESA

Section 4(f) of the ESA requires NMFS to develop and implement recovery plans for species listed as endangered or threatened under the Act. These plans must contain to the maximum extent practicable, (1) a description of site-specific management actions necessary to achieve the Plan's goal for the conservation and survival of the species; (2) objective, measurable criteria which, when met, would result in a determination that the species be removed from the list; and (3) estimates of the time required and cost to carry out the measures needed to achieve the Plan's goal and to achieve intermediate steps toward that goal. This Plan is not a regulatory document, in that it does not require actions to be implemented. However, Oregon and NMFS expect that existing efforts will continue. The Plan can also serves as a useful guide for regulatory agencies to use for implementing existing laws, regulations and agreements, to guide their decisions. If assessments and monitoring indicate that the status of the fish and the threats is not improving, more restrictive management, and possibly new or enhanced regulatory programs, may be necessary.

NMFS is the agency responsible for recovery planning for salmon and steelhead, and also for decisions to list and delist marine species, including anadromous fish, as endangered or threatened. Nevertheless, NMFS recognizes that local support of recovery plans is essential to their successful implementation. The agency is committed to involving local citizens and groups—those whose activities directly affect the listed species, and whose activities are most affected by recovery requirements—in development of the plans.

The State of Oregon has taken the lead, in collaboration with NMFS and many other agencies, in developing the Recovery Plan for UWR salmon and steelhead. This Plan fulfills the initial ESA recovery planning requirements for these species, and represents the participation and leadership of local citizen groups.

The primary goal of ESA recovery plans is for the species to reach the point that it no longer needs the protection of the Act and can be delisted. A Federal recovery plan describes those actions that will remove threats to the species and its habitat so that the species becomes self-sustaining in the wild, as well as the objective, measurable criteria and estimates of the time required and cost to carry out the measures needed to achieve the Plan's goal mentioned above. The Recovery Plan will be considered a "living document" where, as new information and analyses becomes available, revised and additional strategies and actions can be added to the Plan.

Once a species is deemed recovered, and removed from a 'listed status,' section 4(g) of the ESA requires the monitoring of the species for a period of not less than five years to ensure that it retains its recovered status and does not decline to such a state that requires the need to again list it as either a threatened or endangered species under the ESA.

1.3 State of Oregon Recovery Planning

The State of Oregon considers this Plan its conservation Plan for the UWR spring Chinook salmon and steelhead ESUs. The Plan supports the State of Oregon's Plan for Salmon and Watersheds (Oregon Plan) and the Oregon Conservation Strategy. These two planning efforts are described in Section 1.5 below. The Plan is designed to meet the requirements of Oregon's Native Fish Conservation Policy (OAR 635-007-0502 to 0509)[4]. The NFCP, adopted by the Oregon Fish and Wildlife Commission in November 2002 and revised in September 2003, provides policy guidance to support implementation of the Oregon

[4] http://www.dfw.state.or.us/fish/nfcp/rogue_river/docs/nfcp.pdf

Plan. The NFCP is Oregon's policy for managing native fish and determining restoration priorities that improve the effectiveness of conservation efforts under the Oregon Plan. The NFCP focuses on the conservation of naturally produced fish because they are the basis for Federal ESA listings and are the foundation for productive fisheries programs. As outlined in the NFCP, a recovery plan developed by ODFW should meet the requirements of conservation plans that are specified in the policy, as well as detail how Oregon proposes to recover each listed species covered in the Plan.

The NFCP uses conservation plans as a means to identify and implement strategies and actions to restore and maintain native fish in Oregon. The conservation plans describe approaches that the State of Oregon can apply to the conservation and sustainability of species and restore biological attributes necessary to achieve desired status goals that will provide significant ecological, economic and cultural benefits for all Oregonians. Conservation plans are developed through a sequential process, nearly identical to the one used for this recovery planning effort, and includes the following elements:

- Determine the management unit
- Determine its current status
- Define a desired status (viability and broad sense goals)
- Determine any gap between the two and the factors causing the gap (limiting factors)
- Identify strategies and actions that address the limiting factors
- Monitor and evaluate the status and actions implemented and use adaptive management to make adjustments.

As a conservation plan under the NFCP, the Plan for UWR spring Chinook and winter steelhead populations go beyond achieving ESA recovery requirements. Its desired status includes achievement of 'broad sense goals,' including meeting social and cultural benefits. This approach to species recovery includes development of goals for harvestable population levels viewed essential by all the parties involved. Although somewhat broader than the definition of recovery provided in the ESA, these broad sense recovery goals incorporate many of the traditional uses as well as rural and Native American values deemed important in Oregon and throughout the Pacific Northwest. Consistent with the Oregon Plan and NFCP, as well as the ESA, this Plan provides structure and guidance to efforts to protect and restore UWR spring Chinook salmon and winter steelhead and their habitats, while providing flexibility for actions to be determined by appropriate parties. It is designed to support and build on the existing conservation network across the ESU and DPS. This partnership of regulatory and non-regulatory entities, private landowners, and others represents an effective means for achieving viability targets and broader recovery goals.

1.4 Plan Development

This Plan is one piece of a larger recovery planning effort for listed species across the Pacific Northwest. It is also part of a broader planning effort by the State of Oregon to conserve and rebuild Oregon's native salmon and steelhead runs. These overlapping processes are discussed in this section. The Plan is the product of a multi-year, collaborative process led by the Oregon Department of Fish and Wildlife, with extensive participation by the Oregon Governor's Natural Resources Office (GNRO), NMFS, and the Oregon UWR Planning and Stakeholder teams (described below). In addition to the cooperative efforts of those entities, the Plan has benefited from the involvement of a number of other State, Federal, and local agencies. The primary authors of the Plan, representing ODFW and NMFS, benefited from the cooperative efforts of those entities as well as the involvement of a number of other State, Federal, and local agencies.

The Plan was developed with the premise that local support is essential to successful implementation, therefore this Plan considered Oregon's contemporary political, social, and infrastructure landscape which includes a broad range of Federal, State, Tribal, and local needs. The Plan also recognized that implementation of recovery actions will depend on the statutory and management authorities of a wide range of State and Federal agencies, and the willing participation of local governments, community-based conservation organizations, industries, and private landowners that influence salmon and steelhead survival throughout their life cycle.

This Recovery Plan provides an informed, comprehensive, and strategic approach to recovery of the UWR spring Chinook ESU and winter steelhead DPS by addressing the limiting factors and threats within population and across life cycle stages. It is based on science, supported by stakeholders, and is built on existing efforts supplemented by new recovery actions as needed. It is intended to be a realistic roadmap to recovery that will adapt over time in response to new threats, societal values, and new information obtained from research and monitoring.

1.4.1 NMFS's Regional Process

Currently, 17 ESUs and DPS's of Pacific salmon and steelhead in the Pacific Northwest are listed under the ESA. NMFS has designated five geographically-based recovery domains for preparing recovery plans for the listed species (Figure 1-1).

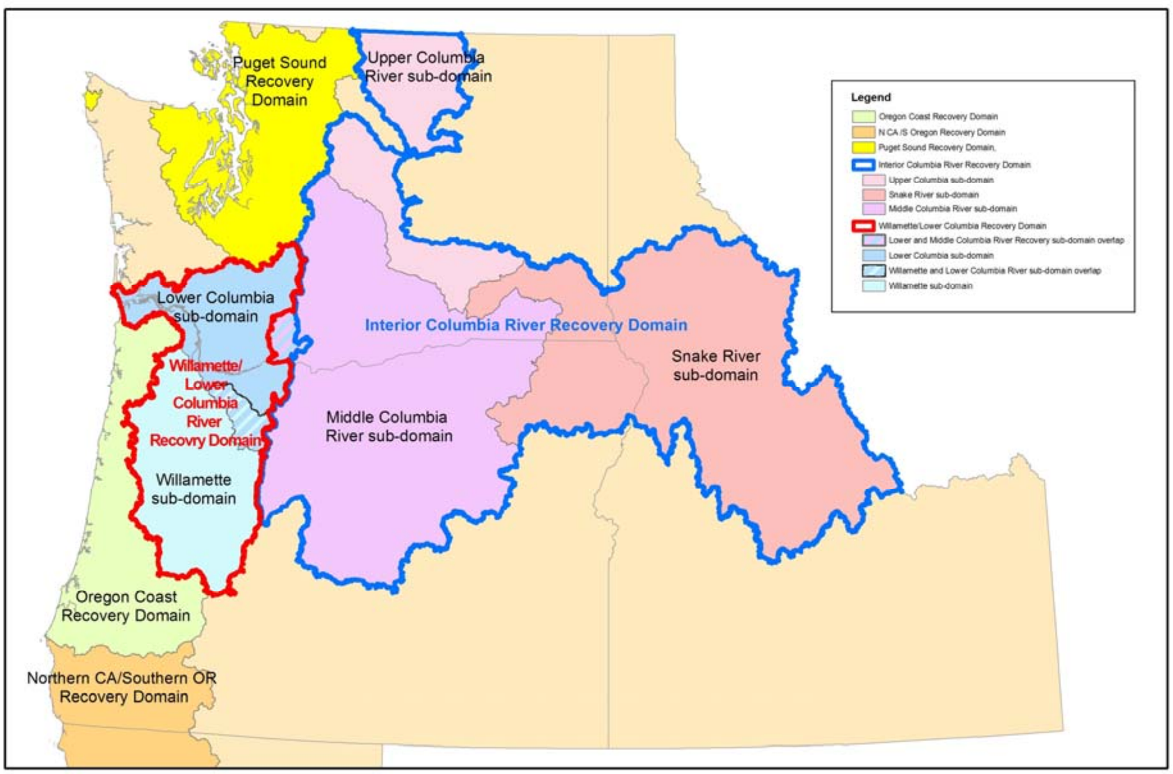

Figure 1-1. Recovery domains for ESA listed salmon and steelhead in Washington and those portions of Oregon and Idaho within the Columbia Basin.

The UWR Chinook salmon ESU and steelhead DPS are within the Willamette/Lower Columbia Domain, which includes all Columbia River subbasins downstream from (and including) the Hood River in Oregon and the White Salmon River in Washington. The other domains are the Interior Columbia River; Puget Sound and Washington Coast; Oregon Coast; and the Southern Oregon/ Northern California Coast domains. Technical and stakeholder involvement in each domain included the following:

- *Technical Recovery Teams*: For each domain, NMFS appointed an independent Technical Recovery Team (TRT) that had geographic and species expertise for the domain and provided a solid scientific foundation for recovery plans. The charge of each TRT was to define ESU/DPS structures, to develop recommendations on biological viability criteria for ESUs/DPSs and populations, to provide scientific support to local and regional recovery planning efforts, and to provide scientific evaluations of recovery plans. The TRTs included biologists from NMFS, State, tribal, and local entities, agencies, academic institutions, and private consulting groups.

  All the TRTs operated from a common scientific foundation. Each TRT used the same biological principles for developing its recommended ESU/DPS and population viability criteria – criteria that will be used, along with threats-based criteria, to determine whether a species has recovered sufficiently to be down-listed to threatened (if endangered) or delisted – although they have developed regionally specific approaches for applying these criteria. Each TRT's recommendations were assessed using the Viable Salmonid Population (VSP) framework, with viability criteria expressed in terms of abundance, productivity (population growth rate), spatial distribution, and diversity (McElhany et al. 2000). The TRT responsible for the domain pertinent to this Plan was the Willamette/Lower Columbia Technical Recovery Team (WLC-TRT).[5]

- *Management Units and Sub-Domains in the Willamette/Lower Columbia Domain* In each domain, NMFS worked with State, tribal, local and other Federal stakeholders to develop local planning forums appropriate to the domain, which built on ongoing, locally led efforts. The Willamette/Lower Columbia Domain is composed of the Lower Columbia River sub-domain and the Upper Willamette River sub-domain. The Upper Willamette River sub-domain, which this Plan addresses, includes the Willamette Basin above Willamette Falls, and spring Chinook in the Clackamas River Basin.

NMFS will ensure that any interdependencies and overlap between the Lower Columbia River "roll up" Plan and this Plan are adequately addressed and that a recovery strategy for the entire domain is clearly communicated. In addition, some recovery actions related to harvest, hatcheries, the Federal Columbia River Power System, and the estuary are regional in scope and will require a regionally consistent set of assumptions and actions. To provide a basis for regional discussion of these issues, NMFS has developed a series of recovery planning modules that are posted on their regional website.[6]

1.4.2 State of Oregon Recovery Planning Process and Use of the Plan

ODFW took the lead in drafting this Plan with the assistance of a cadre of other entities. Partners included NMFS, other State and Federal natural resources agencies, local communities and interested members of the public. The development process was collaborative with broad technical, stakeholder and public involvement. Critical players in the Plan's development were involved at each stage in the decision-making process. The Plan reflects the substantial review, discussion, critique and recommendations of three planning forums: an "expert panel," a diverse public stakeholders' group, and a recovery planning team. Common key staff attended the planning forums to facilitate and oversee the collaborative decision making process. Appendix A identifies the members and affiliations of the Planning and Stakeholder Teams. Appendix C identifies the members of the expert panel. The WLC-TRT

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[5] http://www.nwfsc.noaa.gov/trt/wlc.cfm
[6] http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Other-Documents.cfm

was also involved in the process. In addition, this Plan has been reviewed for scientific and technical soundness by an Independent Multidisciplinary Science Team (IMST[7]). The involvement of a wide spectrum of participants has been vital to the Plan's development and will help ensure that it is both scientifically and technically sound and supported by various stakeholders and private landowners.

Briefly, the function and composition of the groups was as follows:

- *Upper Willamette Expert Panel.*[8] The Oregon Upper Willamette Expert Panel (Expert Panel) was created by ODFW to assist in recovery planning. The panel consisted of biologists with significant knowledge of the limiting factors and threats influencing Oregon's listed salmon and steelhead populations. Panelists identified common key and secondary threat themes and limiting factors for the populations. The findings of the Expert Panel were passed on for review by the Planning and Stakeholder Teams.

- *Upper Willamette Stakeholder Team*. The Upper Willamette Stakeholder Team (Stakeholder Team) consisted of representatives of local communities; agricultural, business, fishing and timber interests; water and land users and managers; local and State governing bodies; and environmental interests. The Stakeholder Team provided policy guidance in the development of all aspects of the Plan and ensured locally appropriate and locally supported recovery actions that will achieve species recovery goals are included. The Stakeholder Team was particularly instrumental in the development of broad sense recovery goals, recovery scenarios, recovery strategies, and strategic guidance for the development and prioritization of management actions.

- *Upper Willamette Planning Team.* The Upper Willamette River Planning Team (Planning Team) included members from State and Federal agencies, many of whom had technical expertise with salmonids and habitat. The team provided technical guidance and assisted in writing different aspects of the Plan. A list of Stakeholder Team and Planning Team members and their affiliations may be found in Appendix A.

The intent of Oregon's recovery planning effort is to develop recovery plans, including this Plan, that meet ESA requirements, are technically sound, and are supported at the community level. The plans are being developed within the context of Oregon's contemporary infrastructures and political and social landscape and will consider a broad range of State, tribal, and local needs. Involvement by these different entities helps ensure that recovery goals and actions are consistent and compatible with the goals and direction adopted in related efforts. This integrated approach establishes partnerships that allow actions to be implemented effectively and efficiently. Ultimately, the successful implementation of recovery actions will depend on the willing participation of most, if not all, of the entities that influence salmon and steelhead

As with other Oregon recovery plans, this Plan describes strategies to protect and restore a sufficient level of ecologic function to achieve delisting and broad sense recovery of ESA listed species. The Plan recommends actions that could be carried out under the statutory and management authorities of a wide range of State and Federal agencies, industries, local governments, community-based conservation organizations and private landowners. The Plan will evolve as limiting factors and societal values change and as research, monitoring, and evaluation yield new information.

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[7] http://www.fsl.orst.edu/imst/
[8] Panel Team Members are listed in Appendix C.

It is anticipated that on August 4, 2011 the Oregon Fish and Wildlife Commission will approve this Plan and adopted associated administrative rules as required by the NFCP. The Plan provides ODFW with conservation and fish management direction, and it will be integrated into other plans and planning processes that ODFW undertakes. The Plan will also be used to guide budget priorities through the Governor's Office, as well as funding and program priorities with State agencies, boards, and commissions. In particular, it will be used to help guide the Oregon Watershed Enhancement Board's (OWEB) funding decisions for watershed councils, soil and water conservation districts (SWCD's), and other implementers. The State of Oregon and NMFS are co-developers of the Plan.

1.4.3 Plan Review, Revision, Adoption and Implementation

The authors used other existing plans, documents, assessments, or requirements in developing this Plan, notably, actions contained in the *Estuary Module* (a recovery plan addressing the Columbia River estuary), the *Willamette River Basin Flood Control Project Biological Opinion* (WP BiOp), Federal Energy Regulatory Commission (FERC) hydropower re-license agreements, the Willamette Total Maximum Daily Load Allocation (TMDL) report, and local habitat restoration or conservation plans. In addition, the contents of this Plan are consistent with, complementary to, or build upon strategies or actions contained in the *Oregon Plan for Salmon and Watersheds*, the *Oregon Conservation Strategy*, the Hatchery Science Review Group's assessment of UWR hatchery programs as well as other recent scientific papers and reports, and the Northwest Power and Conservation Council subbasin plan.

NMFS published a Notice of Availability of the Proposed *Upper Willamette River Conservation and Recovery Plan for Salmon and Steelhead* in the Federal Register on October 22, 2010 and NMFS, ODFW and the Oregon Governor's Office held four formal public meeting and a number of informal sessions in order to obtain comments on the proposed Plan. More than thirty comments were received.

NMFS and ODFW reviewed all comments received for substantive issues and new information and revised the Plan as appropriate. We received a number of very detailed and substantive comments, as well as editorial clarifications and minor corrections, requests to cite specific documents, and suggested changes in wording to clarify the document. Most comments offered support for the Plan and its implementation, along with thoughtful comments. NMFS addressed the comments in the response to comments document, which is available on the NMFS Regional Office website - *http://www.nwr.noaa.gov/*

Based on a number of the comments, the Final Plan places additional emphasis on:

- the importance of successful reintroduction of naturally reproducing salmon and steelhead above the flood control dams in the Willamette River subbasins, and downstream passage for their offspring;
- the long-term challenges associated with setting priorities to protect the existing salmon and steelhead habitat and restoring the additional habitat needed to recover these two species, including the high priority habitat in North and South Santiam, Middle Fork Willamette and McKenzie subbasins and the rearing habitat in the entire mainstem Willamette River (including the lower Willamette River below Willamette Falls);
- the need for over-all integration of research, monitoring and evaluation of spring Chinook, steelhead, and their habitat, to better inform future decisions.
- Climate change and human population growth and how salmon and steelhead recovery efforts can adapt.
- Details describing strategies and actions concerning the effects of hatcheries.

The Oregon Fish and Wildlife Commission was presented with a draft of the Plan in January 2011, and is expected to provide final approval for the Plan as a State of Oregon conservation plan on August 4, 2011.

The Plan will also be published in the Federal Register as a Federal recovery plan for the UWR sub-domain.

1.5 Relationship to Other Planning and Program Efforts

There are other recently completed or currently underway planning efforts that have a significant bearing on the design and/or implementation of this Plan. These planning efforts include:

The Lower Columbia River Conservation Plan for Oregon Populations of Salmon and Steelhead[9]

Many of the analyses in this UWR Plan are similar to those developed in Oregon's final Lower Columbia ESA Recovery Plan for Oregon populations (hereafter the OrLCR Plan), and the OrLCR Plan was used as a design template for organization of this Plan. This established some consistency between the plans. In addition, many of the actions in the OrLCR Plan are common to actions in this Plan, particularly those relating to actions that take effect in the estuary where populations from both domains occur for some portion of their life cycle. Further detail of how OrLCR actions where incorporated into this Plan are noted in relevant sections of this Plan.

Oregon Plan for Salmon and Watersheds[10]

In 1997, Oregon's governor and legislature adopted the Oregon Plan for Salmon and Watersheds to begin State-led recovery efforts. The Oregon Plan is funded principally by Oregon Measure 66 funds (Lottery funds) and seeks to restore salmon runs, improve water quality, and achieve healthy watersheds and strong communities throughout the state. It is a comprehensive partnership between government, communities, private landowners, industry and citizens funded by the Oregon Legislature. The Plan's mission is:

To restore Oregon's native fish populations and the aquatic systems that supports them to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits. The Plan has a strong focus on salmon because they are important indicators of watershed health and have great cultural, economic and recreational importance to Oregonians.

The Oregon Plan organizes actions around the factors that contribute to the decline in fish populations and watershed health. Most of these actions focus on improving water quality and physical habitat quality and quantity. Watershed councils and soil and water conservation districts lead efforts in many basins. Landowners and other private citizens, sport and commercial fishing interests, the timber industry, environmental groups, agriculture, utilities, businesses, tribes, and all levels of government also come together to organize, fund, and implement these measures, which rely on scientific oversight, coordinated tribal and government efforts, and ongoing monitoring and adaptive management to achieve program success.

The Oregon Plan relies on Oregon's spirit of volunteerism and stewardship, along with public education and awareness, strong scientific oversight, coordinated tribal and government efforts, and ongoing monitoring and adaptive management to achieve program success. Oregon will implement the Oregon Plan consistent with ESA recovery planning and with other Oregon related-salmon programs.

Oregon Conservation Strategy[11]

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[9] http://www.dfw.state.or.us/fish/CRP/lower_columbia_plan.asp
[10] http://www.oregon-Plan.org/
[11] http://www.dfw.state.or.us/conservationstrategy/

The Oregon Conservation Strategy (Conservation Strategy) was developed by ODFW in response to a national effort guided by Congress and the U.S. Fish and Wildlife Service (USFWS) to encourage states to develop comprehensive wildlife planning. The Conservation Strategy was approved by the Oregon Fish and Wildlife Commission in August 2005 and by the USFWS in March 2006. Oregon's approach was to establish a long-term vision and set specific goals not only for conservation actions to be implemented by ODFW, but also as a conservation blueprint for all Oregonians. The overarching goal of the Conservation Strategy is to "maintain healthy fish and wildlife populations by maintaining and restoring functioning habitats, prevent declines of at-risk species, and reverse declines in these resources where possible." The Conservation Strategy emphasizes the proactive conservation and management of 11 strategy habitats across eight state ecoregions. It addresses species conservation through a fine filter approach and identified 286 strategy species based on their population status or that represent the diversity and health of wildlife in Oregon.

The two ESA listed species addressed in this Plan are also listed as strategy species in the Conservation Strategy. This Plan's actions also address the six key issues identified in the Conservation Strategy, in addition to others.

Willamette Valley Project Biological Opinion 2008[12]

The Willamette River Basin Flood Control Project (Willamette Project; WP) is operated and maintained by the U.S. Army Corps of Engineers (USACE) and includes 13 multipurpose dams and reservoirs, and about 43 miles of revetments in the upper Willamette River basin and subbasins. Bonneville Power Administration (BPA) markets power generated at some of the Willamette Project dams, and the U.S. Bureau of Reclamation (USBOR) sells a portion of the water stored in WP reservoirs for irrigation purposes. As part of a mitigation agreement, a majority of the fish hatchery programs are funded by these Federal entities. A full description of the Willamette Project is included in the Supplemental Biological Assessment (USACE 2007a).

NMFS issued a Biological Opinion (hereafter WP BiOp; NMFS 2008a[13]) on the impact of the Willamette Project on species listed for protection under the Endangered Species Act. NMFS found that the Action Agencies' Proposed Action alone was not sufficient to avoid jeopardy or adverse modification of critical habitat for UWR Chinook salmon ESU and steelhead DPS, and would destroy or adversely modify their critical habitat.

The WP BiOp noted that the Willamette Project adversely affects UWR Chinook and steelhead by blocking access to a large amount of their historical habitat upstream of the dams and by contributing to degradation of their remaining downstream habitat. In the consultation process the Action Agencies proposed several measures to address these effects in their Proposed Action. Overall, NMFS found these actions insufficient to ensure the species' survival with an adequate potential for recovery, or to prevent destruction or adverse modification to their critical habitat. Therefore, the NMFS opinion proposed a Reasonable and Prudent Alternative (RPA) with additional measures which, combined with the Proposed Action, would allow for survival of the species with an adequate potential for recovery, and avoid destruction or modification of critical habitat. These RPA measures include providing fish passage at three dams and temperature control at another, adjustments to downstream flows, improving water quality, improving hatchery program practices, screening irrigation diversions and conducting habitat mitigation. Some of the modifications to flow have already begun, and other measures will be

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[12] http://www.nwp.usace.army.mil/pm/e/reports/environmental/ba/Final_Will_Supp'l_BA.pdf _.
[13] http://www.nwr.noaa.gov/Salmon-Hydropower/Willamette-Basin/Willamette-BO.cfm

implemented in the short-term to decrease the species' risk of extinction until the longer-term passage and temperature control measures are completed.

This Plan relies on the WP BiOp RPA's as a foundation for management actions to address fish access, flow, hatchery fish mitigation, and habitat issues associated with the Willamette Project. Several members of the Upper Willamette Planning Team are also technical representatives in the Willamette Action Team for Ecosystem Restoration (WATER) coordination process (see NMFS 2008a). It is important that Federal and State agencies coordinate implementation of the WP BiOp RPA and this Plan on an ongoing basis.

Northwest Power and Conservation Council Subbasin Plans[14]

In 1980 Congress created the Northwest Power and Conservation Council (NPCC) to give Washington, Oregon, Idaho, and Montana a regional voice in mitigating the effects of Federal energy generating systems on fish and wildlife. Subbasin plans became a vehicle to further define regional mitigation objectives, and to guide BPA mitigation expenditures. In April 2003, the NPCC designated the Willamette Restoration Initiative (WRI) as the lead entity for developing the *draft Willamette Subbasin Plan*. The draft plan (WRI 2004) collated a large amount of habitat and fish/wildlife information that was essential for the development of this Plan. The WRI has since transitioned into the Willamette Partnership[15].

The WRI was originally established to develop and implement a long-range conservation Plan for the Willamette River and its watershed. Completed in 2001, this conservation Plan, called the *Willamette Restoration Strategy*, is the "Willamette chapter" of the Oregon Plan for Salmon and Watersheds. The *Willamette Restoration Strategy* identified 27 critical actions needed to preserve and improve watershed health in the areas of water quality, water supply, habitat and hydrology, and institutions. Two of the actions call for more detailed identification of fish and wildlife conservation priorities and more integrated environmental planning. As they pertain to UWR Chinook and steelhead, this Plan has adopted, expanded, and refined many of the actions, strategies, and priorities that were developed in the restoration strategy and subbasin Plan.

Columbia River Hatchery Scientific Review Group[16]

The Hatchery Scientific Review Group (HSRG) is the independent scientific review panel of the Pacific Northwest Hatchery Reform Project established by Congress in 2000 in recognition that while hatcheries play a legitimate role in meeting harvest and conservation goals for Pacific Northwest salmon and steelhead, the hatchery system was in need of comprehensive reform. The HSRG has reviewed all State, tribal and Federal hatchery programs in Puget Sound and Coastal Washington, and released their final report for those in the Columbia River Basin in early 2009. A Recovery Implementation Science Team (RIST17) subsequently reviewed the HSRG recommendations, and noted some areas of uncertainty with the recommended HSRG broodstock genetic management guidelines. In addition, the ODFW subsequently reviewed emerging information regarding the use of integrated broodstock programs and the draft HGMP levels of wild fish integration. The ODFW analysis brought into question the level of wild fish integration in the draft HGMPs, and proposed new integration guidelines for hatchery programs involving UWR fish. As a result, there is some current uncertainty regarding the best approach for broodstock management and the type of hatchery program that will best promote recovery goals. A goal

[14] http://www.nwcouncil.org/fw/subbasinplanning/willamette/Plan/
[15] http://www.willamettepartnership.org
[16] http://www.hatcheryreform.us/mfs/welcome_show.action
[17] http://www.nwfsc.noaa.gov/trt/index.cfm

in this Plan is to continue to engage key experts doing empirical and/or theoretical research on genetic and ecological hatchery-wild issues, with the objective of providing some guidance on successful re-introduction in the UWR Chinook ESU.

Columbia River Estuary Recovery Plan Module[18]

The Estuary Module (NMFS 2008b) is part of a larger regional planning effort to develop recovery plans for ESA-listed salmon and steelhead in the Columbia River basin. The Module focuses on habitat in the lower Columbia River below Bonneville Dam and Willamette falls, and how that habitat affects the survival of ESA-listed chum, steelhead, Chinook, and coho from throughout the Columbia River basin. This includes impacts on UWR Chinook and steelhead populations. Geographically, the Module covers the tidally influenced reaches of the lower Columbia River, estuary, and plume. The goal of the Module is to identify actions that, if implemented, would improve the survival of ESA-listed salmon and steelhead during their migration and rearing in the estuary and Columbia River plume.

The Module identifies and prioritizes limiting factors and threats in the estuary that affect the viability of salmon and steelhead populations. The Module lists 23 broad actions whose implementation would reduce the threats and thus increase survival of salmon and steelhead during their time in the estuary. The Module also estimates the cost of implementing each action over a 25-year period. A description of monitoring, research, and evaluation needs is being completed and will be included as an appendix to the Module. The science and regulatory obligations provided through these forums have been incorporated into the NMFS's proposed and final ESA recovery plans for listed Columbia Basin salmon and steelhead. The Estuary Module will be incorporated or adopted by reference into the Plan for the ESU and DPS.

Other Efforts

A number of local governments and non-governmental organizations are actively working to improve the health of the Willamette River. NMFS and ODFW recognize the valuable contribution these organizations are making; Chapter 9 describes our intent to support and coordinate with these efforts as we implement this Plan.

1.6 Tribal Treaty/Trust Obligations

Northwest Indian Tribes have legally enforceable rights reserving to them a share of the salmon harvest. A complex history of treaties, executive orders, legislation, and court decisions have culminated in the recognition of tribes as co-managers who share management responsibilities and rights for fisheries in the Columbia Basin.

Ensuring a sufficient abundance of salmon and steelhead to sustain harvest is an important element in fulfilling trust responsibilities and treaty rights as well as garnering public support for recovery plans. ESA and tribal trust responsibilities complement one another. Both depend on a steady upward trend toward ESA recovery and delisting in the near term, while making aquatic habitat, harvest, and land management improvements for the long term.

1.7 Overview of Recovery Plan Objectives

Recovery plans can provide a central organizing tool for the recovery of listed species. Chapter 3 explains the ESA and Broad Sense Recovery Goals and Criteria that provide the multiple objectives for this Plan.

[18] http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Estuary-Module.cfm

Chapter 2: Environmental and Biological Background

This chapter describes briefly the geographic setting of the Recovery Plan, life history information for the different species, and the independent populations that are contained within the listed UWR Chinook ESU and UWR steelhead DPS[19]. More detailed information can be found in Plan appendices and supporting plans and documents in citations.

In an earlier Federal decision, NMFS determined that any hatchery stocks found to be part of an ESU or DPS would be considered in determining whether the ESU or DPS is threatened or endangered under the ESA, and would be included in any listing of the ESU or DPS (FR 70 37204). According to the NMFS Hatchery Policy: "Hatchery stocks with a level of genetic divergence relative to the local natural population(s) that is no more than what occurs within the ESU: (a) are considered part of the ESU; (b) will be considered in determining whether an ESU should be listed under the ESA; and (c) will be included in any listing of the ESU." The Hatchery Policy further recognized that the role of hatchery fish in status assessment and recovery would be determined "… in the context of their contributions to conserving natural self sustaining populations." Hatchery fish were recognized to potentially have either positive or negative effects on the status of natural populations. Finally, hatchery fish were not given full protection under Section 4(d) of the ESA; instead "For ESUs listed as threatened, NMFS will, where appropriate, exercise its authority under section 4(d) of the ESA to allow the harvest of listed hatchery fish that are surplus to the conservation and recovery needs of the ESU, in accordance with approved harvest plans."

Hatchery stocks were included in the UWR Chinook ESU and are listed along with naturally produced fish. The inclusion of hatchery stocks in the ESU was based on a review and analysis of hatchery broodstock origins, broodstock age, management history, and life history and genetic information conducted by Drake et al. (2003). The specific hatchery stocks included in the ESU are provided in the final listing notices (70 FR 37160 and 71 FR 834). Most hatchery fish released into the Willamette subbasins are now marked with an adipose fin clip and are available for use in harvest (70 FR 37204), and other management needs. The UWR hatchery stocks will be used to implement some recovery strategies for the ESU and DPS, but recovery goals are focused on the development and conservation of self-sustaining naturally-produced populations.

As defined under the ESA, a "species" includes "any subspecies of fish or wildlife or plants and any other group of fish or wildlife of the same species or smaller taxa in common spatial arrangement that interbreed when mature." The NMFS ESU policy, which applies to Pacific salmon, and the joint NMFS-USFWS DPS policy, which applies to all other species (including *O. mykiss* – anadromous steelhead and resident rainbow trout), implement this provision of the statute. The ESU definition emphasizes reproductive isolation and evolutionary significance. The DPS definition emphasizes discreteness and significance to the taxon. Steelhead and rainbow trout within a common geographic area are not

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[19] The ESA defines a species to include any species, sub-species, or distinct population segment (ESA section (3)(15)). NMFS defines distinct population segments as Evolutionarily Significant Units (ESUs) for listing Pacific salmon (and previously used the ESU for listing West Coast steelhead as well) (Waples 1991). An ESU is a group of Pacific salmon that is (1) substantially reproductively isolated from other groups and (2) represents an important component of the evolutionary legacy of the species. Recently, NMFS revised its species determinations for West Coast steelhead (*Oncorhynchus mykiss*) under the ESA, delineating anadromous, steelhead-only "distinct population segments" (DPS). Rainbow trout, the resident form of *O. mykiss*, are under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS). NMFS listed the lower Columbia River steelhead DPS as threatened in January 2006. The Federal Register notice (71 FR 834) contains a more complete explanation of the listing decision and of previous ESA actions related to steelhead.

necessarily reproductively isolated but the two life history forms are discrete (Kostow 2003). NMFS used the DPS policy to delineate listing units of steelhead for the reasons described in the listing notice (70 CFR 37160).

The two species units addressed in this Plan use freshwater habitat in the Willamette River basin for reproduction, juvenile rearing and adult holding, and adult and juvenile migration. UWR Chinook spawn and rear in the Clackamas, Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and Middle Fork Willamette subbasins. Steelhead of the UWR DPS spawn and rear in the Molalla, North Santiam, South Santiam, and Calapooia subbasins. With the exception of the Clackamas River, the principal subbasin rivers join the Willamette River mainstem above Willamette Falls.

2.1 Climate and Geomorphology

Recovery planning efforts for the UWR ESU and DPS focused mostly on conditions within the ecological zones that characterize the upper Willamette River basin and subbasins, and to a lesser extent on the Columbia River estuary. The combined influences of climate and geomorphology of the Willamette Basin have shaped both the life history characteristics and distribution of native salmon and steelhead populations.

The Willamette Basin covers 11,500 square miles and encompasses parts of three physiographic provinces.[20] The Cascade Range covers 60% of the basin and consists of volcanic rocks with elevations exceeding 10,000 feet. The range forms the eastern boundary of the basin. The Willamette Valley covers 30% of the basin. The elongated valley floor is structurally an erosional lowland, filled with flows of Columbia River Basalt (in the northern half of the basin) and younger unconsolidated sediment (Wentz 1998). The Coast Range, comprised of marine sedimentary and volcanic rocks at elevations over 4,000 feet, covers the remainder of the basin and constitutes the western boundary of the Willamette Valley.

Willamette Falls is a natural geomorphic feature that was formed by basalt intrusions. The falls are located in the lower Willamette River basin, ~ 26 miles upstream from the confluence of the Willamette and Columbia rivers. These horseshoe-shaped falls are 40 ft high and 1,500 ft long, and represent the largest waterfall in the Pacific Northwest. Historically the falls limited the upstream migration of some salmon and steelhead races, and in this Plan the falls delineate a geographic boundary between the upper Willamette River basin and the lower Willamette River basin, which has some tidal influence. Major drainage subbasins to the mainstem Willamette River that represent natal freshwater habitats of independent populations of Chinook and steelhead include the Clackamas, Molalla, Santiam, Calapooia, McKenzie, and Middle Fork rivers (natal). The lower reaches of some of the west-side subbasins (termed "West-Side tributaries" in this Plan) have had documented presence of adult Chinook and steelhead, but it is not clear how these fish contribute or are related to the independent populations assigned in Myers et al. 2006). In the larger metapopulation context, fish produced in these subbasins presumably functioned as dependent populations of the UWR ESU. Some of the lower reaches in West-Side tributaries have also had documented presence of Chinook and steelhead juvenile life stages. These fish may be juvenile UWR Chinook and steelhead that were produced in natal Cascade Range subbasins, and are using these reaches for rearing habitat, or they were produced from extant dependant populations. These Coast Range subbasins include the Tualatin, Yamhill, Luckiamute, Marys, Coast Fork, and Long Tom rivers.

The upper Willamette River basin has a moderate climate with cool, wet winters and warm, dry summers. Approximately 10% of the average annual precipitation of 63 inches occurs between May and September.

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[20] Analogous to U.S. EPA level 3 ecoregions (http://www.epa.gov/bioindicators/html/lv3-eco.html).

Precipitation varies markedly with altitude and ranges from about 40 inches at lower elevations to greater than 200 inches in the mountains. Most of the annual streamflow in the Willamette River mainstem occurs typically between November and March in response to winter rain and spring snowmelt; however, melting of late spring snow in the high Cascade Range can prolong runoff into June or July in rivers flowing out of the Cascade Range (Wentz 1998). The peak flows in December and January are sustained at 50% of peak flow for 6 or 7 months of the year. Low flows occur in August and September, with the volume about 20% of the peak flow. Summer flows in the Coast Range tributaries are especially low because of the general absence of any substantial snowpack, and these tributaries historically may never have sustained independent Chinook salmon populations (Dimick and Merryfield 1945).

Anthropogenic Conditions

The Willamette River valley is home to 70% of Oregon's human population (NPCC 2004) including Oregon's three largest cities (Portland, Eugene, and Salem). Figure 2-1 shows the spatial relationships of major land use types. Approximately 70% of the basin is forested, with approximately 36% of the basin in Federal forest ownership. Most of the Federal forest land is located in the higher elevations of the Cascade and Coast ranges and is managed by the U.S. Forest Service (USFS) and U.S. Bureau of Land Management (USBLM). About 22% of the basin area is in agricultural production, and the remaining 8% is urbanized or in other uses (Wentz 1998). More than 60% of the basin area is outside the urban growth boundaries and more than 90% of the valley floor is privately owned (Pacific Northwest Ecosystem Research Consortium 2002).

Several major flood control or hydropower facilities have been developed in the Clackamas River subbasin, and in subbasins of the upper Willamette River basin, including facilities in the North Santiam, South Santiam, McKenzie and Middle Fork Willamette rivers (Figure 2-1). As will be detailed in Chapter 5 of this Plan, dam construction and operations impact salmonids by hindering fish passage to historical upstream spawning and rearing habitat, and by altering the natural hydrologic regimes, especially during summer and fall low flow periods.

2.2 Salmon and Steelhead Distribution and Life Histories

Life histories and habitat use for UWR Chinook and steelhead are discussed below.

2.2.1 UWR Chinook

UWR Chinook salmon have been shown to be genetically strongly differentiated from nearby populations, and are considered one of the most genetically distinct groups of Chinook salmon in the Columbia River Basin (Waples et al. 2004, Beachum et al. 2006). For adult Chinook salmon, Willamette Falls historically acted as an intermittent physical barrier to upstream migration into the upper Willamette River basin, where adult fish could only ascend the falls at high spring flows. It has been proposed that the falls served as an zoogeographic isolating mechanism for a considerable period of time (Waples et al. 2004), and has led to, among other attributes, the unique early run timing of these populations relative to other lower Columbia River spring-run populations. Historically the peak migration of adult salmon over the falls occurred in late May (Wilkes 1845). Low flows during the summer and autumn months prevented fall-run salmon and coho from reaching the upper Willamette River basin.

The Willamette Valley was not glaciated during the last epoch (McPhail and Lindsey 1970) and Willamette Falls likely served as a physical barrier for reproductive isolation of Chinook salmon populations. This isolation had the potential for produce significant local adaptation relative to other Columbia River populations (Myers et al. 2006). Fish ladders were constructed at the falls in 1872 and again in 1971, but it is not clear what role they may have played in the present day in reducing localized adaptations in UWR fish populations. Little information exists on the life history characteristics of the historical UWR Chinook populations, especially since early fishery exploitation (starting in the mid 1880s), habitat degradation (starting in the early 1800s in the lower Willamette Valley), and pollution in the lower Willamette River (by early 1900s) likely altered life history diversity before data collections began in the mid 1900s. Nevertheless, it is thought UWR Chinook salmon still contain a unique set of genetic resources compared to other Chinook stocks in the WLC Domain.

The generalized life history traits of UWR Chinook are summarized in Table 2-1. Today, adult UWR spring Chinook begin appearing in the lower Willamette River in January, with fish entering the Clackamas River as early as March. The majority of the run ascends Willamette Falls from late April through May, with the run extending into mid August (Myers et al. 2006). Chinook migration past the falls generally coincides with a rise in river temperatures above 50°F (Mattson 1948, Howell et al. 1985, Nicholas 1995). Historically, passage over the falls may have been marginal in June because of diminishing flows, and only larger fish would have been able to ascend. Mattson (1963) discusses a late spring Chinook run that once ascended the falls in June. These fish were apparently much larger (11.4–13.6 kg) and older (presumably 6-year-olds) than the earlier part of the run. Mattson (1963) speculated that this portion of the run "intermingled" with the earlier run fish on the spawning ground and did not represent a distinct run. The disappearance of the June run in the 1920s and 1930s was associated with the dramatic decline in water quality in the lower Willamette River (Mattson 1963). This is also the period of heaviest dredging activity in the lower Willamette River. The main channel of the river was moved from the east side of Swan Island, enough dredge material was removed from the Willamette River to increase the size of Swan Island to three times its original size. Dredge material was also used to fill floodplain areas like Guilds Lake (some came from other sources too). Chinook salmon now ascend the falls via a fish ladder.

Table 2-1. A summary of the general life history characteristics and timing of UWR Chinook salmon. Data are from numerous sources.

Life History Trait	Characteristic
Willamette River entry timing	January-April; ascending Willamette Falls April-August
Spawn timing	August-October, peaking in September
Spawning habitat type	Larger headwater streams
Emergence timing	December – March
Rearing habitat	Rears in larger tributaries and mainstem Willamette
Duration in freshwater	12-14 months; sometimes 2-5 months
Estuarine use	Days to several weeks
Life history type	Stream
Ocean migration	Predominately north, as far southeast Alaska
Age at return	3-6 years, primarily 4-5 years

After ascending Willamette Falls, adult Chinook migrate quickly to the upper portions of the larger subbasins and "hold" in the deeper pools with cooler water temperatures through the summer. The historic spawning period for UWR Chinook probably extended from July through October, but at the present spawning generally begins in late August and continues into early October, with peaks spawning in September (Mattson 1948, Nicholas 1995, Willis et al. 1995). Adult Chinook salmon must deposit their eggs at a time that will insure that fry emerge the following spring when productivity is sufficient for survival and growth (Myers et al. 2006). Exact timing varies with water temperature with fish in colder areas, such as the headwaters, spawning earlier than fish lower in the subbasin. Because Chinook spawn in the fall and their offspring emerge from the gravel the following spring, the success of spawning is greatest in areas with relatively stable substrates so that gravel and cobbles shifting during high water events do not damage the eggs.

Chinook fry emerge from gravels from February through March, and sometimes as late as June (Mattson 1962). Unnaturally warm water released in the fall from the large flood control dams on several tributaries hastens the development of eggs and emergence of fry compared to emergence in tributaries with unregulated water flows (Downey et al. 1993). The juveniles rear in areas with a variety of cover types that provide protection. A general trait found in other populations is that older juvenile migrants primarily use mid-channel areas and usually migrate at night, presumably to avoid predators. UWR Chinook typically exhibit a stream-type life history (see Healey 1991 for details of Chinook salmon life history races based on adult and juvenile migration timing), where adults begin migrating upstream through freshwater zones in the Columbia River in the spring. Unlike some stream-type Chinook populations, the rearing and migratory life history pattern of UWR Chinook is more of a continuum. Migration peaks occur in most years, but sometimes there is a very broad distribution (Kirk Schroeder, personal communication). A significant proportion, if not the majority of UWR Chinook, emigrate from freshwater as yearlings, similar to other stream-type Chinook salmon. In general, once fish reach this age, this is a directional downstream migration, although there is evidence that fish are growing during this passage, implying they are eating and rearing as they migrate. Variants to this "classic" timing of stream-type yearling migration have been described for UWR Chinook salmon (Figure 2-2). Juvenile emigration Distinct phases of juvenile emigration out of tributaries into the Willamette River are variable with environmental conditions include: 1) Late winter to early spring as fry, 2) fall to early winter as fingerlings, and 3) late winter through spring as yearlings. These three primary migration types are discussed below based on information provided by Schroeder et al. (2007) for the McKenzie River. The three migratory types have been documented in the McKenzie River subbasin, which is the most natural system remaining in the Willamette Basin, and are also representative of other spring Chinook populations in the Columbia Basin (Schroeder et al. 2007).

- *Fry and early fingerling migration*. Shortly after emergence some UWR Chinook fry can migrate long distances and continue to migrate through spring. It is thought that most of these migrating fish are derived from late-emerging fry from the colder tributaries, or from fish that spent a short time rearing near the spawning areas before migrating and reach fingerling size. ODFW has documented fry from the McKenzie River migrating into the upper and middle reaches of the mainstem Willamette River, and early studies documented fry moving into the Willamette River just upstream of Willamette Falls and migrating over Willamette Falls. For example, Craig and Townsend (1946) showed that juveniles began moving downstream during March soon after emergence. It is thought that historically, many juvenile fish resided for a period of time in the Willamette River. The NPCC (2004) cited studies in the 1940s that reported large numbers of fry in the Willamette River from February through early April.

  ODFW sampling and tagging data are starting to indicate that most fry and fingerling rear in the lower reaches of spawning tributaries and in the Willamette River mainstem in late winter and early spring (Schroeder et al. 2005, 2007). Some fish grow quickly in this area and migrate as subyearling smolts out of the Willamette River basin, probably beginning in early to mid May for the larger fish and continuing into mid July in most years. These fish have been captured in the upper estuarine zone of the lower Columbia River, and have also been captured in June in near-shore ocean samples. Scale samples collected from adults indicate that some of these subyearlings survive and return as spawners. A larger percentage of these subyearlings are from the Santiam River basin, where the altered temperature regime from reservoir releases causes eggs to develop faster and fry to emerge sooner from the gravel, than from the McKenzie Basin, which has a more natural temperature regime.

- *Subyearling migration.* Some Chinook salmon fry remain in the upper Willamette River subbasins and subordinate tributaries through their first spring and summer, and migrate in the fall and early winter. Fall migrations may relate in part to increased flow (and water temperatures) caused by Willamette Valley Flood Control Project operations (e.g., reservoir drawn down for flood risk reduction operations). Sometimes these fall migrations are quite large and the average size of these fish is often larger than the fish that will migrate out of the upper subassins the following spring as yearling smolts. Some of these fall migrants move past Willamette Falls and presumably into the Columbia River mainstem. We do not know if they migrate to the ocean; they likely spend the winter in the Columbia River or estuary before entering the ocean, maybe as early as March.

- *Yearling migration.* Many Chinook salmon rear in the upper Willamette River subbasins through the year and migrate from March through May during their second spring as yearling smolts. These fish generally move fairly quickly through the Willamette River mainstem and over Willamette Falls. We note that juvenile Chinook salmon are also collected in West-side tributaries of the Willamette River. Presumably these fish are migrants from natal basins and use West-side tributaries as a portion of their rearing habitat.

Once they enter the Pacific Ocean, UWR Chinook migrate north along the coasts of British Columbia and southeastern Alaska (Myers et al. 2006). The majority of both hatchery-origin and natural-origin UWR Chinook adults are four and five years old when they return to freshwater, with small proportions of age-3 and age-6 fish. In general, returning hatchery-origin Chinook adults tend to be younger than natural-origin fish, with a higher proportion of age-4 fish.[21] Life history characteristics and genetic background of UWR Chinook populations may have been reduced or traits redirected by artificial propagation, migration barriers, and habitat degradation (Myers et al. 2006; NMFS 2005b).

[21] Age-of-return of hatchery fish can be modified by manipulating the season and size at which the juveniles are released (see Hankin 1990).

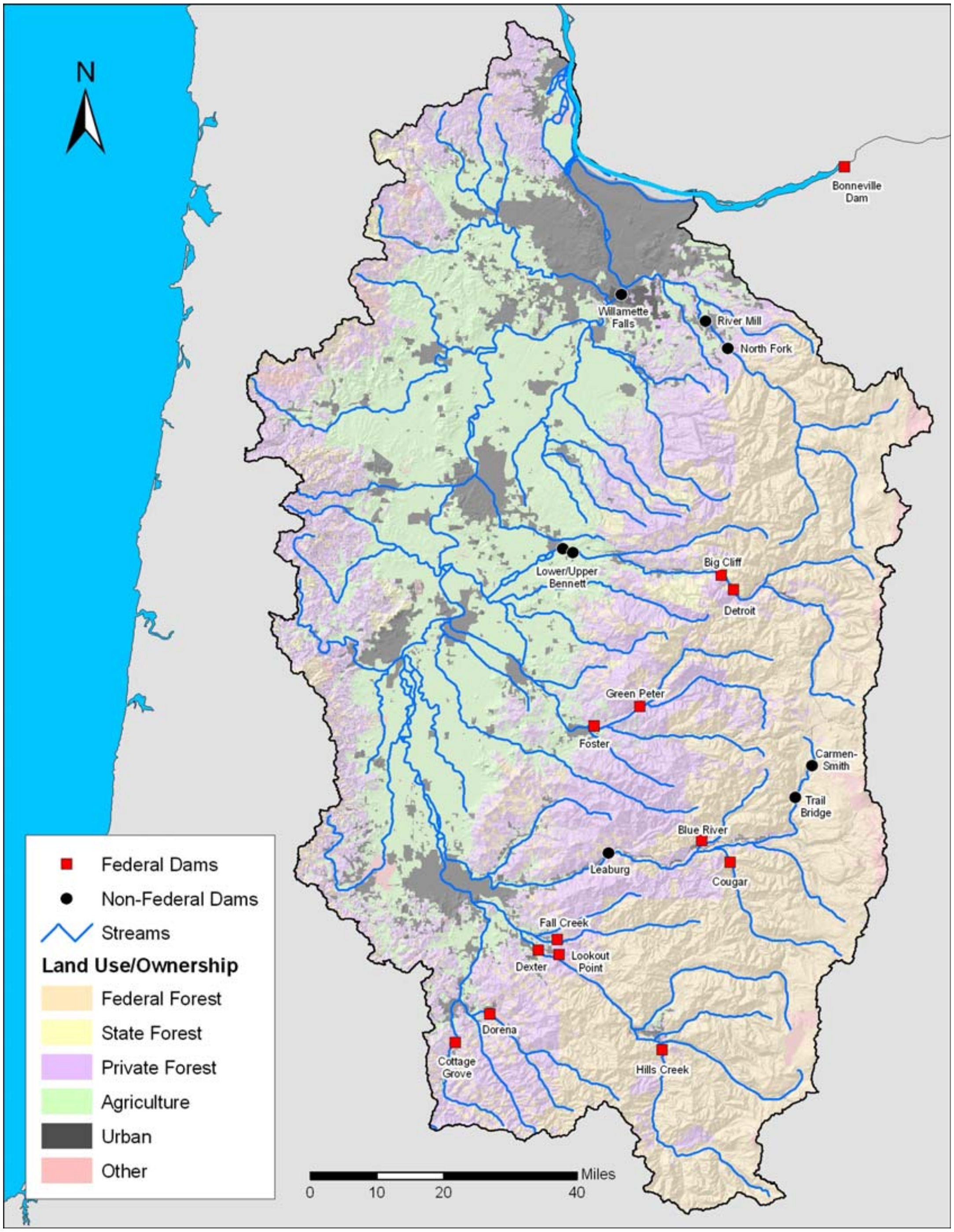

Figure 2-1. Pattern of major land use categories and major flood control/hydropower infrastructures in the Willamette Basin.

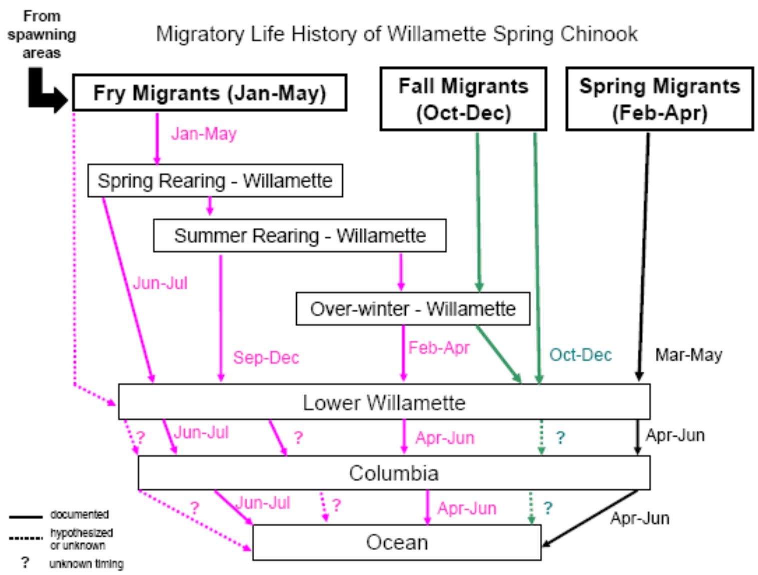

Figure 2-2. A model of variation in outmigration timing and use of different hydrological domains by UWR Chinook salmon (Schroeder et al. 2005).

2.2.2 UWR Steelhead

The run timing of UWR steelhead is a legacy of the fact that, before construction of a fish ladder at Willamette Falls in the early 1900s, flow conditions allowed steelhead to ascend Willamette Falls only during the late winter and spring. As a result, the majority of the UWR winter steelhead run return to freshwater in January through April, pass Willamette Falls from mid February to mid May, and spawn in March through June, with peak spawning in late April and early May. Compared to spring Chinook, UWR steelhead typically migrate further upstream and can spawn in smaller, higher gradient streams and side channels. . Table 2-2 summarizes the generalized life history traits for UWR steelhead. UWR steelhead may spawn more than once, although the frequency of repeat spawning is relatively low. Repeat spawners are predominantly females and usually spend one year post spawning in the ocean and spawn again the following spring.

Juvenile steelhead rear in headwater tributaries and upper portions of the subbasins for one to four years (most often two years), then as smoltification proceeds in April through May, migrate quickly downstream through the mainstem Willamette River and Columbia River estuary and into the ocean. The downstream migration speed depends to some extent on river flow, with faster migration occurring at higher river flows. UWR steelhead typically forage in the ocean for one to four years (most often two years) and during this time are thought to migrate north to Canada and Alaska and into the North Pacific including the Alaska Gyre (Myers et al. 2006).

Table 2-2. A summary of the general of life history characteristics and timing of UWR Steelhead. Data are from numerous sources.

Life History Trait	Characteristic
Willamette River entry timing	February – May
Spawn timing	March – June
Spawning habitat type	Headwater streams
Emergence timing	8-9 weeks after spawning, June - August
Rearing habitat	Headwater streams
Duration in freshwater	1-4 years (mostly 2), smolt in April – May
Estuarine use	Briefly in the spring, peak use in May
Ocean migration	North to Canada and Alaska, and into the North Pacific
Age at return	3 - 6 years, primarily 4 years

2.3 Population and Strata Structure

ESA recovery planning focuses on a biologically-based hierarchical structure that starts at the species level and can be partitioned to a level below an individual population. This hierarchy reflects the fact that historically, anadromous salmonid species typically contained multiple races and distinct populations that were connected to some degree of genetic exchange that reflected local adaptation to geographical and other environmental conditions in the river basins in which they spawned. Thus, the overall biological structure of salmonids is hierarchical; spawners in the same area of the same stream will share more characteristics than those in the next stream over.

For recovery planning purposes the WLC-TRT formally identified two levels in this biological hierarchy: the ESU for salmon or DPS for steelhead, and the independent population (McElhany et al. 2000). The WLC-TRT further defined the hierarchy by grouping the independent populations into larger aggregates that share similar genetic, geographic (hydrographic and ecoregion), and/or habitat characteristics. They called these "major groupings" stratum (plural: strata). This Recovery Plan focuses actions largely at the scale of local independent populations. Although the WLC-TRT did not define strata for the UWR ESU and DPS, we include a brief discussion of biological hierarchy to provide some background.

Three levels of biological hierarchy are defined below:

- *Evolutionarily Significant Unit or Distinct Population Segment:* The ESU or DPS is essentially a metapopulation defined by the common characteristics of populations within a geographic range. Two criteria define a salmon ESU or steelhead DPS listed under the ESA: 1) it must be substantially reproductively isolated from other nonspecific units, and 2) it must represent an important component of the evolutionary legacy of the species (Waples 1991). ESUs and DPSs may contain multiple populations that are connected by some degree of migration, and hence may have broad geographic areas, transcending political borders.

- *Strata:* Strata are groups of populations that have been isolated from one another over a longer time scale than the individual populations, but which retain some degree of connectivity greater than that between ESUs or DPSs. They represent groups of populations with similar life history characteristics, mainly run timing, that spawn within an ecological zone (McElhany et al. 2003). Strata are analogous to the "Major Population Groups" (MPGs) that were defined by the Interior Columbia TRT, and to the "geographic regions" that were described by the Puget Sound TRT.

- *Independent Populations:* McElhany et al. (2000) defined an independent population 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" (Myers et al. 2006, following McElhany et al. 2000).

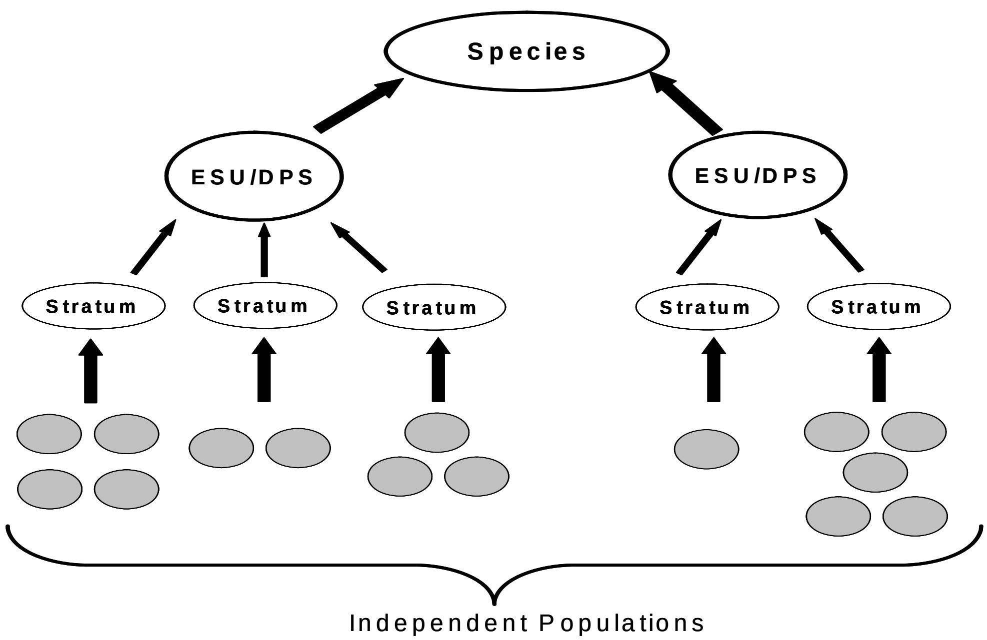

Figure 2-3. A hierarchical population structure for ESA-listed Pacific salmonids as identified by Technical Recovery Teams (TRT's).

2.3.1 UWR Chinook Structure

The WLC-TRT identified seven demographically independent populations of spring Chinook in the UWR Chinook ESU: Clackamas, Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and the Middle Fork Willamette (Figure 2-4). The WLC-TRT classified the Clackamas, North Santiam, McKenzie and Middle Fork Willamette populations as "core populations" and the McKenzie as a "genetic legacy population." All the populations are part of the Cascades Tributaries Stratum for the ESU. The WLC-TRT delineated the populations based on geography, migration rates, genetic attributes, life history patterns, phenotypic characteristics, population dynamics, and environmental and habitat characteristics (Myers et al. 2006).

At the time of listing, the ESU included seven artificial propagation programs: McKenzie River Hatchery (ODFW stock #24), Marion Forks/North Fork Santiam River (ODFW stock #21), South Santiam Hatchery (ODFW stock #23) in the South Fork Santiam River, South Santiam Hatchery in the Calapooia River, South Santiam Hatchery in the Molalla River, Willamette Hatchery (ODFW stock #22), and Clackamas hatchery (ODFW stock #19) spring-run Chinook hatchery programs (NMFS 2005b). Since then, ODFW discontinued the South Santiam Hatchery in the Calapooia River.

2.3.2 UWR Steelhead Population Structure

The WLC-TRT identified four historical demographically independent populations for UWR winter steelhead: the Molalla, North Santiam, South Santiam, and Calapooia (Myers et al. 2006). These population delineations were based on geography, migration rates, genetic attributes, life history patterns, phenotypic characteristics, population dynamics, and environmental and habitat characteristics with guidance found in (McElhany et al. 2000). The populations are shown in Figure 2-5.

The UWR steelhead DPS includes all naturally spawned winter-run steelhead populations in the Willamette River and its tributaries upstream from Willamette Falls to the Calapooia River (inclusive). The North Santiam and South Santiam rivers are thought to have been major production areas (USFWS 1948) and these populations were designated as “core” and “genetic legacy” (McElhany et al. 2003). The four “east-side” subbasin populations are part of one stratum, the Cascade Tributaries Stratum, for UWR winter steelhead. There are no hatchery programs supporting this DPS (NMFS 2006). The hatchery summer-run steelhead that are produced and released in the subbasins are from an out-of-basin stock and not considered part of the DPS.

Winter steelhead have been reported spawning in the West-side tributaries to the Willamette River above Willamette falls, and ODFW recognizes the Tualatin, Yamhill, Rickreall, and Luckiamute West-side subbasins as part of the Willamette Winter Steelhead SMU. In the WLC-TRT assessment these tributaries were not considered to have constituted independent populations historically. Rather, these tributaries may have functioned and continue to function as a population sink with the DPS meta-population structure (Myers et al. 2006). Conversely, under current or future conditions, steelhead production from West-side subbasins may help buffer or compensate for independent populations that are not meeting recovery goals. In future ESA assessments, ODFW would like to discuss with NMFS the possible inclusion of these production areas within the DPS.

In addition, although a naturally reproducing population of UWR steelhead became established in the Middle Fork Willamette in the 1950’s following introductions of hatchery produced fish from the North Santiam, it is generally agreed that steelhead historically did not emigrate farther upstream than the Calapooia River (Dimick and Merryfield 1945; Fulton 1970) and these fish are not included in the DPS.

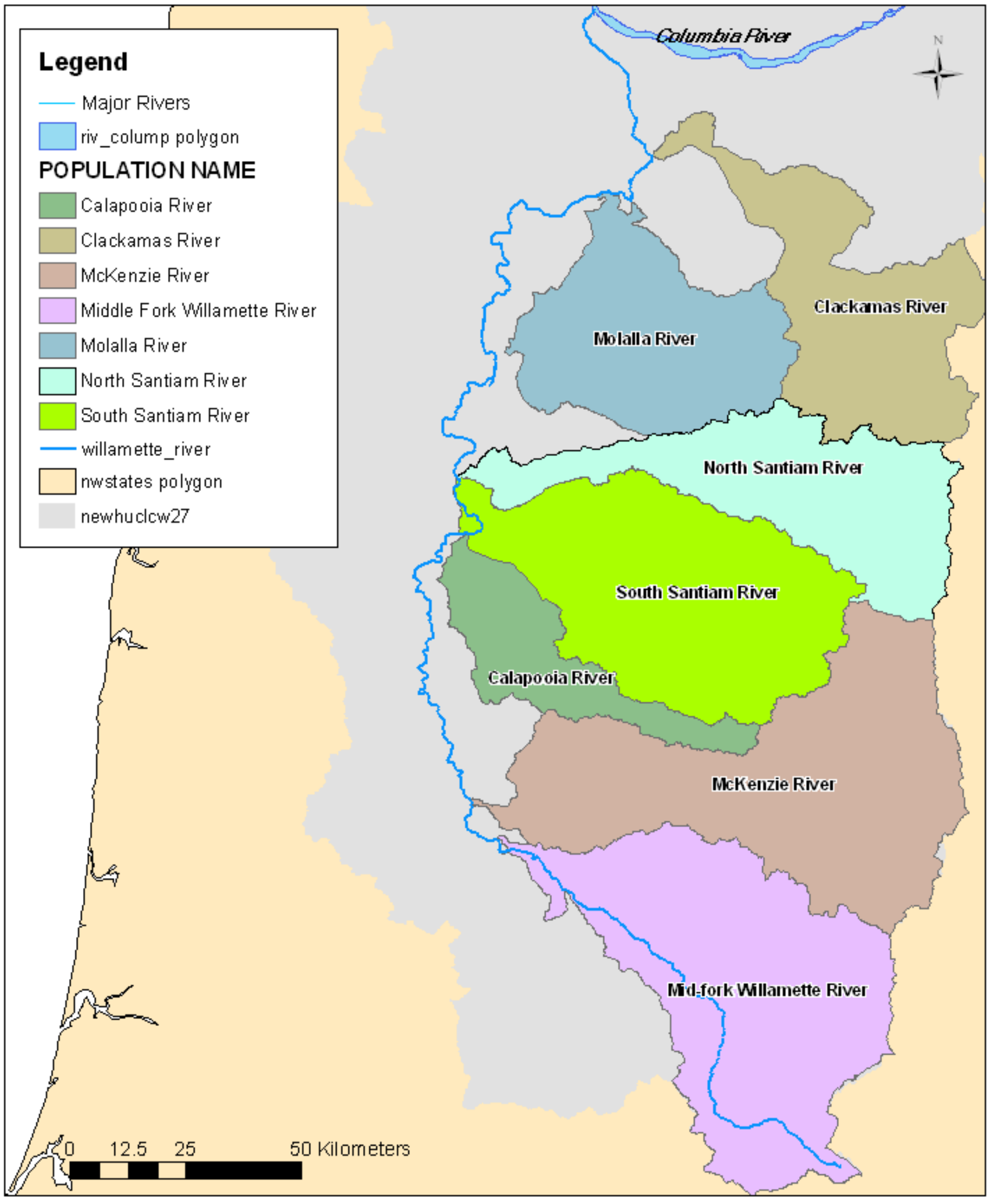

Figure 2-4. Historical populations in the UWR Chinook ESU as proposed by Myers et al. (2006). Figure is from that document.

Addressing Resident Rainbow Trout

The resident form of the species *Oncorhynchus mykiss* (referred to as rainbow or redband trout, depending on location) is sympatric (occupies the same areas) with anadromous *O. mykiss*, or steelhead, in some areas of the UWR steelhead DPS. However, the WLC-TRT did not include the resident form in their delineation of populations within the UWR steelhead DPS, and the NMFS DPS policy and decision to list steelhead separately was recently upheld by the 9th Circuit. Resident *O. mykiss* have not been considered in the viability assessments or recovery strategies for steelhead described in this Plan[22].

Although resident *O. mykiss* are not expressly addressed in this Plan, ODFW and NMFS recognize the potential importance that these fish may play in the viability of UWR steelhead in some populations. A future rainbow trout conservation planning process, if funded, could build off of the strategies and actions identified in this Plan that address tributary habitat issues for steelhead. Actions that improve the habitat for steelhead will benefit resident rainbow trout and are likely to address some of the key or secondary limiting factors for resident *O. mykiss*. As a result, the exclusion of resident rainbow trout in much of this Plan will not adversely impact either the UWR steelhead populations or the resident populations, and the presence of resident *O. mykiss* should actually provide another conservation buffer for UWR steelhead populations in addition to those factored into this Plan.

Kostow (2003) summarized the information available on the inter-relation or isolation between resident rainbow trout and steelhead throughout the Columbia River basin, and found several examples of interactions between the two forms, though the levels to which resident and anadromous *O. mykiss* interactions occur in a particular population and how significant those interactions are to the viability of that population have not been quantified. There are several documented examples of each form producing offspring that adopted the other form's adult life-history (Ruzycki et al. 2003, Blouin 2003, Ardren 2003, Berg 2001, Viola and Schuck 1995, McMichael et al. 1999, as cited in Kostow 2003). There are also occurrences of steelhead adults spawning with rainbow trout (Zimmerman and Reeves 1996; B. Knox [ODFW, personal communication], T. Unterwegner [ODFW, retired, personal communication], as cited in Kostow 2003).

It is difficult to differentiate resident trout from steelhead juveniles during routine sampling. As a result, ODFW has used the presence of larger trout (>20 cm) and the professional opinions of local biologists to characterize the occurrence of resident trout in the UWR steelhead DPS. No estimates have been made of the abundance of any resident populations but they are thought to be common and in moderate abundance.

[22] Kostow (2003) summarized data on *O. mykiss* and determined that the documented interactions between these two sympatric forms met the NMFS definition of populations to include in one ESU

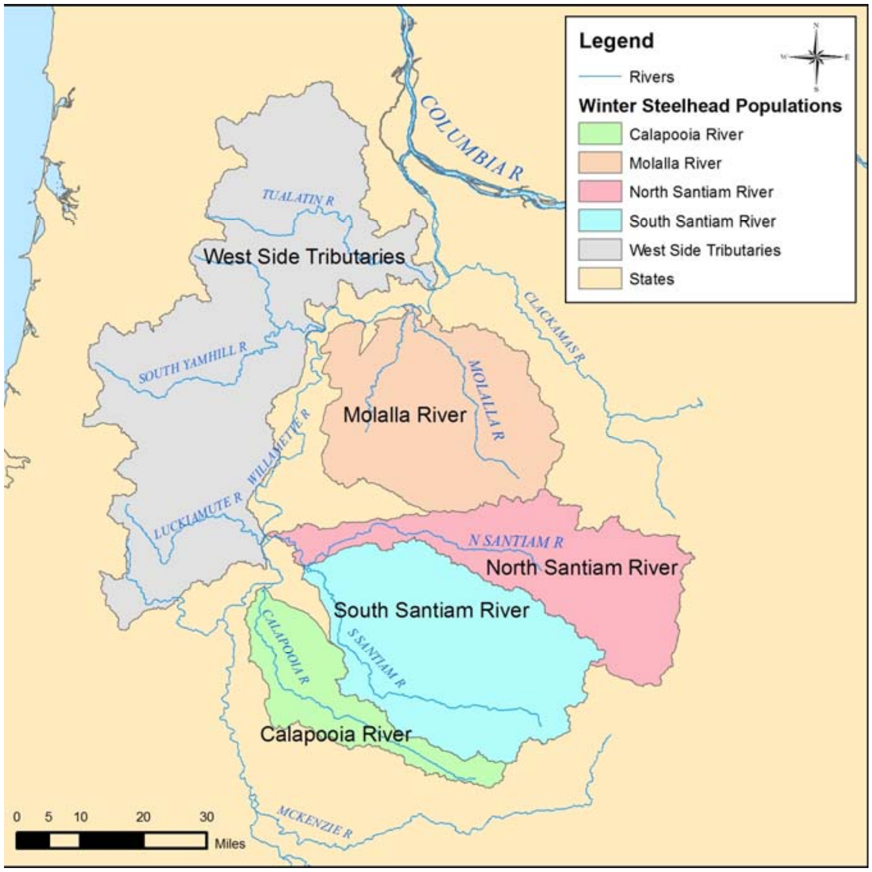

Figure 2-5. Historical independent populations in the UWR steelhead DPS (modified from Myers et al. 2006).

2.4 Critical Habitat

NMFS designated critical habitat for UWR Chinook and steelhead on September 2, 2005 (70 FR 52630). Essential features of designated critical habitat include attributes of substrate, water quality, water quantity, water temperature, food, riparian vegetation, access, water velocity, space, and safe passage that are associated with viability for the ESU and DPS. NMFS identified critical habitat by assigning a value of high, medium, or low to watersheds depending on the conservation value of the watershed to the listed species. Conservation value was determined by evaluating habitat quantity and quality and the relationship to other habitat areas, and with respect to the population occupying that area. The designations focused on physical and biological elements that support one or more life stages and were identified as essential to the conservation of the species, for example spawning gravels, water quality and quantity, side channels, and forage species.

The ratings of areas that provide the greatest biological benefits for listed salmon and steelhead were balanced with economic and other costs to determine final critical habitat designations. Recovery plans use critical habitat designations as one element to consider in identifying and prioritizing recovery actions. Critical habitat designations recognized that salmon habitat is dynamic and that understanding of areas that should be protected and restored for conservation will likely change. Figures 2-6 and 2-7 show the current designated critical habitat for UWR Chinook and UWR steelhead. NMFS will update the critical habitat designations as needed.

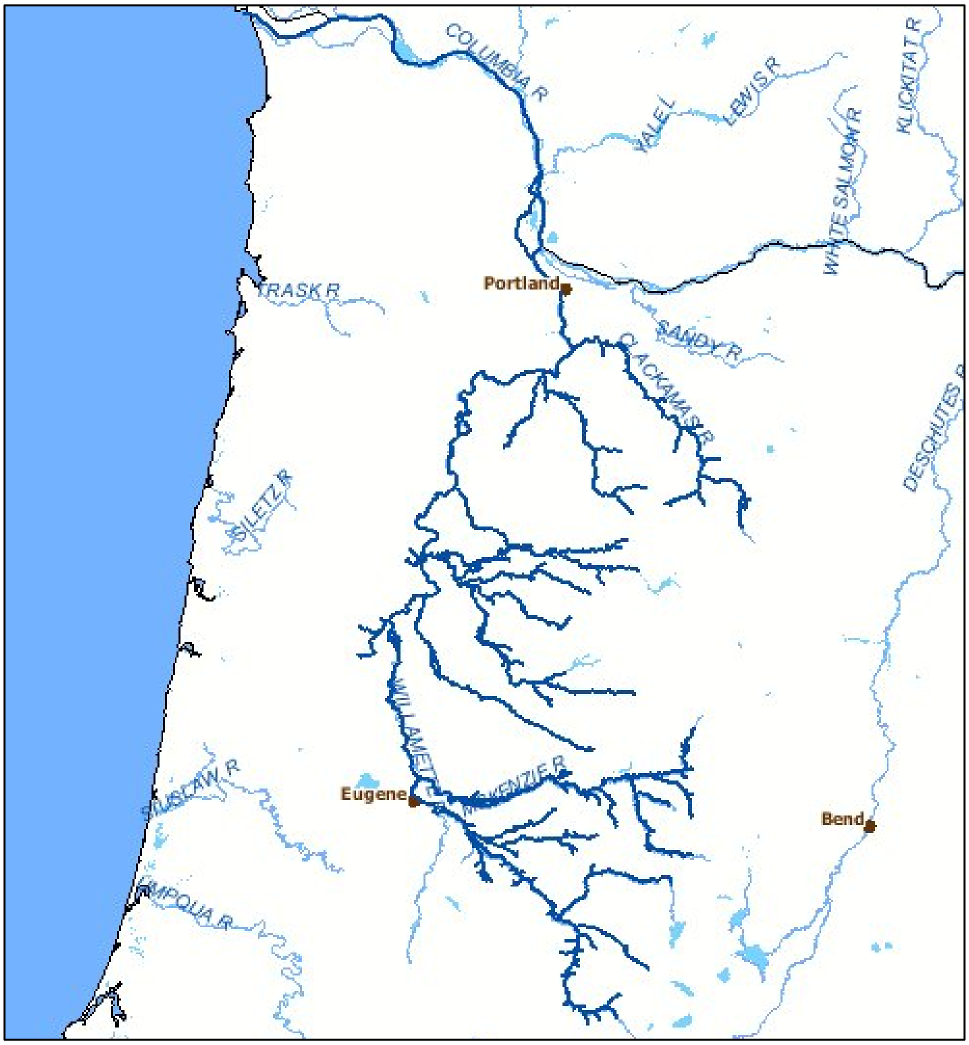

Figure 2-6. Critical habitat designated for the UWR Chinook ESU. **Map Source: http://map.streamnet.org/website/CriticalHabitat/viewer.htm**

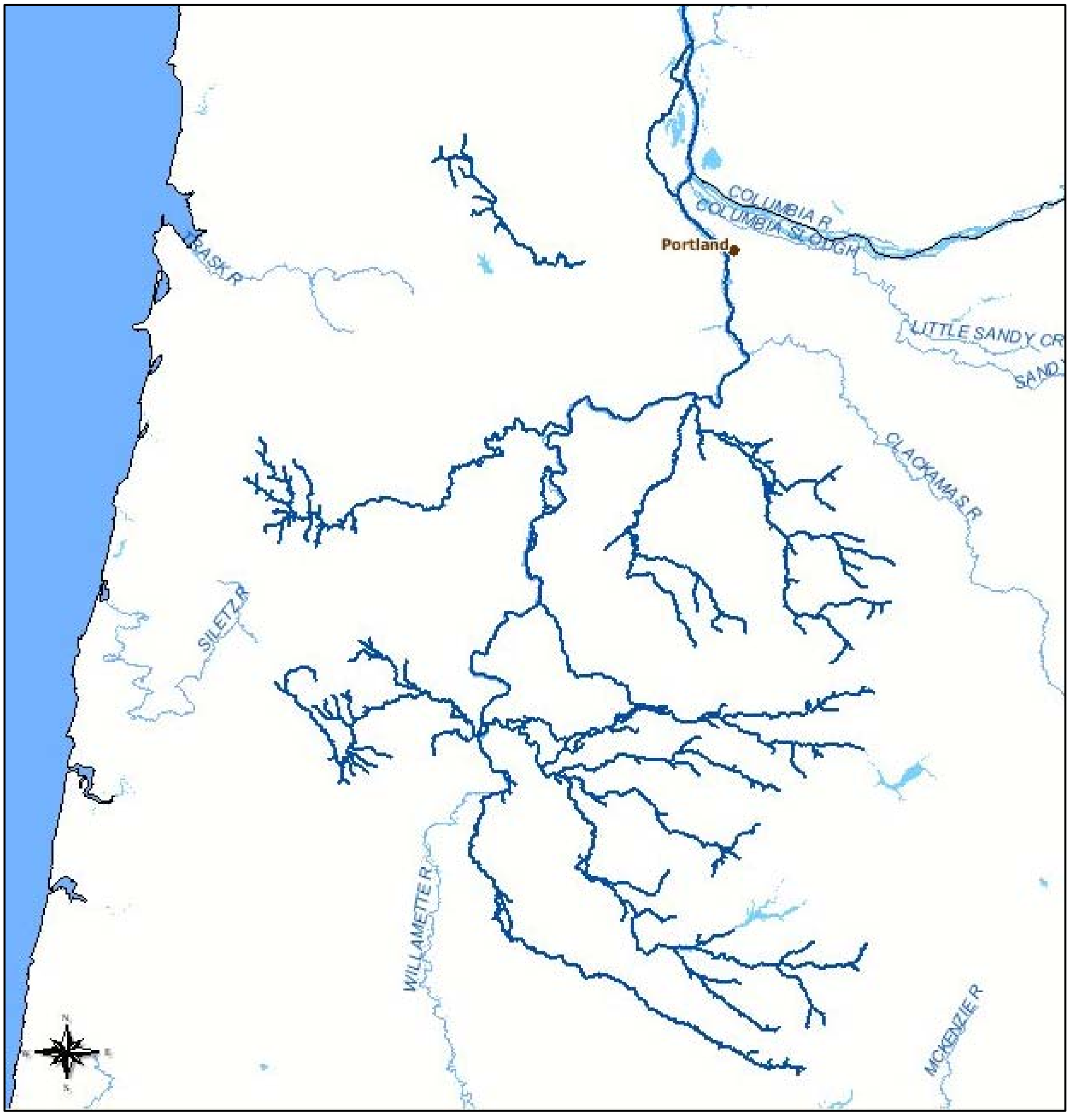

Figure 2-7. Critical habitat for the UWR steelhead DPS.
Map Source: http://map.streamnet.org/website/CriticalHabitat/viewer.htm

Chapter 3: Conservation and Recovery Goals and Criteria

Chapter 3 describes the goals that frame the State of Oregon's and NMFS's path toward recovery of UWR Chinook salmon and steelhead.

- First, the populations must reach desired levels of biological viability and the recovery effort must reduce the impact of the 'listing factors' and 'threats' (see an explanation of these terms in section 1.1) in order to warrant removal of the UWR Chinook ESU and steelhead DPS from the threatened and endangered species list (referred to in this plan as either delisting or ESA recovery). Section 3.1 describes the goals and proposed criteria that would need to be met in order to achieve delisting.

- Second, the State of Oregon seeks to rebuild the wild populations to reach 'broad sense recovery' to provide for sustainable fisheries and other ecological, cultural and social benefits. Section 3.2 describes broad sense recovery goals.

3.1 ESA Recovery Goals

Delisting criteria are objective, measurable criteria that, when met, would result in a determination by NMFS that the ESU is not likely to become endangered within the foreseeable future throughout all or a significant portion of its range. The delisting criteria described here are not necessarily the only set of criteria that would result in delisting. In addition, as new information emerges, NMFS may revisit the delisting criteria. At least every 5 years, NMFS will conduct a review of the each ESU/DPS and determine whether it should be removed from the list or changed in status. Such reviews will take into account a number of factors, including the following:

- The biological and threats criteria described below.
- Management programs in place to address the threats.
- The principles presented in the Viable Salmonid Populations paper (McElhany et al. 2000.)
- Best available information on population and ESU status and new advances in methods to evaluate risk.

To consider delisting, NMFS requires an evaluation of population or demographic parameters (the biological delisting criteria), and threats under the five ESA listing factors in ESA section 4(a) (1) (the threat delisting criteria). Together these make up the "objective, measurable criteria" required under section 4(f) (1) (B) of the ESA.

Biological viability criteria are quantitative metrics that describe DPS characteristics associated with a low risk of extinction for the foreseeable future. These criteria are based on the VSP parameters of abundance, productivity, spatial distribution, and diversity, according to guidelines developed by NOAA's Northwest Fisheries Science Center and published as a NOAA Technical Memorandum, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000).

'Limiting factors' are the physical, biological, or chemical features (e.g., inadequate spawning habitat, high water temperature, and insufficient prey resources) experienced by the fish that result in reductions in viable salmonid population (VSP) parameters (abundance, productivity, spatial structure, and diversity). Key limiting factors are those with the greatest impacts on a population's ability to reach a desired status.

"Threats," in the context of salmon recovery, are understood as the activities or processes that cause the biological and physical conditions that limit salmon survival (the limiting factors). "Threats" also refer directly to the listing factors detailed in section 4(a)(1) of the ESA. ESA section 4(a)(1) listing factors are the following:

A. Present or threatened destruction, modification, or curtailment of [the species'] habitat or range;
B. Over-utilization for commercial, recreational, scientific, or educational purposes;
C. Disease or predation;
D. Inadequacy of existing regulatory mechanisms; or
E. Other natural or human-made factors affecting [the species'] continued existence.

NMFS has developed a decision framework for making delisting decisions that consists of sets of questions that address the status and change in status of a salmonid ESU/DPS and the risks posed by threats to the ESU/DPS (NMFS 2007a). The relationship between biological criteria, threats criteria, and research, monitoring and evaluation as it pertains to determining an ESU/DPS status is summarized in Figure 3-1. NMFS developed the framework to inform recovery planners how NMFS intends to evaluate ESU/DPS status along with the questions that research, monitoring and evaluation programs should answer in support of status evaluations.

In order to establish objective, measurable criteria for purposes of evaluating the statutory listing factors (ESA section 4(a)(1)(A)-(E)), NMFS must first describe the threats contributing to each listing factor. NMFS must then describe how the severity and trend of a given threat can be monitored and quantifiably evaluated. Typically, this is best accomplished by monitoring the liming factor(s) being altered by the treat. Specific empirical metrics can be identified for each limiting factor to establish quantifiable measures of the impact a given threat is having on the salmonid environment. Ideally, the threat delisting criteria will detail quantitative limiting factor metrics and thresholds that represent low or acceptable levels of risk for a given threat. For example, in order to measure the reduction in habitat-related threats such as removal of stream-side vegetation and operation of dams, we can measure the water temperature to see if it is within the acceptable range. In some cases it may not be feasible or cost effective to monitor the many limiting factor metrics that reflect a threat's impact on salmonid viability. Proxy measures can be identified that, while not quantifying the physical and biological conditions that are limiting salmonid survival and productivity, depict the magnitude and trend of a threat. For example, it may not be feasible to monitor the multitude of limiting factors altered by the threat of urbanization, but monitoring landscape trends in land-use type may serve as a useful proxy for evaluating the impact of urban development on important juvenile rearing habitat.

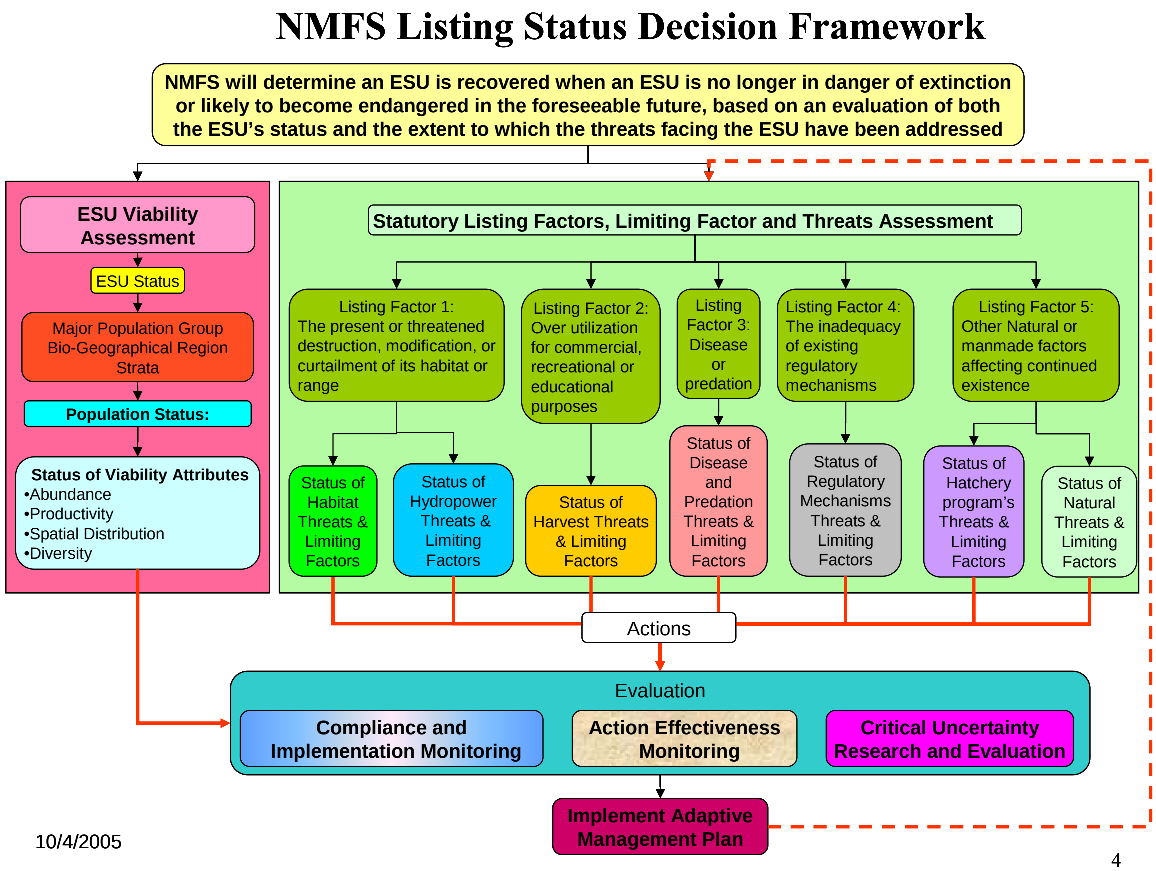

Figure 3-1. NMFS listing status decision framework (from NMFS 2007a).

3.1.1 ESA Biological Goals and Criteria

For ESU/DPS-level status evaluations, this Recovery Plan adopts the viability criteria identified by the WLC-TRT (McElhany et al. 2003, 2006) as the foundation for biological delisting criteria. These criteria were used as technical input into the recovery planning process and provided a technical foundation for development of biological recovery criteria.

The viability criteria relate most directly to the biological delisting criteria; however, they are not synonymous. NMFS establishes delisting criteria based on both science and policy considerations. For instance, science can identify the best metrics for assessing extinction risk and thresholds of those metrics associated with a given level of risk, but setting the acceptable level of risk for purposes of the ESA is a policy decision (McElhany et al. 2006)

To provide a technical foundation for developing biological delisting criteria, NMFS appointed geographically based technical recovery teams[23] (TRTs), which recommended biologically based viability criteria for application to ESA-listed salmonid ESUs. The WLC-TRT (McElhany et al. 2003, 2006) defined biological viability criteria at the levels of the ESU, strata (spatially related populations),

[23] A complete description of the TRT composition, tasks, relationship to ESA recovery planning, and operating principles can be found in the NMFS document *Recovery Planning Guidance for Technical Recovery Teams (TRTs)* http://research.nwfsc.noaa.gov/cbd/trt/guidanc9.pdf

and component populations. The WLC-TRT's approach to viability criteria was guided by a NMFS Technical Memorandum (McElhany et al. 2000). It applied the same biological principles as other TRTs, yet was specific to information available for ESA-listed UWR ESU and DPS populations. The viability criteria identified the biological characteristics and conditions that defined viable populations and strata, and by extension, viable ESUs. At the population level the criteria are based on the biological parameters of abundance, productivity, spatial structure, and diversity[24]. For ESU-level viability criteria, the WLC-TRT considered the geographic distribution and characteristics of component populations to maintain a viable ESU in the context of longer-term ecological and evolutionary processes (see review in Ruckelshaus et al. 2002). Therefore, the ESU-level viability criteria include a framework that determines how many and which populations should be at a particular extinction risk level (very low, low, moderate, high, very high; see Chapter 4 for how these risk levels are determined) for the ESU to have an acceptable low risk of extinction. Population boundaries for listed Pacific salmonids in the Willamette/Lower Columbia recovery domain have been previously identified by Myers et al. (2006). The ESU-level viability criteria adopted by the WLC-TRT were guided by the attributes of recreating some of the basic structure of an historical metapopulation template, and incorporated population-level risk assessment attributes. The criteria had five essential elements:

1. *Stratified Approach*: Life history and ecological complexity that historically existed should have a high probability of persistence into the future. The WLC-TRT partitioned the Willamette/Lower Columbia recovery domain populations into strata based on ecoregion characteristics, life history types and other geographic and genetic considerations[25].
2. *Number of Viable Populations*: Some individual populations within a stratum should have persistence probabilities consistent with a high probability of stratum persistence. The WLC-TRT defined high persistence probability based on the presence of at least two, or one-half, of historic populations, whichever is greater, with a high probability of persistence (>95% probability of persistence over 100 years). The WLC-TRT noted that based on a simple probability analysis, having 2 to 3 populations with a low extinction risk in a stratum provides a relatively significant reduction in risk compared to a single population, but having four or more populations does not greatly reduce the risk. They concluded that a low risk stratum is one with at least two viable populations (i.e., persistence category ≥3; see definition of persistence in Chapter 4), where the average of the persistence categories for all historical populations is ≥2.25.
3. *Representative Populations*: Representative populations need to achieve viability criteria or be maintained, but not every historical population needs to meet the viability criteria. Viable combinations of populations should include "core" populations that are highly productive, "legacy" populations that represent historical genetic diversity, and dispersed populations that minimize susceptibility to catastrophic events.
4. *Non-deterioration*: No population should be allowed to deteriorate until ESU/DPS recovery is assured, and all extant populations must be maintained. Current populations and population segments must be preserved. Recovery measures will be needed in most areas to stop further decline and offset the effects of future impacts.
5. *Safety Factors*: Higher levels of recovery should be attempted in more populations than the minimum needed to achieve ESU/DPS viability because not all attempts will be successful. In addition, there needs to be sufficient viable populations to ensure that the ESU is buffered from the risks of catastrophic events, degraded metapopulation processes, and degraded evolutionary processes.

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[24] The VSP report separates abundance and productivity into two separate attributes for a total of four attributes, but because the effects of abundance and productivity on extinction risk are so interconnected, the WLC-TRT analyzed them together.
[25] The WLC-TRT did not identify strata within the UWR Chinook ESU or steelhead DPS, so it is assumed the attributes of a viable stratum are by extension, attributes of a viable ESU.

Recovery efforts must target more than the minimum number of populations and more than the minimum population levels thought to ensure viability. Some populations should be highly viable. Support for these recommendations is provided in the viability reports cited below.

After reviewing the viability criteria developed by the WLC-TRT (McElhany et al. 2003, 2006), Oregon and NMFS used the WLC-TRT viability criteria in developing the following ESU/DPS ESA biological goals and delisting criteria:

1. *ESU/DPS*: the ESU/DPS demonstrates a high probability of persistence, when:
    a. At least two populations in the ESU and DPS meet Population viability criteria (see 2 below)
    b. The average of all population extinction risk category scores with the ESU or DPS is 2.25 or greater. Details of the logic behind using this averaging approach are in McElhany et al. (2003), which recognizes that having some populations that exceed the VSP population criteria can help mitigate risk from populations with higher risk.
    c. The ESU/DPS maintains a semblance of historical normative metapopulation processes by restoring to viable most of the "core" populations (historically most productive: Chinook 3 of 4 populations, steelhead 2 of 2 populations)
    d. The ESU/DPS maintains a semblance of normative evolutionary processes by improving to very low risk of extinction the remaining "genetic legacy" populations (Chinook: McKenzie population, steelhead: Santiam populations),
    e. All populations not meeting Population viability criteria do not deteriorate and are maintained at a minimum at their current risk of extinction.
2. *Population Viability:* a population is "viable" based on an integrated assessment of the population's abundance, productivity, spatial structure, and diversity statuses that produces an extinction risk classification score of 3 or 4 (based on a scale from 0-4, based on the WLC-TRT's scoring system (Table 2.3 in McElhany et al. [2003])[26, 27].

During technical review of this Recovery Plan the IMST discussed challenges associated with data limitations and uncertainty and how viability criteria were established. In response, we acknowledge that, although the approaches for determining viability at the population level have a robust analytical framework (stock-recruitment, PVA, etc.), scaling up these population attributes to the ESU/DPS scale has far less analytical foundation. However, lacking a full quantitative approach to test the performance of these guidelines, and having no empirical or qualitative basis (which may only serve to propagate uncertainty) to propose an alternate set of guidelines, ODFW and NMFS have determined that the WLC-TRT guidelines are sound, comprehensive, and conservative.

3.1.2 ESA Threats Delisting Criteria

Evaluating the potential reclassification or delisting for a species or ESU also requires an explicit analysis of the five ESA listing factors in Section 4(a) (1) of the ESA. Within each listing factor, NMFS evaluates the severity and trend of the threats (human activities or natural phenomena) that contribute to the species' risk due to the subject listing factor. Establishing measureable criteria for each of the relevant listing/delisting factors helps to ensure that underlying causes of decline have been addressed and

[26] Viable populations have an extinction risk less than 5%, corresponding to at least a 95% persistence probability and a risk classification score of 3 or greater.
[27] Additional measurable criteria related to monitoring a population's progress in these four VSP parameters through time relative to its desired status (Chapter 6) are given in Chapter 8.

mitigated before considering a species for delisting. However, not all of the listing factors and their component threats are of equal importance in securing the recovery of an ESU or DPS and they may change in importance over time, therefore every potential threat may not need to be fully addressed before delisting is possible.

In 1999, when UWR spring Chinook and winter steelhead were listed under the ESA (64 FR 14308), NMFS cited all of the five listing factors as contributing to the decline of these species. Specifically, the major concerns described were related to: loss of historic spawning and rearing habitat due to dam blockages in the eastside tributaries of the Willamette River, adverse thermal effects downstream from operation of the dams, riparian and stream habitat loss and degradation particularly in the lowland, valley areas (see listing factors A and D below), excessive fishery harvest (see listing factor B below), and adverse effects from hatchery programs (see listing Factor Ebelow).

In addition to evaluating the listing factors and component threats identified at the time of listing, NMFS must also assess any new threats identified since listing to ensure that the species no longer requires protection as a threatened or endangered species.

Section 4(a)(1) of the ESA organizes NMFS' consideration of threats into five factors:

A. The present or threatened destruction, modification, or curtailment of the species' habitat or range
B. Over-utilization for commercial, recreational, scientific, or educational purposes
C. Disease or predation
D. The inadequacy of existing regulatory mechanisms
E. Other natural or human-made factors affecting the species' continued existence

These factors may not all be equally important in securing the continuing recovery of a particular ESU, and each ESU faces a different set of threats within each listing factor. It also is possible that currently perceived threats will become insignificant in the future as a result of changes in the natural environment or changes in the way threats affect the life cycle of salmon and steelhead.

NMFS will use the listing factor criteria below in determining whether an ESU or DPS has recovered to the point where it no longer requires the protections of the ESA. However, NMFS, along with the State of Oregon and our partners in ESA recovery, will continue to work to refine and establish more specific metrics for evaluating threats.

NMFS provides threats criteria, including several examples of more detailed criteria, below:

A. The present or threatened destruction, modification, or curtailment of a species' habitat or range:
    1. Habitat-related threats have been ameliorated such that limiting factors no longer constrain attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.
        a. Recovery plan actions addressing habitat [threats and/or] limiting factors have been substantially implemented, including related research, monitoring, and evaluation actions. An example, described in more detail in section 8.4, of a simple criterion is a pass/fail test:

           Pass – Positive trend in the status of the habitat degradation metrics

           Fail – Negative trend or no improvement in the status of the habitat degradation metrics

b. To evaluate whether this criterion has been met, additional, specific metrics for assessing habitat conditions and action effectiveness will need to be developed, tracked, and periodically evaluated. NMFS provides the following as examples of specific criteria being implemented or developed:

   i. Specific stream and river reaches (those with designated beneficial uses of anadromous fish spawning, rearing or migration in Willamette River tributaries for each of the populations targeted for low or very low risk, and the mainstem Willamette River), meet the numerical and narrative water temperature, dissolved oxygen, and pH standards set by the Oregon Department of Environmental Quality,[28] or meet the established TMDL load limits

   ii. Specific stream and river reaches (those with designated beneficial uses of anadromous fish spawning, rearing or migration in Willamette River tributaries for each of the populations targeted for low or very low risk, the mainstem Willamette River, the tributary watershed for each of the populations targeted for low or very low risk, and the mainstem Willamette River), meet the numerical and narrative water quality standards for toxics and turbidity once EPA has completed consultation under section 7 of the ESA with NMFS and approved the subject standards.

   iii. Major tributaries and the mainstem Willamette River have sufficient habitat conditions to allow juvenile spring Chinook and steelhead adequate "rest areas" (e.g. thermal refugia, off-channel areas, etc.).

c. Trends in overall habitat condition, in addition to the criteria described above, are stable or improving, including habitat access, hydrograph/water quantity, physical habitat quality and quantity.

d. *Non-deterioration*: No population has deteriorated and all extant populations have been maintained.

2. Hydropower and/or flood control dam related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations, as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.

   i. a. The Willamette Project Biological Opinion, including the RPA has been substantially implemented, including related research, monitoring, and evaluation actions. To evaluate whether this criterion has been met for delisting, NMFS will develop more specific criteria in the future.:

b. Including, but not limited to a. above, the threat reduction targets for flood control/hydropower outlined in section 6.2 of this recovery plan have been met or flood control/hydropower impacts are otherwise consistent with the desired status

[28] On February 23, 2004, NMFS completed a biological opinion under section 7 of the ESA on the proposed approval of the revised state of Oregon water quality standards for water temperature and intergravel dissolved oxygen by the U.S. Environmental Protection Agency (EPA). The NMFS had previously (July 7, 1999) completed a biological opinion under section 7 of the ESA with EPA that included the revised state of Oregon water quality standard for water column dissolved oxygen. In these biological opinions, NMFS found that the subject water quality standards met the biological requirements of ESA-listed salmon and steelhead for survival and recovery.

of the ESU/DPS and its constituent populations. This includes improved passage (upstream and downstream) for all four tributaries mentioned in a. above. Hydropower management actions will continue to allow for ESUDPS persistence given projected climate changes and other large-scale environmental and ecological impacts. Example of specific criteria are:

i. Evaluation Thresholds for Flood Control/Hydropower Related Metrics for Adult Fish passage

Pass – sufficient number of natural origin adults are allowed above barriers to seed available habitat

Fail – insufficient number of natural origin adults are allowed above barriers to seed available habitat

ii. Prespawn mortality (for mature female fish on or near spawning grounds)

Pass – viable populations: % mortality < 10%[29]; non-viable populations: < 30%

Fail – viable populations: % mortality > 10%; non-viable populations: > 30%

iii. Physical habitat conditions (including flow)

Pass – TBD

Fail – TBD

iv. Water quality conditions

Pass – meet TMDL load allocations for each subbasin

Fail – exceed TMDL load allocations for each subbasin

B. Overutilization for commercial, recreational, or educational purposes:

1. Harvest related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.
   a. The threat reduction targets for harvest outlined in section 6.2 of this recovery plan have been met or harvest impacts are otherwise consistent with the desired status of the ESU/DPS and its constituent populations. To evaluate whether this criterion has been met, an example of a specific criterion related to harvest impacts and action effectiveness (described in section 8.4) is:

      Pass – Chinook: annual total freshwater mortality < 15% and annual total mortally <25%; steelhead: annual total annual mortality < 20%;

      Fail – Chinook: annual total freshwater mortality >15%; steelhead: annual total freshwater mortality > 20%;

2. Any other threats related to overutilization for commercial, recreational, or educational purposes (for example, utilization for research purposes) have been reduced such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.

[29] Based on McKenzie estimates for a population already at a low risk of extinction

C. Disease or predation:
   1. Predation related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.
      a. Recovery plan actions related to threats from predation by marine mammals, birds, and fish (including predation among salmon species and predation by hatchery-origin salmon on natural-origin salmon) have been substantially implemented, including related research, monitoring, and evaluation actions.
      b. The threat reduction targets for predation outlined in Section 6.2 of this recovery plan have been met or threats from predation are otherwise consistent with the desired status of the ESU/DPS and its constituent populations. To evaluate whether this criterion has been met, specific metrics related to predation and action effectiveness may need to be developed, tracked, and periodically evaluated.
   2. Disease related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.
      a. Hatchery management practices sufficient to limit disease-related threats are being implemented. An example of an additional level of specificity is to require these management practices to be based on protocols recommended by a American Fisheries Society (AFS)-certified disease pathologist.
      b. Monitoring is in place to detect disease and disease impacts on population status.

D. The inadequacy of existing regulatory mechanisms:
   1. Regulatory mechanisms have been maintained and/or established and are being implemented in a way that allows the desired status of the ESU/DPS and its constituent populations, as defined by the biological criteria in this recovery plan, to be attained and maintained.
      a. Regulatory programs that govern land use and resource extraction are in place, enforced, monitored, and adaptively managed and are adequate to ensure effective protection of salmon and steelhead habitat, including water quality, water quantity, and stream structure and function, and to attain and maintain the biological recovery criteria in this recovery plan.
      b. The State of Oregon has set instream flow levels for all reaches in which the target populations spawn, rear, or migrate and have regulatory mechanisms in place to ensure that water withdrawals do not prevent instream flow targets from being achieved. [monitoring, and enforcement too]
      c. Regulatory programs are in place and are being implemented, monitored, evaluated and adaptively managed adequately to manage fisheries at levels consistent with the biological recovery criteria of this recovery plan.
      d. Regulatory, control, and education measures are in place and are being implemented, monitored, evaluated and adaptively managed to prevent introductions of non-native plant and animal species.
      e. Regulatory programs have adequate funding, prioritization, enforcement, coordination mechanisms, and research, monitoring, and evaluation to ensure habitat protection and effective management of fisheries.

E. Other natural or man-made factors affecting continued existence.

1. Hatchery related threats have been ameliorated such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.
    a. Recovery plan actions related to threats from hatcheries have been substantially implemented, including related research, monitoring, and evaluation actions.
    b. The threat reduction targets for hatcheries outlined in Section 6.2 of this recovery plan have been met or hatchery impacts are otherwise consistent with the desired status of the ESU/DPS and its constituent populations. To evaluate whether this criterion has been met, the specific metrics for evaluating the genetic and ecological risks posed to natural-origin salmon and steelhead by hatchery origin salmon and steelhead described in section 6 form the basis for measuring this listing factor. These are:
        i. If the overall desired status goal for a population is low risk or very low risk, then the target is achieving an average pHOS of ≤10%, regardless of their spawn timing and
        ii. If the recovery goal risk category for a population is 'moderate' then the target average pHOS is ≤ 30%.
        iii. An example of specific criterion is:

            Pass – Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to that shown in Table 6-10.

            Fail – Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average higher than that shown in the Table 6-10.
    c. Hatchery programs are being operated in a manner consistent with the target status (and ecological carrying capacity) of each population, and appropriate criteria are being used for managing the interaction of hatchery and natural populations, including hatchery-origin fish spawning naturally.
    d. Hatcheries are operated using appropriate ecological, genetic, and risk containment measures for: (1) release of hatchery juveniles, (2) handling of natural-origin adults, (3) withdrawal of water for hatchery use, (4) discharge of hatchery effluent, and (5) maintenance of fish health during propagation in the hatchery.
    e. Monitoring and evaluation plans are in place and being implemented to measure population status, hatchery effectiveness, and ecological, genetic, and demographic risk containment measures.
2. Other natural and man-made factors have been accounted for such that they do not limit attainment of the desired status of the ESU/DPS and its constituent populations as defined by the biological criteria in this recovery plan, and such that the desired status will be maintained.

Although hatchery-related threats are described above, they are not the only source of threats to the diversity criteria, so it is important to consider any threats that impact biological criteria. For instance, McElhany et al (2003), suggest that metrics and benchmarks for evaluating the diversity of a population should be evaluated over multiple generations and should include:

- substantial proportion of the diversity of a life-history trait(s) that existed historically,
- gene flow and genetic diversity should be similar to historical (natural) levels and origins,
- successful utilization of habitats throughout the range,
- resilience and adaptation to environmental fluctuations.

NMFS concludes that the Biological Delisting Criteria and the Threats Delisting Criteria, as specified above, define conditions that, when met, would likely result in a determination that the UWR spring Chinook ESU and winter steelhead DPS are not likely to become endangered within the foreseeable future throughout all or a significant portion of their range. These conditions represent the best available science at this time. However they may not necessarily be the only conditions that could result in a decision to delist. In addition, as new information emerges, NMFS may revisit the delisting criteria.

3.2 Broad Sense Recovery Goal

Broad sense recovery criteria: Criteria developed by the State of Oregon that go beyond the criteria for ESU delisting, to attain population goals defined in the recovery planning process, generally by local stakeholder groups, that, for example, address other legislative mandates or social, economic, and ecological values. These criteria are outlined in Chapter 10 of this Recovery Plan.

Oregon's 'broad sense recovery is defined as State of Oregon goals of having populations of naturally produced salmon and steelhead sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) that the ESU/DPS as a whole (a) will be self-sustaining, and (b) will provide significant ecological, cultural, and economic benefits.

Details of broad sense recovery are in Chapter 10. Oregon's broad-sense recovery goal was developed under the intent of the State's Native Fish Conservation Policy (NFCP) to fulfill the mission of the Oregon Plan for Salmon and Watersheds, which is to restore "Oregon's native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits." The Oregon Plan for Salmon and Watersheds is founded on the principle that citizens throughout the region value and enjoy the substantial ecological, cultural and economic benefits that derive from having healthy, diverse populations of salmon and steelhead.

The broad-sense goal in this Recovery Plan was defined in the recovery planning process by local stakeholder and planning teams. This recovery goal is consistent with ESA delisting but is designed to achieve a level of performance for the ESUs and constituent population that is far more robust than needed to remove the ESUs from ESA protection. Broad-sense recovery incorporates ESA delisting goals in the sense that ESA delisting goals would be achieved first during an extended and stepwise process of achieving broad sense recovery goals. Broad-sense recovery represents a level of population performance that may considerably exceed the level at which an ESU or DPS could be delisted, and is a goal that could be based on a combination of legislative mandates, cultural commitments, social values, and voluntary contributions.

Broad Sense Criteria

Oregon's broad-sense recovery criteria are:

- All UWR salmon and steelhead populations have a "very low" extinction risk and are "highly viable" over 100 years throughout their historic range[30]; and
- The majority of UWR salmon and steelhead populations are capable of contributing social, cultural, economic and aesthetic benefits on a regular and sustainable basis.

[30] Having a "very low" extinction risk is equivalent to being "highly viable" in the parlance of population status assessment for recovery plans. A "highly viable" naturally-producing salmonid population with a "very low" extinction risk has less than a 1% probability of extinction over a 100-year period, corresponding to at least a 99% persistence probability. Probabilities result from an integrated assessment of the population's abundance, productivity, spatial structure, and diversity statuses

Chapter 4: Population Status and Conservation Gaps

This chapter provides a brief review of the 2007 status assessment (McElhany et al. 2007) of UWR Chinook and steelhead populations, and an updated status assessment based on new data and modeling methodology. The updated assessment changed some of the status scores for some UWR populations, and this chapter documents those changes. The chapter also describes how the updated population status provides a baseline for current viability attributes for each population, and describes the methodology for estimating the magnitude of improvement (conservation gap) needed in each population to achieve a desired status level. The updated modeling approach was based upon comments received in 2009 from technical reviewers of the OrLCR Plan (which used a similar modeling platform), with respect to an earlier version of the CATAS viability model (see Appendix B for details). The population data files used for the 2007 assessment were updated with new information, and a new procedure was crafted to evaluate the A/P attribute for populations for which there were little or no data.

The chapter focuses on the status of the previously identified independent populations, and does not describe how improvements in the status level for individual populations will be combined to meet the ESU viability criteria developed in Chapter 3 of this Plan. The conservation gaps developed in this chapter contributed to the scoping process for choosing which populations require more recovery effort to meet the ESU viability criteria, and the updated current status and conservation gaps influenced the formation of the ESU-level delisting scenarios described in Chapter 6.

4.1 Population Current Status Assessment

As noted in a previous chapter, the UWR Chinook ESU and steelhead DPS are the listing units under the ESA, but individual populations are the biological units used in this chapter for evaluating the status of UWR Chinook and steelhead ESU/DPS. While the focus of the ESA is on species conservation, we assess the status of populations in terms of extinction risk. Therefore this assessment equates the term “status” with extinction risk. Population status (extinction risk) is a condition that may be thought of ranging from almost 0% (no risk of extinction) to 100% (certain extinction).

As described in the previous assessment of these populations (McElhany et al. 2007), the primary focus of the status assessment was to determine which populations were or were not viable, based on the definition of a viable salmon population (VSP) developed by McElhany et al. (2000). Clearly, one characteristic of a viable population is that the risk of extinction is acceptably low, and McElhany et al. (2006) established a benchmark for population viability as being defined as one with < 5% chance of extinction over a 100-year period. The previous assessment also examined benchmarks for other levels of extinction risk, because population extinction probabilities are along a continuum, ranging from zero (no chance of extinction) to one (extinction is certain). However, the Willamette/Lower Columbia Technical Recovery Team (TRT, McElhany et al. 2003) noted in their supporting documents that that there is limited precision in persistence probabilities estimates (the converse of extinction probabilities estimates) and for criteria development and risk assessment they simply divided the risk continuum into five categories. However, the TRT also recognized that this categorization of discrete risk scores did not convey very well the distribution of uncertainty in risk scores. Therefore, McElhany et al. (2007) explored the uncertainty associated with both the source population data and some analytical features of the assessment by presenting risk as distribution of possible extinction risk scores for each VSP attribute. Graphically, this was represented as diamond shaped profiles whose shape was controlled by the range and frequency of possible extinction risk determinations (Figure 4-1). For each population, the range of possible extinction risk values was bounded by the upper and lower points of the diamonds. The extent of this vertical range reflected a determination of how much uncertainty there was for a particular population’s status. The diamond width at any point on the vertical axis represented the likelihood a particular level of extinction risk might be correct. Therefore, the widest point of the diamond corresponded with the most probable extinction risk classification. To visually check the updated status assessment results, each VSP attribute was plotted as extinction risk diamonds, and an overall risk determination for each population was made by combining the scores and ranges for each of the three population attributes (described in McElhany et al. 2007), and plotted in the same diamond profiling for a combined risk determination[31].

Recognizing the limitations above, but to facilitate reporting the population status summaries and subsequent conservation gap development, we have separated the range of extinction probabilities into the five risk categories in Table 4-1. These risk category designations (from very low to very high) are referenced throughout this Plan.

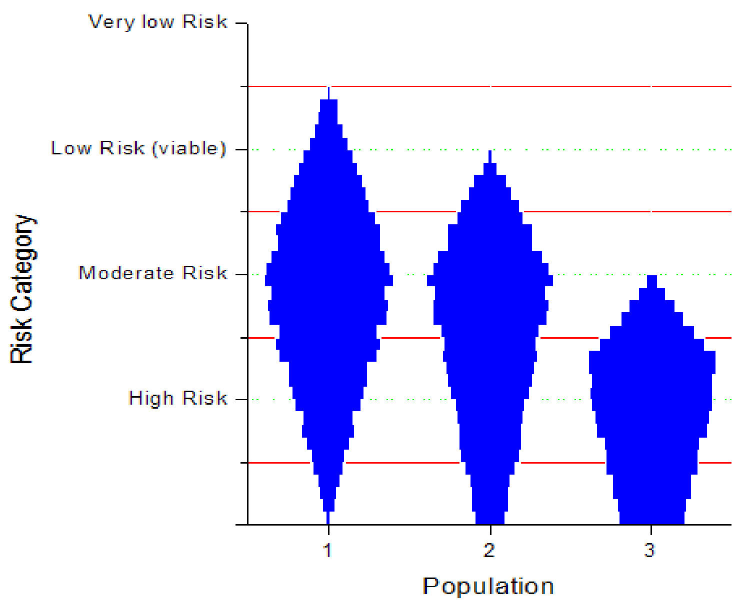

Figure 4-1. Diamond profiles for a single VSP attribute for three hypothetical populations that have different extinction risk profiles.

Table 4-1. Range definition of extinction probabilities and associated risk categories over a 100 year projection (from McElhany et al. 2007).

Probability of Extinction	Extinction Risk (viability) Category	Extinction Risk Category	Risk Category Score
0.00 to 0.01	Viable	Very Low (VL)	4
0.01 to 0.05	Viable	Low (L)	3
0.05 to 0.25	Non-viable	Moderate (M)	2
0.25 to 0.60	Non-viable	High (H)	1
0.60 to 1.00	Non-viable	Very High (VH)	0

[31] As an additional step to address uncertainty inherent to extinction risk modeling, a precautionary change was made in interpreting the extinction risk diamonds. These modifications are described later in this chapter. Those relatively uncommon cases where these modifications resulted in a population assessment that was different from the 2007 assessment (McElhany et al. 2007) are flagged and described.

The risk assessment focused on the four biological VSP attributes of viable populations identified by McElhany et al. (2000): abundance, productivity, diversity, and spatial structure. Specific information for each of these VSP attributes was used in forecasting extinction risk. However, because the four attributes are often interrelated and it is difficult to separate how each variable independently affects extinction risk. This interaction is particularly strong between the abundance (A) and productivity (P) VSP attributes, and for this assessment these two attributes were treated as a single entity of abundance/productivity (A/P). The two attributes were evaluated and ranked as one attribute because abundance cannot be evaluated without the context of productivity, and productivity cannot be evaluated without the context of abundance. For example, a population with low abundance but high productivity may have exactly the same extinction vulnerability (and therefore risk category) as a population with high abundance and low productivity. Further, there are a very large number of possible combinations of abundance and productivity values that may produce the same range of extinction risk probabilities, which underlies the abundance and productivity viability curves developed for several UWR populations (McElhany et al. 2007).

The spatial structure (SS) and diversity (D) attributes were treated as separate attributes for the assessment. However, because of the difficultly of developing metrics for the SS and D attributes that could be quantitatively characterized to extinction risk, a mix of qualitative and quantitative metrics were used, recognizing that relationship to extinction risk in most cases could not be explicitly modeled, unlike the case for the A/P attribute. The methodological details used to score the SS, D, and A/P attributes are presented in McElhany et al. (2007).

4.1.1 Spring Chinook ESU Status – High to Very High Extinction Risk

Of the seven populations that historically comprised the UWR Chinook ESU, the natal subbasins supporting these populations are tributaries within the Willamette River basin[32]. The UWR Chinook ESU is considered to be extremely depressed, likely numbering less than 10,000 fish compared to a historical abundance estimate of 300,000 (Myers et al. 2003). Currently, significant natural production occurs in only the Clackamas and McKenzie populations (McElhany et al. 2007). Juvenile spring Chinook produced by hatchery programs are released throughout many of the subbasins and adult Chinook returns to the ESU are typically 80-90% hatchery origin fish. Flood control/hydropower development has eliminated or adversely changed freshwater habitat for spring Chinook habitat in most subbasins. In addition, a large fraction (30% to 80%) of adult spring Chinook reaching each subbasin die before spawning, for reasons not yet clearly understood.

In the previous assessment, McElhany et al. (2007) determined that the Clackamas population was the only population in the ESU with an extinction risk rating of low or better (i.e. viable), that the Mckenzie population fell into the moderate risk category, and the remaining five populations were classified as being at very high risk (Figure 4-2, from McElhany et al. 2007). Although there was uncertainty in the status determinations for these five populations, mostly due to lack of abundance and productivity data, it was not to the extent that it cast doubt on whether they were viable or non-viable, and the results of the updated assessment did not differ appreciably from the results of the earlier status evaluation. However, the classification for Clackamas Chinook salmon was downgraded from low to moderate risk and the classification for McKenzie Chinook salmon was upgraded from moderate to low risk.

[32] The Clackamas population was originally addressed in the OrLCR Plan because of its shared geography with other LCR species and populations. That assessment and recovery strategy are superseded by the updated analyses performed for the Clackamas population described in this Plan.

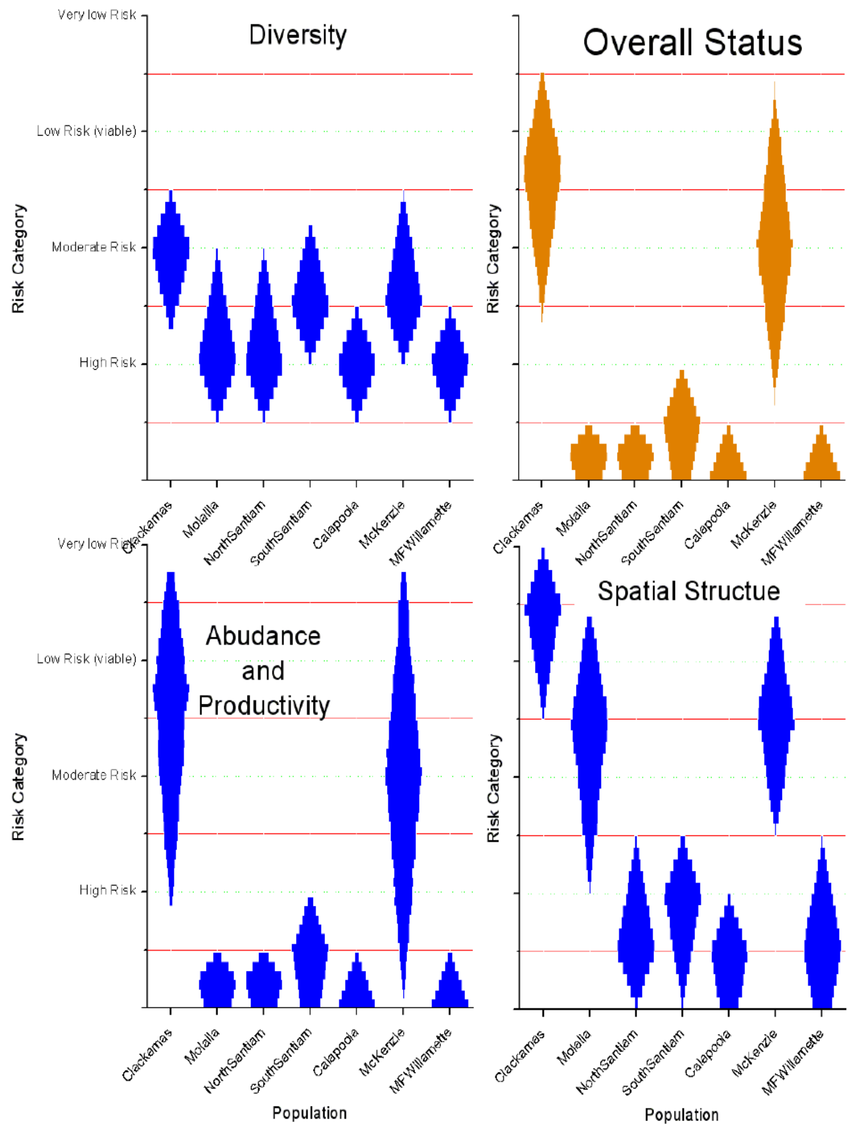

Figure 4-2. Extinction risk ratings for UWR spring Chinook populations from an earlier assessment (McElhany et al. 2007).

4.1.2 Winter Steelhead DPS Status –Low to Moderate Extinction Risk

The UWR steelhead DPS was historically comprised of four winter-run populations occurring in subbasins that originate in the Cascade Mountains. Steelhead also use West-side tributaries on an intermittent basis, but as a unit these subbasins are not thought to have functioned as an independent population (Myers et al. 2006).

For UWR steelhead, although the DPS is depressed relative to historical levels, the risk of extinction is modest, especially compared to the UWR Chinook populations that share much of the same geography. In their assessment of these populations, McElhany et al. (2007) found that while most of these populations probably fell into the 'moderate' extinction risk classification, there was a large degree of uncertainty in this result as illustrated by the elongated status diamonds in Figure 4-3. As a result of the most recent assessment of these populations, the overall risk status for the North Santiam, South Santiam, and Molalla populations was upgraded from moderate to low extinction risk. This was largely due to new estimates of extinction risk that were obtained from running an updated version of the CATAS population viability model (Appendix B).

4.2 Population Conservation Gaps

As discussed in the preceding section, many UWR Chinook populations were determined to have extinction risk levels that are consistent with a classification of non-viable. The term "conservation gaps" is used here to help describe the magnitude of improvements needed to improve a population's current condition to a targeted "recovery" condition, and address the extinction risks of each risk category. For example, if the current extinction risk classification for a population is high risk, then the magnitude of improvements needed to reach moderate, low, and very low risk levels, would each be defined as a conservation gap.

Conservation gaps were estimated for each of the three VSP attributes: abundance/productivity, diversity, and spatial structure. Methodology for these conservation gaps are in Appendix I. Although conservation gaps were developed for both the diversity and spatial structure attributes, there are several reasons to emphasize the abundance/productivity conservation gap. First, abundance/productivity is weighed more heavily than spatial structure and diversity attributes in the overall status determinations (McElhany et al. 2007) and has a greater influence on a population's overall extinction risk determination. Second, none of the population viability attributes are truly independent. For example, a population that has limited life cycle and genetic diversity will be less likely to have the productivity and resilience to rebound from periods of unfavorable environmental conditions. Likewise, a spatially fragmented population will be more vulnerable to local disturbances and be slow to recover after such events. This condition will effectively depress overall population abundance and as a result make the population more vulnerable to extinction. Third, for salmonid populations the process of extinction is better understood as it relates to abundance and productivity, whereas the process is less direct and more difficult to quantify for population diversity and spatial structure.

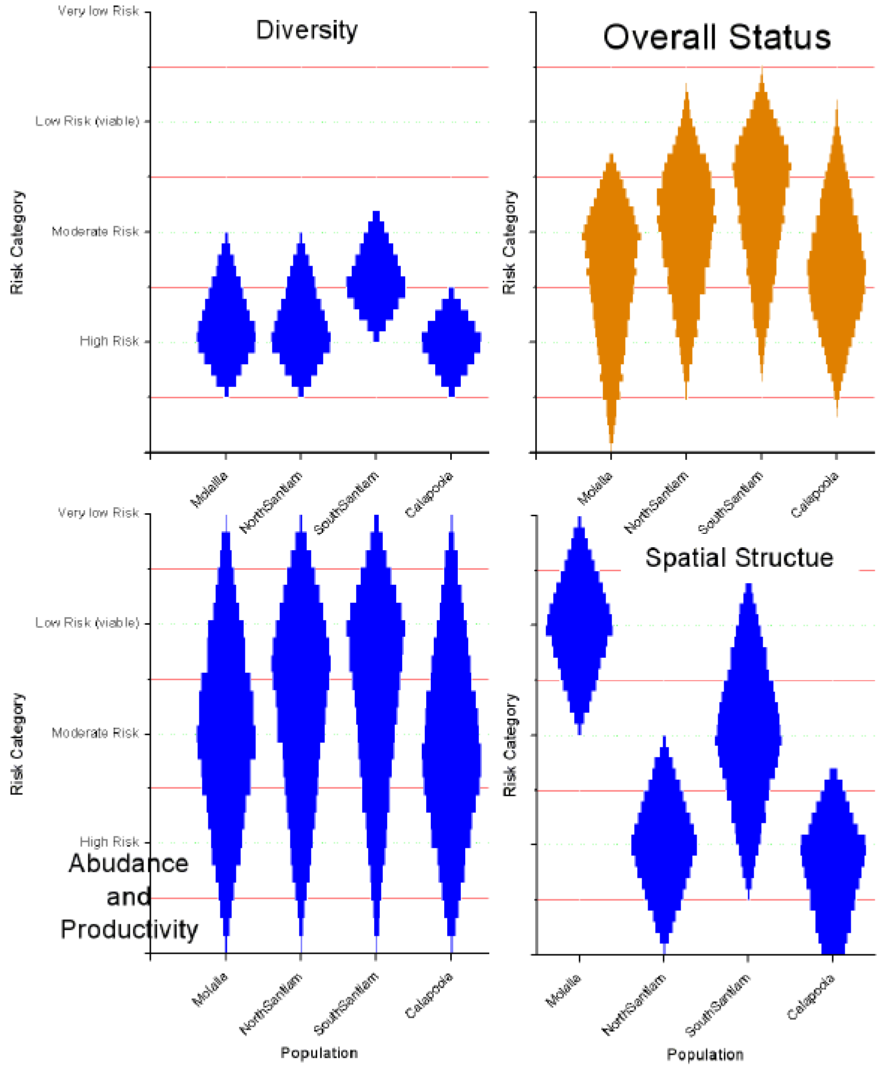

Figure 4-3. Extinction risk ratings for UWR steelhead populations from an earlier assessment (McElhany et al. 2007).

4.2.1 Summary of Current Status and Conservation Gap

Given the individual extinction scorings for VSP attributes in the previous subsections, Table 4-2 summarizes the overall extinction risk for each UWR Chinook salmon and steelhead population.

Table 4-2. Summary of the key elements and their respective scores used to determine current status risk classification for the diversity attribute for UWR Chinook salmon and steelhead. See Table 4-1 for extinction risk classification abbreviation.

Species / Population	A/P	Diversity	Spatial Structure	Overall Extinction Risk Category
Chinook				
Clackamas	M	M	L	M
Molalla	VH	H	H	VH
North Santiam	VH	H	H	VH
South Santiam	VH	M	M	VH
Calapooia	VH	H	VH	VH
McKenzie	VL	M	M	L
MF Willamette	VH	H	H	VH
Steelhead				
Molalla	VL	M	M	L
North Santiam	VL	M	H	L
South Santiam	VL	M	M	L
Calapooia	M	M	VH	M

The conservation gaps presented in Table 4-3 are reported as single numbers without a range or uncertainty bars. However, for each gap there is a range of possible results, in terms of population status, that cover more than one extinction risk classification.

To illustrate this principle we provide an example using a coho population in the Lower Columbia River ESU:

> The risk classifications of high, moderate, low, and very low for Sandy coho as described in the OrLCR Plan correspond with A/P conservation gap values of 416, 1,387, 2,656, and 3,766 adult spawners respectively (Figure 4-6). However, these values do not represent point estimates but rather underlying distributions of possible values. Therefore, as illustrated in Figure 4-6, a survival increase that results in the population growing by 1,387 wild coho would 'lift' the status diamond for Sandy coho from its current very high risk classification to a moderate risk classification (i.e. close the A/P conservation gap).
>
> However, there is considerable uncertainty how much the extinction risk will actually decline with a 1,387 increase in population abundance. As the placement of the diamond on this graph reflects, there is a chance that the population would not raise above the zone of high risk. Conversely there is also a chance, somewhat greater, that the population would enter the low risk zone. There is even a small possibility in this example that the extinction risk could fall into the very low risk zone.

As applied to UWR populations, there is a diamond-like distribution of extinction probabilities for each conservation gap value listed in Table 4-2. Therefore, as a practical matter, when recovery actions are taken to deliver the survival improvements necessary to close a particular conservation gap, there is a possibility that the future resulting population status could land above or below the intended target.

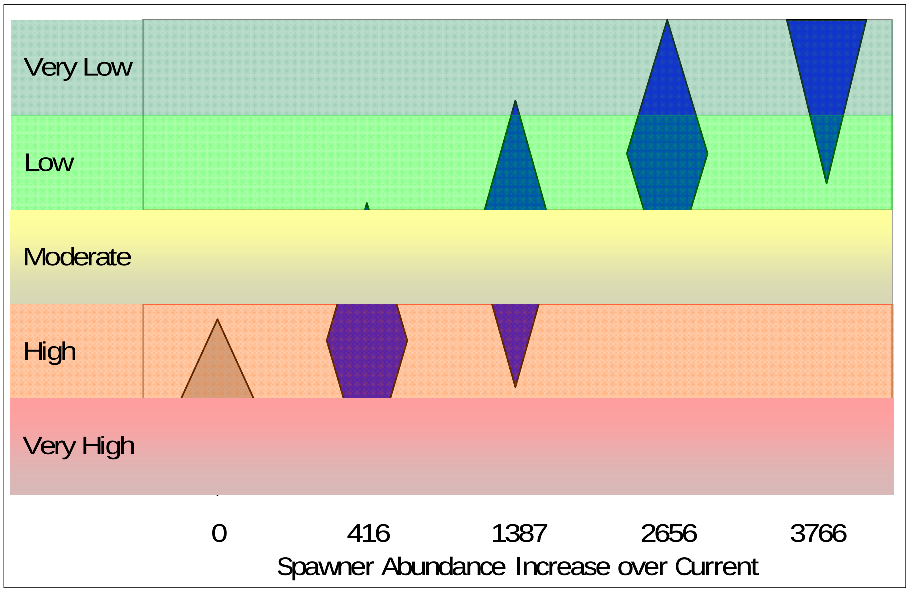

Figure 4-4. An example of forecasting a distribution of possible status outcomes (blue diamonds) if the abundance increases necessary to close A/P conservation gaps. Gaps identified for an example population from the LCR coho ESU (Sandy coho). Current conditions status represented diamond on far left.

Table 4-3. Estimated conservation gaps for UWR Chinook and steelhead population attributes of abundance/productivity (A/P; gap in number of spawners), and for category scores of diversity (D) and spatial structure (SS). The A/P gaps include a 20% conservation buffer, as described in Chapter 6 of this Plan. A/P gaps with * were not calculated. Shaded cells indicate the population is already above a risk threshold for that attribute and therefore does not have a conservation gap at that risk level.

Species/Population	Conservation Gaps											
	High Risk			Moderate Risk			Low Risk			Very Low Risk		
	A/P	D	SS	A/P	D	SS	A/P	D	SS	A/P	D	SS
Chinook												
Clackamas							*	1		946	2	1
Molalla	696			*	1	1	1,409	2	2	*	3	3
North Santiam	*			*	1	1	5,400	2	2	*	3	3
South Santiam	*			3,100			4,860	1	1	*	2	2
Calapooia	590		1	*	1	2	1,200	2	3	*	3	4
McKenzie							*	1	1	3,491	2	2
MF Willamette	*			*	1	1	5,820	2	2	*	3	3
Steelhead												
Molalla							*	1	1	557	2	2
North Santiam				*		1	*	1	2	4,687	2	3
South Santiam							*	1	1	1,212	2	2
Calapooia			1	21		2	331	1	3	498	2	4

As might be expected, the A/P conservation gaps that were calculated varied among populations. For several of the spring Chinook populations in particular the A/P conservation gaps were large. However, since the finding was primarily for the 'no data' populations, the accuracy of these gap estimates is strongly dependent on the adequacy of the approach used to build the recruitment models for these populations (Appendix B).

Further, the A/P conservation gaps estimated for some populations are very large relative to the current size of the population. It is likely that some of these estimates are too large and may be an artifact of the gap estimation methodology, which assumes a linear population response at all population densities and conservation levels. For the nearly extinct populations, this linear assumption is probably incorrect and has likely led to the generation of some exceptionally large A/P conservation gaps.

The estimation procedure could have been modified to reflect a more non-linear behavior at these low abundance levels. However, it was not clear how the nonlinearity should be modeled and there was no assurance a more complicated model would reduce output uncertainty. Therefore, the current approach was applied for all populations. Still, the response for some populations to the proposed recovery actions will not be accurately known until the response can actually be observed at some point in the future. An active post-implementing monitoring program for these populations will be especially critical.

The spatial structure conservation gaps for most populations were greater than for the diversity gaps (Table 4-3). This reflects the fact that much of the historical habitat remains inaccessible for most of the populations, resulting in most populations being in the non-viable category with respect to spatial structure (Table 4-2)[33].

[33] From Maher et al. (2005): "It is important to note that physical accessibility does not equate to fish presence and just because a stream is deemed accessible does not mean it is now or was ever used by a salmonid species. In presenting these data we do not mean to say that fish have or will utilize 100% of the accessible reaches and it is reasonable to assume that these data overestimate the stream lengths associated with current or historical distribution (see fish distribution maps)."

Chapter 5: Limiting Factors and Threats

Chapter 5 describes limiting factors and threats to the recovery of the UWR Chinook ESU and steelhead DPS. Limiting factors are the physical, biological, or chemical conditions (e.g., inadequate spawning habitat, habitat connectivity, high water temperature, insufficient prey resources) and associated ecological processes and interactions experienced by the fish that result in reductions in viable salmonid population parameters (abundance, productivity, spatial structure, and diversity). Threats are the human activities or natural events (e.g., road building, floodplain development, fish harvest, hatchery influences, and volcanoes) that cause or contribute to limiting factors. These limiting factors and threats (LFTs) were identified and ranked for importance through a comprehensive review of potential limiting factors and threats across the entire lifecycle. Identifying how suites of management actions (Chapters 6 and 7) strategically addressed these LFTs provides the conceptual basis for restoring viability of UWR Chinook and steelhead.

This chapter is divided into four sections. The first section describes the components of limiting factors and threats and the basic approach that the Expert Panel and the Planning Team used to develop them. The remaining sections provide the results of this process.

Development Process

The process of identifying LFTs for UWR Chinook and steelhead populations is based on strong technical, policy-level and stakeholder involvement. Individuals with expertise about conditions at the State, ESU and watershed levels were brought in at different steps of an iterative process to identify the LFT's at the independent population level, as well as common threat themes across the ESU and DPS.

- ODFW created an Expert Panel to establish a foundation for LFT determinations. Pooling their collective knowledge, nine biologists with significant knowledge of UWR Chinook and steelhead convened to provide their professional opinion on the LFTs that significantly influence the current status of UWR Chinook and steelhead populations. The specific purpose for convening the panel of experts was to quickly develop an initial list and ranking of potential LFTs that would serve as a starting point for more detailed and lengthy deliberations by the UWR Planning Team. This first step of an iterative process is described in greater detail in Appendix C.
- The initial list of LFTs developed by the Expert Panel was extensively reviewed and modified during a series of meetings by the Planning Team. At these planning team meetings, additional information was presented and discussed that either supported or refuted the initial list provided by the Expert Panel. Based on the consensus of the Planning Team, the initial list of LFTs was modified to reflect additional information and more detailed deliberations of the Planning Team. The Planning Team also modified the Expert Panel's findings regarding LFTs that occur in the estuary based on the Columbia River Estuary Recovery Plan Module[34] (LCREP 2007).
- The updated list of LFTs was provided to the Stakeholder Team for their review. Stakeholder comments and input on the updated list of limiting factors and threats were reviewed by the Planning Team, who again modified the list by consensus.
- The Planning and Stakeholder teams then reviewed the revised draft of this chapter of the recovery Plan. The Planning Team then reviewed these comments received on the draft and revised the LFT's and discussions as appropriate. This iterative process involving the Expert Panel, Planning Team and Stakeholder Team resulted in the LFTs described in subsequent sections of this chapter.

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[34] http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/Estuary-Module.cfm

Approach to Uncertainty

There are several sources of uncertainty related to the LFT assessment. For example, there is the likelihood some threats were not identified with enough detail or some critical limiting factors were not correctly ranked as to their importance. It should be noted that in addition to the information reported in the listing determination, this Plan applied a multistep threat review undertaken by scientists with a high level of salmonid and ecosystem knowledge, as described above, and it is assumed the life cycle approach to LFT determination has identified the most important factors limiting UWR Chinook and steelhead viability. However there is a lack of empirical data linking specific limiting factors to VSP metrics for UWR Chinook and steelhead populations, and that the interactive or cumulative nature of some LFTs is not completely understood. The risk of this uncertainty is that the impact of some factors may not have been sufficiently unmasked, relative to repairing life cycle bottlenecks. This source of uncertainty is addressed by having robust and flexible suites of integrated actions that target known life cycle bottlenecks. The scenario analyses (Chapter 6), management actions (Chapter 7), and implementation strategy (Chapter 9) are essentially the treatments designed to repair the major life cycle bottlenecks represented by the LFTs. To the extent there is no measurable biophysical response to these treatments (suites of strategic actions), it would subsequently be assumed that the importance of some of the LFTs was not adequately characterized, or that actions have not been sufficiently implemented. In either case, this Plan relies on a testable adaptive management strategy to reduce uncertainty in the LFT assessment through re-alignment of critical uncertainty research, actions, monitoring, and evaluation.

5.1 Limiting Factor and Threat Analysis Components

5.1.1 General Limiting Factor Categories

As described above, limiting factors are the physical, biological, or chemical conditions and associated ecological processes and interactions (e.g., population size, habitat connectivity, water quality, water quantity, etc.) experienced by the fish that may influence VSP parameters (abundance, productivity, spatial structure, and diversity). After considering a set of draft guidelines and list of limiting factor categories developed by NMFS (NMFS 2005a), Oregon chose a modified set of limiting factors (Table 5-1), based on the premise that this set better identifies LFTs at specific life stages and spatial scales, and therefore better for identifying effective recovery actions.

Table 5-1. General limiting factor categories identified for UWR Chinook and steelhead populations, category definitions, and the VSP parameters they affect. Factor categories are in alphabetical order.

Limiting Factor Category	Definition	VSP Parameters Potentially Affected *
Competition	Adverse interaction between naturally produced fish and other fish or other species, both of which need some limited environmental factor (i.e. food or space).	A, P, D, SS
Disease	Pathological condition in naturally produced fish resulting from infection.	A, P, D, SS
Food web	Changes in the food web, such as from macrodetritus-based to a microdetritus-based input, or because of reduced salmon carcasses.	A, P, D, SS
Habitat access	Impaired access to spawning and/or rearing habitat. Examples include impassable culverts, direct mortality at dams, delayed migration over dams, dewatered stream channels, etc. If, for example, a stream has been diked- thereby eliminating access to off-channel habitat- habitat access should be considered a problem. If off-channel habitat to which access has been eliminated is in impaired condition, it is also considered an element of the physical habitat quality/quantity limiting factor.	A, P, SS, (sometimes D)

Hydrograph/water quantity	Altered hydrograph, timing and magnitude of flows	A, P, D, SS
Physical habitat quality/quantity	Habitat characteristics include floodplain connectivity and function, channel structure and complexity, channel morphology, riparian condition (including loss or alteration of stream habitat) and large wood recruitment, sediment routing (fine and coarse sediment), and upland processes. Quantity refers to the amount of accessible habitat for different life history stages.	A, P, D, SS
Population traits	Impaired population condition(s) including: genetic, life history, morphological, productivity, fitness, behavioral characteristics, and population size. Population traits may be lost through such means as hatchery influences, selective harvest mortality, and altered environmental conditions from human actions or natural occurrences. Although population traits are caused by other limiting factors, they may also act independently as a limiting factor.	Harvest: A, P, D, SS Hatcheries: A, P, D Hydro: A, P, D, SS
Predation	Consumption of naturally produced fish by another species (does not include fishery mortality).	A, P, D, SS
Water quality	Water characteristics including temperature, dissolved oxygen, suspended sediment, pH, toxics, etc.	A, P, D, SS

*VSP parameters: A- abundance, P – productivity, D –diversity, SS – spatial structure

5.1.2 General Threat Categories

As described above, threats to UWR Chinook and steelhead are human impacts, including fishing , hatchery operations, flood control/hydropower system operations, the introduction of exotic species, and land use practices (e.g., road building, riparian development, etc.), or natural occurrences (e.g., flood, drought, volcano, tsunami, etc.) that *cause or contribute to* limiting factors. A single threat may cause or contribute to one or more limiting factors and may affect one or more life stages, and conversely, a single limiting factor may be caused by one or more threats. This implies that LFTs can have interacting and cumulative impacts on UWR Chinook and steelhead VSP's. In addition, past threats can have legacy effects, and may continue to contribute to current limiting factors.

For this LFT assessment, five broad threat categories were considered originally: fish harvest management, hatchery management, flood control/hydropower management, land use management (excluding flood control/hydropower), and introduced species. The "introduced species" threat category was redefined as "other species" in Table 5-2 and in subsequent sections to better reflect management strategies that address both native and non-native species impacts would be addressed (see description below of different LFT effects of other species).

In Chapters 6 and 7 these threat categories were further partitioned into threat sub-categories that better reflected specific threats and how they would be addressed in this Plan. We re-emphasize that there is considerable uncertainty regarding emerging threats such as climate change and population growth and how they will affect salmon and steelhead. We did not define climate change and population growth as unique threat categories in this Plan, because we assume these additional sources of risk will be manifested through LFTs already accounted for in the existing categories. We assume the ramifications of climate change and human population pressure will increase the need for coordination among management actions to address LFTs.. We provide a general description of the potential impacts of climate change and human population growth to UWR ESUs in section 5-3 below. Chapters 7 and 9 describe an approach for assessing the risk of climate change.

Table 5-2. The general threat categories and a brief description of how they are manifested into limiting factors for UWR Chinook and steelhead populations.

Threat Category	How Threats Cause or Contribute to Limiting Factors
Flood Control/Hydro Management	Hydropower and flood control management cause a loss or alteration of stream habitat. Management includes dam construction and operations, conversion of riverine habitat to reservoir, and water withdrawals and flow alterations.
Land Management	Land management practices associated with agriculture, timber harvest, mining and grazing activities, diking, damming, development of transportation corridors, and urbanization can degrade or destroy ecosystem function by altering habitat characteristics, including sediment, connectivity of side channels and water quality
Other Species	Effects of other species include predation and competition effects by native and non-native fish, or other animals, and habitat degradation effects by non-native plants.
Harvest Management	Fisheries cause direct and indirect mortality to naturally produced fish. Direct mortality occurs when a fish is caught and killed directly as a result of an authorized fishery. Indirect mortality includes mortality of fish that are caught and released or that encounter fishing gear but are not landed. Most harvest regimes target abundant hatchery fish and are regulated to limit impacts on naturally spawned fish. However, naturally spawned fish can be incidentally caught and killed in fisheries aimed at hatchery fish. Fisheries can also result in genetic selection (e. g. size or age)
Hatchery Management	Hatchery programs can harm salmonid viability in several ways: hatchery-induced genetic change can reduce fitness of wild fish; hatchery-induced ecological effects—such as increased competition for food and space—can reduce population productivity and abundance; hatchery-imposed environmental changes can reduce a population's spatial structure by limiting access to historical habitat; hatchery-induced disease conveyance can reduce fish health. Practices that introduce native and non-native hatchery fish can increase predation on juvenile life stages. Hatchery practices that affect natural fish production include removal of adults for broodstock, breeding practices, rearing practices, release practices, number of fish released, reduced water quality, and blockage of access to habitat.

5.1.3 Life Stages and Geographic Areas Considered

Life-Stage Definitions

ODFW provided guidance to the Expert Panel and Planning Team regarding life stages to consider. These life stages are described below.

- *Egg / alevin*: Life stages from egg deposition until emergence from the gravel. An alevin has not absorbed its yolk sac, a primary source of nutrition.
- *Fry:* Life stage between alevin and parr. A fry has emerged from the gravel but has not left the redd; it has absorbed its yolk sac.
- *Summer parr*: A summer parr is any juvenile Chinook salmon or an Age 1+ or older juvenile steelhead that is actively foraging in freshwater rearing habitat in summer.
- *Winter parr*: A winter parr is an Age 1 juvenile Chinook salmon or any juvenile steelhead using winter rearing habitat for foraging and shelter.
- *Smolt*: A juvenile salmonid migrating downstream to the ocean. A smolt is undergoing physiological adaptations in order to osmoregulate in saltwater.
- *Sub adult*: Fish rearing in the ocean.
- *Adult*: Maturing fish, either in the ocean or freshwater, that are migrating toward spawning areas
- *Spawner*: Sexually mature fish.
- *Kelt*: A post spawn steelhead returning to saltwater.

The purpose of dividing the parr life stage into summer and winter seasons is that juveniles use winter and summer habitat differently, and different actions are often required to address LFTs impacting this seasonal use. The Planning Team also partitioned the juvenile life stages in two different ways based on geographic considerations. Juvenile life stages in freshwater were based on the concept that differences in seasonal habitat needs often require different actions to adequately address LFT concerns. Juvenile life stages in the estuary were based on a condensed version of the life history strategies used to identify LFTs in the Estuary Module (NMFS 2008b), (Table 5-3).

Geographic Areas

UWR Chinook and steelhead experience LFTs that are life-stage specific as they navigate through different geographic areas during their life cycle. The Planning Team examined the wide range of factors impacting the UWR Chinook and steelhead populations in the different locations, and recognized five distinct geographic areas where life-stage specific LFTs may occur. These areas span the lifecycle of UWR Chinook and steelhead, and are summarized in Table 5-4 and depicted spatially in Figure 5-1. The key and secondary threats to UWR Chinook and steelhead in these geographic areas are discussed under the various threat categories in the sections below.

Table 5-3. Juvenile life history categories used in the analysis of LFTs and threats in the UWR Chinook and steelhead Recovery Plan and the analogous life history strategies defined in the Estuary Module (NMFS 2008b).

Classifications of juvenile life history stages in the estuary used in this Plan	Classifications of juvenile life history stages used in the Estuary Module
Parr	Early fingerling - Freshwater rearing: 60 - 120 days. Size at estuarine entry: 60-100 mm. Time of estuarine entry: Apr.-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-Oct., present through winter. Estuarine residence time: 0 -80 days.
Smolt	Subyearling - Freshwater rearing: 20 - 180 days. Size at estuarine entry: 70-130 mm. Time of estuarine entry: April-Oct. Estuarine residence time: <20 days.
	Yearling - Freshwater rearing: >1 year. Size at estuarine entry: >100 mm. Time of estuarine entry: Feb.-May. Estuarine residence time: <20 days.

Table 5-4. Geographic areas used to organize LFTs in the UWR Chinook and steelhead Recovery Plan.

Geographic Area	Description	Life Stage and Principal Function
Natal Subbasin	Streams and reservoirs within a specific population area where production occurs	egg/alevin (hatching, early life development) fry, summer and winter parr (rearing) smolt (migration, some rearing) adult (migration, staging) spawner (spawning), kelt (downstream migration)
Mainstem Willamette	The mainstem Willamette River above Willamette Falls	fry (rearing, migration)[35] parr (rearing) smolt (migration, some rearing) adults (migration)
West-Side Tributaries	Streams on the west side of the Willamette River above Willamette Falls	parr (rearing)
Estuary	Tidally influenced areas of the Columbia River below Bonneville Dam and the Willamette River below Willamette Falls including the Columbia River Plume	parr (rearing) smolt (migration, some rearing) adults (migration)
Ocean	Saltwater areas outside of the estuary	Sub-adult (foraging)

[35] CHS survey data indicate presence of fry in the mainstem Willamette River, with a possible rearing role (see Schroeder et al. 2005)

Figure 5-1. A map of the five principal geographic areas encompassing the life cycles of UWR Chinook and steelhead populations. These areas were used to spatially organize LFTs according to life stages. Legend indicates independent population boundaries. Shaded parallel hatching represents areas above large Federal flood control facilities that have limited or no provisions for fish access to historical spawning areas.

5.1.4 Prioritizing Limiting Factors and Threats

The developers of this Plan believe successful implementation of a recovery plan should be based on strategic guidance that identifies the relative importance of LFTs. Rather than provide a comprehensive list of potential LFTs, the authors have identified the LFTs that the planning team predicts will be the most significant impediments to viable populations of UWR Chinook and steelhead. Toward this end, this Plan recognizes two categories of LFTs:

Key limiting factors and associated threats that expected to have had the greatest impact on current population viability.

Secondary limiting factors and associated threats are also expected to have had significant impacts on population viability, but to a lesser degree than key concerns.

The words underlined in the previous two sentences underscore a number of important points regarding the process used to identify key and secondary LFTs. Ideally, the process of ranking LFTs would include mortality estimates (loss of production) at each life stage for each species and population. Unfortunately, empirical estimates do not exist for most life stages and populations, so we have based the key and secondary limiting factors for each population on the consensus expert opinion of the Planning Team.. The Team used existing data and analyses where appropriate (see subsections in Appendix C) to make these determinations. However, the team did not have sufficient data to quantify the effect of any of the LFTs on population survival rates, either acting alone or together." Nor does it address the issue of whether multiple and related secondary LFTs can act together to be elevated to a key concern. During Planning Team discussions it became clear that some LFTs would have to be addressed before others to meet recovery targets. The scenarios in Chapter 6 attempt to address these priority and timing issues.

5.2 Overview of Common Threats and Associated Limiting Factors

This section summarizes background information on the broad threats that are common to multiple populations within the UWR ESUs. Appendix C contains subsections with more extensive and detailed background information that was developed by NMFS, and used by the Expert Panel and subsequent teams to evaluate the threats. Section 5.4 below includes information on the LFTs specific to UWR populations.

Flood Control/Hydropower Management

Specific threats from flood control and hydropower management include: 1) blocked or impaired fish passage for adults and juveniles, 2) loss of some riverine habitat (and associated functional connectivity) due to reservoirs, 3) reduction in instream flow volume due to water withdrawals, 4) lack of sediment transport and role in habitat function, 5) altered physical habitat structure, and 5) altered water temperature and flow regimes.

Within the Willamette River basin, the largest flood control/hydropower complex is termed the Willamette Project, managed principally as a flood control system by the US Army Corps of Engineers (USACE; see the supplemental BA [USACE 2007a] for more detail). The most recent Biological Opinion for the Willamette Project (NMFS 2008a), and supporting references within, provides an extensive review of the multiple impacts this project has on UWR Chinook and steelhead populations and habitats within subbasins, but also as they contribute to habitat quality impacts in the Willamette River mainstem. Within the Willamette subbasins where these projects are located, the flood control structures block or delay adult fish passage to major portions of the historical holding and spawning habitat for UWR Chinook (North Santiam, South Santiam, McKenzie and Middle Fork Willamette subbasins), and for UWR steelhead in the North Santiam and South Santiam basins. In addition, most Willamette Project dams have limited facilities or operational provisions for safely passing juvenile Chinook salmon and steelhead downstream of the facilities. Past operations and current configurations of the Willamette Project have impacted several salmonid life stages, through impacts on water flows, water temperatures, total dissolved gas (TDG), sediment transport, and channel structure.

In addition to the Federally owned and operated flood control/hydropower facilities, other subbasin facilities such as the PGE complex in the Clackamas basin, the EWEB Carmen Smith complex (and associated structures) in the McKenzie basin, and municipal flow control facilities contribute to the flood control/hydropower LFTs. Improvements for anadromous fish at these facilities are negotiated and formalized under processes and subsequent relicensing under the FERC.

Hydropower impacts also extend to the Columbia River estuary, through which UWR Chinook and steelhead adults migrate, and juveniles rear and migrate. The indirect but cumulative impacts on estuarine habitat quality and quantity are related to the more than 450 Columbia Basin dams in the United States and Canada that provide active storage > 42 million acre-feet of water. Within the United States, 14 of these dams are mainstem multi-purpose hydropower projects in the Columba and Snake drainages, and are referred to collectively as the Federal Columbia River Power System (FCRPS). Other (non-Federal) hydropower facilities also contribute to storage, and dams in Canada account for about half of the total storage. Management of the FCRPS (and co-coordinated non Federal projects) for hydropower, flood control and other uses has significantly changed the quantity and timing of flows entering the Columbia River estuary and plume from historical conditions (Fresh et al. 2005). The operation of the FCRPS and other facilities in the Columbia basin principally influences juvenile life stages of UWR salmonid populations as they migrate below Willamette Falls. Jay and Naik (2002) reported a 16% reduction of annual mean flow over the past 100 years and a 44% reduction in spring freshet flows. Jay and Naik (2002) also reported a shift in the hydrograph from 14-30 days earlier in the year, meaning that spring freshets are occurring earlier in the season. In addition, the interception and use of spring freshets (for irrigation, reservoir storage, etc.) have increased flows during other seasons (Fresh et al. 2005).

Land Management

Impacts of land management on UWR Chinook and steelhead include current land use practices causing limiting factors, as well as current practices that are not adequate to restore limiting factors caused by past practices (legacy impacts). Past and present land management may affect salmonid population viability by affecting abundance, productivity, spatial structure and/or diversity. Past land use (including agricultural, timber harvest, mining and grazing activities, diking, damming, development of transportation, and urbanization) are significant factors now limiting viability of UWR Chinook and steelhead. These factors severed access to historically productive habitats, and reduced the quality of many remaining habitat areas by weakening important watershed processes and functions that sustained them. The IMST recently published an extensive review of land use effects (including those imposed by dams) on the rehabilitation of salmonids in Oregon, and references therein can be reviewed for conditions specific the Willamette basin (IMST 2010). The following is a very brief synopsis of general land use impacts.

Estuarine Areas

The Columbia River estuary provides critical habitat for juvenile salmonids as they achieve the necessary growth and physiological development to survive in the ocean. Historically, the lower estuary contained rich and complex foraging habitat that likely promoted rapid growth and increased survival. Over the years, land and water management activities have degraded the quantity and quality of these attributes of estuarine habitat, resulting in a homogenization of both habitat complexity and the functional use of remaining estuarine habitat by UWR Chinook and steelhead. Combined with the effects of the Columbia basin hydropower/flood control systems, the primary activities that have contributed to current estuary and lower mainstem habitat conditions include channel confinement (primarily through diking), channel manipulation (primarily dredging), floodplain development, and water withdrawal for urbanization and agriculture (LCFRB 2004). The presence of jetties, pile dikes, tide gates, docks, breakwaters, bulkheads, revetments, seawalls, groins, ramps and other structures have changed circulation patterns, sediment deposition, sediment erosion, and habitat formation in the estuary (Williams and Thom 2001). Together, habitat alteration through dredging, disposal of sand/gravel, wetland filling, instream and overwater structures, dikes and navigational structures have significantly altered estuary size/function, and reduced connectivity with peripheral wetland and side channel habitat. . As a result of these changes, the surface area of the estuary has decreased by approximately 20% over the past 200 years (Fresh et al. 2005). In some reaches like the lower Willamette River, the loss of shallow and side channel rearing habitat has been much greater. This loss of access to historical rearing habitats has restricted juvenile UWR salmonids to sometimes sub-optimal habitat.

In addition to physical modification of estuarine habitat, water quality has been severely degraded in parts of the estuary. Agricultural, urban and industrial practices in the Columbia River Basin have led to higher water temperatures and contaminants in the estuary. The amounts of urban and industrial contaminants are particularly high in the highly urbanized areas of the lower Willamette River. Degraded water quality, toxins from urban and industrial sources are considered a threat in some stream reaches in Portland, including the lower Willamette River.

Water and sediment quality is also an issue in near shore areas. For example, a site in the estuary near Astoria is in the process of becoming a superfund site, ie added to the National Priorities List. Contaminants of concern include petroleum, PAHs, heavy metals and organotins (chemical compounds based on tin with hydrocarbon substituents).

Upper Willamette Mainstem and subbasins

Land management activities have also severely degraded stream habitat conditions in the Willamette River mainstem above Willamette Falls and associated subbasins. In the Willamette River mainstem and lower sub-basin mainstem reaches, high density urban development and widespread agricultural effects have impacted aquatic and riparian habitat quality and complexity, sediment and water quality and quantity, and watershed processes. In upper subbasin mainstem reaches and subordinate tributary streams, the major drivers of current habitat conditions are past and present forest practices, roads, and barriers. Aquatic habitat degradation is primarily the result of past and/or current land use practices that have affected functional attributes of stream channel formation, riparian connectivity, and magnitude and frequency of contact with floodplains, as well as watershed processes. In many subbasins the flood control/hydropower structures in the principal subbasins created new baseline *control* conditions upon which subsequent habitat alterations have been overlaid. Among the land use activities that have led to current habitat conditions are:

- Timber harvest on unstable slopes and riparian areas has led to the decoupling of watershed processes. Improperly located, constructed, or maintained roads have degraded stream flow and sediment supply processes. The legacy effects of splash dams to transport logs continues to inhibit instream structural complexity and available spawning gravel in several stream systems;
- Agricultural development, especially along lowland valley bottoms in the mainstem Willamette reaches, and lower reaches of principal subbasins has directly impacted riparian areas and floodplains. Historical floodplain habitats were also lost through the filling of wetlands and levee construction. Runoff from agricultural lands where pesticides, herbicides, and fertilizers are applied has reduced sediment and water quality;
- Livestock grazing has directly impacted soil stability (trampling) and streamside vegetation (foraging), and delivered potentially harmful bacteria and nutrients (animal wastes) to streams;

- Construction of small scale dams, culverts, and other barriers has limited access to spawning and rearing habitats;
- Urban and rural-residential development in the lower subbasins and the mainstem Willamette River floodplain has led to the degradation of riparian and floodplain conditions, as well as an alteration of the natural drainage network due to roads, ditches and impervious surfaces. For example, prior to the 1850s, the lower Willamette River was comprised of approximately 80% shallow water and 20% deep habitat. Those proportions have now reversed, and the river is 80% deep and 20% shallow water habitat.
- Sand and gravel mining along some Willamette basin streams has impacted stream channels by altering instream substrate and sediment volumes.

Together these activities continue to inhibit the amount and quality of spawning and rearing habitats available to UWR salmon and steelhead populations, principally by severing access to historically productive habitats, and by weakening the important watershed processes and functions that once created and maintained healthy freshwater ecosystems for UWR Chinook and steelhead production. Today, many streams have lower frequency and complexity of pools compared to historical conditions. And many of those that remain lack the complex structure needed to retain gravels for spawning and invertebrate production, and the connectivity with shallow, off-channel habitat areas that once provided refugia from floods, over-wintering and hiding cover, and productive early-rearing habitat.

These activities have also reduced water quality in the principle subbasins and mainstem Willamette River. Land uses that involve water withdrawals have contributed to elevated water temperatures in many population areas at critical periods. Elevated stream temperatures are often the result of multiple factors including water withdrawals and/or altered hydrology and a lack of intact, functional and contiguous riparian management zones and sufficient streamside buffers. In some areas, water quality has also been reduced because of contaminants for agricultural use, and contaminants generated from urban storm water runoff and industrial sources.

Today, many land use practices are better than they were in the past and, as a result, many stream reaches once degraded by past practices are recovering. Many landowners now understand the advantages of good conservation practices and are changing their approaches to contribute to restoration of healthy watershed processes and functions. A suite of regulatory programs have also been implemented to protect and restore salmon and steelhead physical habitat and water quality. Together these changes are improving the physical quality of salmon and steelhead habitats and providing more suitable environments for spawning and rearing. However, restoration to date has often been opportunistic rather than strategic. Furthermore, restoration of habitat and water quality has been more problematic in urban areas where economic needs play a more prominent role and riparian areas are expected to serve multiple needs (e.g., industrial, residential, recreation, habitat), and floodplain and riparian restoration efforts are exceedingly expensive. Even with significant improvements, many stream reaches remain far below historic habitat potential, and human population growth will continue to exert pressure on functional stream reaches. There will need to be continued effort to protect existing habitat and repair degraded habitat to levels that will support viable salmon and steelhead populations.

Other Species

Negative effects of both native and introduced plant and animal species were identified as LFTs to UWR Chinook and steelhead populations. However, some actions will occur in the context of hatchery management for each sub-basin, , while others will be addressed in the Estuary Module as part of suite of habitat improvement actions, hatchery actions, and direct predator control actions that will benefit multiple ESUs. Anthropogenic introductions of non-native species and out-of-ESU races of salmon or steelhead can increase predation and competition on native UWR Chinook and steelhead.

Predation Effects in the Estuary

Predation by native species may influence salmonid population viability by affecting abundance, productivity, spatial structure and/or diversity. Sources of predation are principally from terns, cormorants, and pikeminnow and the mortality impacts caused by pinniped predation. Ecosystem alterations attributable to hydropower dams and to modification of estuarine habitat have increased predation on all UWR Chinook and steelhead population. In the estuary, habitat modification has increased the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species (LCREP 2006; Fresh et al. 2005). For example, new islands formed through the disposal of dredged materials have attracted terns away from their traditional habitats, which may now be degraded. Reduced sediment in the river increased the terns' efficiency in capturing steelhead juveniles migrating to saltwater at the same time that the birds need additional food for their broods. In 1997 it was estimated that avian predators consumed 10-30% of the total estuarine salmonid smolt production in that year (LCREP 2004). The draft 2005 Season Summary of Research, Monitoring, and Evaluation of Avian Predation on Salmonid Smolts in the Lower and Mid-Columbia River (Collis and Roby 2006) estimates that 3.6 million juvenile salmonids were consumed by terns in 2005. 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. Double-crested cormorants consume a similar number of juvenile salmonids (approximately 3.6 million juveniles) from their East Sand Island nesting grounds (Collis and Roby 2006). Habitat alterations combined with large releases of hatchery juvenile salmonids may have also shifted the balance of historic predator:prey dynamics, such as the native piscivorous Northern Pikeminnow. As noted above, effects of these species will be managed with actions described in the Estuary Module.

Predation Effects above Willamette Falls

In the upper Willamette River subbasins, there is concern that reservoirs associated with flood control/hydropower facilities have created habitat conditions that make juvenile migrants more susceptible to introduced predatory fishes, with greatest concern being largemouth and smallmouth bass. Predation by largemouth bass in Green Peter Reservoir was identified as a LFT for UWR juvenile salmonids. Centrarchid abundance in Lookout Pt. Reservoir is reported to be high, particularly for crappie (Greg Taylor, USACE Willamette Review symposium 2010), but the magnitude of crappie predation on juvenile salmonids is unclear. Predation by bass may be a concern in other areas as well, such as slow water areas in sub-basins and the mainstem Willamette that are associated with the remaining floodplain.

Predation by introduced salmonids in the Willamette basin has also been identified as LFTs for some UWR Chinook and steelhead populations. The loss of winter steelhead habitat due to flood control/hydropower facilities was mitigated with a hatchery program using an out-of-ESU summer steelhead broodstock[36]. Predation on juvenile UWR Chinook by summer steelhead has been identified as a secondary LFT for the North Santiam, South Santiam, and McKenzie Chinook populations. In addition, predation on juvenile UWR Chinook by an introduced strain of rainbow trout (Cape Cod strain) that supports a trout mitigation program[37], has been identified as a secondary LFT for the McKenzie Chinook population. The effects of these species will be managed by hatchery management.

Competitive Effects

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[36] Further program detail: http://www.dfw.state.or.us/HGMP/docs/2006/06-upper-willamette-summer-steelead.pdf
[37] Further program detail: http://www.dfw.state.or.us/HGMP/docs/2006/06-upper-willamette-rainbow-trout.pdf

Other species, both native and introduced, can compete for resources with UWR Chinook and steelhead populations. Hatchery management practices that release large numbers of hatchery juveniles can reduce available food resources for natural origin juveniles, limiting growth and health. Juveniles of the summer steelhead hatchery mitigation program in the Willamette River basin may compete with juveniles of native winter steelhead, and has been identified as a key LFT in the North and South Santiam subbasins. The management of these species for in-basin effects will be managed by actions within hatchery programs affecting UWR spring Chinook and winter steelhead. In the estuary, where juvenile UWR Chinook and steelhead compete with hatchery fish that are produced throughout the Columbia basin, broader hatchery management coordination will be needed.

Harvest Management

Depending on their distribution, run timing relative to fishery openings, and vulnerability to gear, UWR Chinook and steelhead may be caught in ocean, lower Columbia River, mainstem Willamette River, and sub-basin fisheries. These fisheries influence salmonid population viability by causing direct and incidental mortality to naturally produced fish. Direct mortality is associated with fisheries that are managed to specifically harvest target stocks. Incidental mortality includes mortality of fish that are caught and released, captured by fishing gear but not landed, or harvested incidentally to the target species or stock.

As further described below, exploitation rates from commercial and recreational fisheries on UWR spring Chinook have been substantially reduced in response to extremely low returns in the mid-1990's and subsequent ESA listings in 1999. For spring Chinook, freshwater fishery impacts have been reduced by approximately 75% from 2001 to present compared to the 1980 through the late 1990's (Figure 5-2) by implementing selective harvest of hatchery-origin fish in commercial and recreational fisheries, with all unmarked, wild spring Chinook being released. This fishery management change was enabled after all hatchery Chinook returning were adipose finclipped. Impacts from ocean fisheries has averaged 11% from 1996-2006 (the last year of reported data in NMFS 2008c). Excessive fishery harvest was cited as a listing factor for the Willamette Chinook ESU in 1999 when fishery exploitation rates were greater than 50% in ocean and freshwater fisheries (NMFS 2008c) However, in light of the significant reforms in harvest management implemented since the time of listing under the Pacific Salmon Treaty for ocean fisheries (NMFS 2008c) and ODFW's FMEP for freshwater fisheries (ODFW 2001a, 2010[38]), the proposed Plan did not identify fishery harvest as a primary or secondary LFT on populations residing above Willamette Falls and explained that other primary and secondary LFTs are the key bottlenecks currently impeding the recovery of these spring Chinook populations. For example, very high pre-spawning mortality (typically 50-95%) of spring Chinook in every population, except the McKenzie, post-fisheries is the primary factor influencing spawning escapement. The current average freshwater fishery exploitation rate of 8-9% over the last decade is of little consequence to spawning escapement when pre-spawning mortality rates are so high. In addition, of the fish that survive to spawn below the Federal dams in the North Santiam, South Santiam, and Middle Fork Willamette populations, their progeny suffer high mortality rates due to the discharge of unusually warm reservoir water in the fall while the eggs are in the gravel incubating. Since fishery harvest rates have been significantly reduced for more than a decade (two generations) on all Willamette spring Chinook populations, yet significant improvements in the number of naturally-produced fish have not occurred, this Plan does not consider fishery harvest rates to be a primary or secondary LFT now inhibiting the recovery of spring Chinook populations above Willamette Falls. In fact, the lowest returns of naturally-produced fish on record were observed in recent years (2008-2009) while exploitation rates have continued to remain at low levels. The one exception is the Clackamas population, where fishery harvest is still identified as a secondary

[38] http://www.nwr.noaa.gov/Salmon-Harvest-Hatcheries/State-Tribal-Management/upload/FMEP-U-Will-Chnk-2009.pdf

limiting factor because this population does not have the significant problems with pre-spawning mortality, poor egg incubation, inadequate upstream and downstream passage, and loss of oversummering habitat.

The impacts of hatchery programs that support harvest are described below, in this section, in Chapter 6 and in Appendix E.

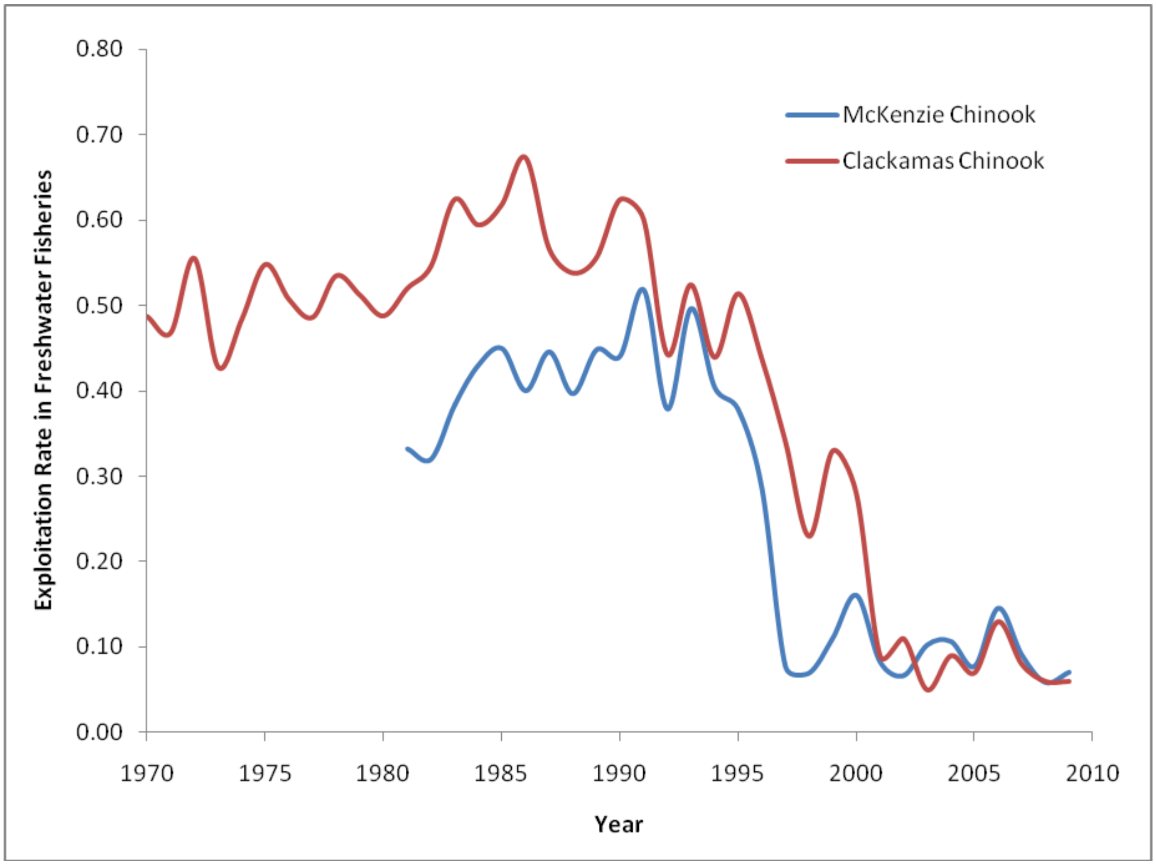

Figure 5-2. Freshwater fishery exploitation rates for McKenzie and Clackamas spring Chinook stocks. Rates include fisheries in the lower Columbia River, mainstem Willamette River, and Clackamas and McKenzie Rivers. Full implementation of selective fisheries, where only adipose finclipped Chinook can be harvested, went into effect in 2002. Data are from ODFW (2001a) and ODFW (2010).

For UWR winter steelhead, a similar situation exists regarding fishery harvest management. Significant reforms were implemented in the early 1990's that required catch and release of all unmarked, wild winter steelhead. Hatchery programs were eliminated and changes to trout stocking and fishing regulations were made to reduce fishery exploitation rates. Whereas fishery harvest may have been a listing factor for winter steelhead, the reforms that have been implemented have reduced fishery harvest impacts such that it is no longer identified as a primary or secondary LFT. The current exploitation rates on wild steelhead from sport fisheries are in the range of 0-3% (ODFW 2001b[39]). Steelhead are not intercepted in ocean fisheries to a measurable degree.

[39] http://www.nwr.noaa.gov/Salmon-Harvest-Hatcheries/State-Tribal-Management/upload/FMEP-U-Will-stlhd.pdf

The specific details of the complex harvest management system that is now in place are discussed below. Significant portions of the following background information were adapted from ODFW (2001a) and a summary white paper prepared for the Expert Panel (Appendix C). UWR Chinook salmon and steelhead cross numerous fisheries jurisdictions as they make their way from natal upper Willamette subbasins all the way to Canada and Alaska and then back again. These various fisheries focus on different stocks and populations, and take fish to meet commercial and recreational needs. Because of their exposure to fisheries across large geographic regions of the West Coast, management of UWR Chinook and steelhead is governed by a number of organizations such as the Pacific Salmon Commission, NMFS (administering the ESA), the Pacific Fishery Management Council, the states of Oregon and Washington, and the Columbia River Compact (see description in NMFS 2008c and NMFS 2008f). Consequently, many regulating factors that affect harvest impacts on Columbia River stocks are associated with laws, policies, or guidelines established to manage other individual or combined stocks, but that indirectly control impacts on Columbia River fish.

Fishery managers adjust harvest annually in response to changes in abundance to achieve specified escapement levels or harvest rate limits to allow harvest of strong (generally hatchery) stocks while protecting weak (generally wild) stocks. Management is governed by international treaty agreements, fisheries conservation acts, regional conservation goals, the Endangered Species Act, and State and tribal management agreements. Management through these various organizations has contributed to the decline of harvest rates for UWR Chinook and steelhead. Fishery managers strive to reduce exploitation rates on wild UWR Chinook and steelhead while meeting various harvest goals by continuously reviewing changes in population abundance and marine survival conditions, and adjusting exploitation rates and timing accordingly. Commercial and recreational harvest of wild Chinook and steelhead has been reduced through a combination of time, area, gear, and mark-selective regulations to optimize harvest of hatchery stocks

The different types of fisheries that may directly or indirectly affect the populations are detailed in the Fisheries Management and Evaluation Plans (FMEP's: Chinook ODFW 2001a; steelhead 2001b), and the NMFS Harvest BiOps (NMFS 2008c, NMFS 2008f). Ocean fisheries affecting UWR spring Chinook salmon include Southeast Alaska and Canadian troll fisheries. Owing to their early run timing, numbers of UWR Chinook salmon taken in Oregon and Washington coastal sport and commercial fisheries are relatively low (ODFW 2001a). The various fisheries occur within the Lower Columbia River and Willamette River basin management area throughout the year. Fisheries in the estuary and freshwater impacting UWR Chinook are currently managed by ODFW to protect and recover wild populations. Mortality of released fish in Columbia River spring Chinook salmon sport fisheries (including the Lower Willamette) is estimated to be 10% (Lindsay et al. 2004). The Lower Willamette River sport fishery has historically had a very large impact on UWR Chinook salmon. The FMEP limits total freshwater fishery impact (commercial and recreational) on wild fish to 15% of the total number of unmarked fish returning to the Willamette River . Management under the Chinook FMEP began in 2001, and the regulation that only marked fish could be retained in fisheries managed under the FMEP began in 2002, the first year that almost all returning hatchery adults would have had such marks (except 6-year olds). This selective fishery has resulted in a 75% reduction in average fishery mortality compared to 1981-1997. The overall freshwater harvest impact on wild fish has been below 15% since implementation of the FMEP, and averaged 8-9% (Figure 5-2).

Because of the FMEP improvements, the harvest impacts of Lower Columbia commercial fisheries have become relatively greater. In 2002, new gear restrictions were initiated for these fisheries to reduce impacts on ESA-listed ESUs, meanwhile also increasing catch of UWR hatchery spring Chinook salmon. To minimize capture and handling of wild winter steelhead, >8"-9 ¾" mesh gillnets are required in February when UWR spring Chinook salmon are abundant in the Lower Columbia, with steelhead excluder panels (i.e., >12" mesh for top 5') also recommended. In March, tanglenets with a maximum mesh of 4 ¼" are used to reduce mortality of fish of ESA-listed populations. Release mortality for the tangle nets (25%) is about half that of the gill nets (50%). Fishing time is reduced in mid March or when wild steelhead are in greatest abundance. Finally, recovery boxes to resuscitate wild fish, short soak times, and reduced net lengths are now mandatory (Joint Staff Report 2011). In recent years, impacts to Chinook from the commercial fishery have been very low (<2%) because of fishery constraints on other ESA-listed stocks.

For steelhead populations, current freshwater harvest objectives and regulations are to provide maximum harvest opportunity on non-native hatchery summer steelhead to an extent that it does not jeopardize recovery of native winter steelhead in the UWR steelhead DPS (Molalla, North Santiam, South Santiam, Calapooia) (ODFW 2001b; Myers et al. 2006). Summer steelhead fisheries occur in both the lower and upper Willamette River mainstem, as well as in the Santiam River, which is home to the two "core" UWR steelhead populations as defined by the WLC-TRT (McElhany et al. 2006). In the Willamette basin, summer steelhead runs begin as early as March when winter steelhead are still in the rivers. Although the season extends from March through December, most effort directed at summer steelhead, and most catch, occurs from May through August.

A brief description follows of the harvest management system that UWR populations are subject to. Further information regarding the fisheries can be found in the Harvest BiOps (NMFS 2008c, NMFS 2008f):

- *Canada/Alaska ocean fisheries*. Numerous fisheries in Canada and Southeast Alaska harvest far-north migrating Chinook stocks from the Willamette River basin. Canadian marine fisheries include commercial troll and net fisheries, and recreational sport fisheries in Northern BC, Central BC, West Coast of Vancouver Island, Strait of Georgia, and Strait of Juan de Fuca. In Southeast Alaska, treaty marine Chinook fisheries include commercial troll and net fisheries, as well as recreational sport fisheries UWR Chinook are caught primarily in troll fisheries off of Southeast Alaska and Canada, because they return to the Columbia River from late February through April, and thus most have exited these areas before ocean fisheries off the Washington coast open on May 1 of each year. Winter steelhead are rarely encountered in Canadian and SE Alaska salmon fisheries, and for practical purposes, ocean fishing mortality on listed steelhead from the Columbia River (and presumably the Willamette) was assumed to be negligible (NMFS 2008c).
- *United States West Coast ocean fisheries*. Recreational and commercial ocean fisheries also occur along the U.S. West Coast and. although they do not account for significant harvest of UWR spring Chinook salmon, we describe them here because there may be some mortality. These fisheries are separated into four major management areas: 1) US/Canada border to Cape Falcon, Oregon; 2) Cape Falcon, Oregon to Humbug Mountain, Oregon; 3) Humbug Mountain, Oregon, to Horse Mountain, California; and 4) Horse Mountain, California to the US/Mexico border. These management areas are further divided into subareas depending on the type of fishery. Recreational fisheries are either selective for fin-clipped hatchery fish or non-selective depending on the species. Commercial fisheries are either selective or non-selective troll fisheries. Numerous treaty Indian commercial troll, non-Indian commercial troll, and recreational marine fisheries exist along the West Coast..
- *Lower Columbia River commercial fisheries*. Winter commercial fisheries occur from the mouth of the Columbia River to Kelly Point near the mouth of the Willamette River, with peaks in Feb-March (ODFW 2001a). The spring fisheries are mark selective for finclipped fish. Commercial fishing seasons in the mainstem Columbia River are established by the Columbia River Compact Select Area terminal fisheries (select off-channel fishing areas) produced from net pen programs have a goal of 100% harvest. Although Select Area fishing effort is relatively small, some incidental take of wild Chinook salmon can occur. Select Area seasons are established by the Columbia River Compact for concurrent waters and by the individual states for state waters. A winter sturgeon fishery extends

from the Columbia River mouth to just below Bonneville Dam, with most effort upstream of the mouth of the Willamette River. Gill net provisions in that fishery limit impacts to spring Chinook. The FMEP's for UWR Chinook and steelhead have summary tables of the timing of different fisheries to which UWR populations are exposed.

- *Lower Columbia River, Mainstem Willamette, and Willamette tributary recreational fisheries*. The lower Columbia River mainstem between the mouth and the I-5 Bridge supports a sport mark selective fishery for Chinook and steelhead. A small Select Area sports fishery occurs in the Lower Columbia River basin. In the Willamette basin, this fishery occurs in the Multnomah Channel and lower Willamette River upstream to Willamette Falls, the lower Clackamas River from the mouth to River Mill Dam, upper Willamette River from the Falls to the mouth of the McKenzie River, Molalla River, Santiam River and Forks, McKenzie River, and the Middle Fork of the Willamette River (ODFW 2001a). In these zones, recreational fisheries may incidentally impact wild spring Chinook.

Types of Fishery Effects

Harvest decreases adult abundance, and thus the total number of spawners. The extent of this decrease in abundance is usually measured either as numbers of spawners or as an exploitation, rate. Harvest may be selective-either intentionally or unintentionally[40]-and influence diversity and spatial structure of populations, and the ESUs.

Fishery managers forecast annual abundance and adjust allowable harvest to achieve established escapement goals or to stay within specified exploitation rate limits on wild stocks. They generally try to manage the fisheries using a combination of gear, time, area, and mark-selective regulations to optimize the harvest of strong (generally hatchery) stocks within the series of constraints for weak (generally wild) stock protection. As a result, today's fishery impact rates for most hatchery-produced Chinook and steelhead are higher than for wild fish of the same species.

- *Directed Harvest Mortality.* Harvest mortality occurs in fisheries directed at a particular species or stock; this harvest can occur in single (terminal) or mixed (intercept) stock fisheries[41]. Single stock fisheries are the most effective method for targeting a specific stock and commonly occur in terminal harvest areas where one stock is known to be present.

  In mixed stock fisheries, the management challenge is to harvest from mixed populations having various available surpluses, sometimes including populations with no surplus, as the populations move through the fishery area at various rates and abundances. Harvest of a specific stock in the mix can be achieved by management decisions (e.g., fishery openings when the targeted stock is abundant relative to other stocks), fishery adaptations (e.g., gear designed to target specific stock/species), or fishery regulations (e.g., prohibitions of retaining certain species). Stock identification techniques are constantly being improved to assist managers in making informed and timely fishery decisions. For example, certain fisheries in the Columbia River focus on harvesting adipose fin-clipped, hatchery-reared fish only by targeting marked hatchery fish while utilizing gear modifications to allow protected stocks to be released. Regulations prohibiting retention of wild fish (i.e., non-adipose fin-clipped fish) have been relatively successful, especially with regards to the impact of recreational fisheries on wild fish.

[40] There is "mark-selective" where only hatchery marked fish are supposed to be harvested. There is also "phenotypic selection", "genetic selection" or "evolutionary selection" caused by the fishery preferentially taking certain phenotypes (e.g. size, age, run time).

[41] In reality nearly all salmon fisheries are to some degree "mixed stock" fisheries. Even fisheries that take place close to spawning grounds may encounter strays from other areas. The closer the fishery is to the spawning grounds the less impact there generally is on other stocks, but it is shades of gray, not black and white

- *Incidental Harvest Mortality.* Despite the various methods used to target a specific stock and minimize effects on weak stocks, the incidental harvest of non-targeted stocks, still occurs, largely because salmonid migration timing and routes can vary considerably from year to year. Most commercial fisheries have specific reporting requirements and limits for incidental bycatch and "drop off mortality[42]" that are intended to lessen the harvest impacts to non-targeted stocks. For the Columbia River, specific incidental harvest percentages are set for protected stocks; fisheries are managed so as not to exceed these harvest limits of protected stocks. Access to strong stocks in the Columbia River and ocean fisheries is regulated by impact limits on the weak populations mixed with the strong populations.
- *Catch and Release Mortality.* Catch and release regulations have been used for years to manage sport fisheries. Generally, catch and release restrictions allow resident fish to grow older and larger, thereby creating improved angling opportunities. More recently, catch and release has been employed in anadromous fish management practices to enable retention of hatchery salmon and steelhead and release of wild fish in mixed-stock fisheries. Because of the wide range of knowledge among sport anglers regarding proper fish handling techniques and the different degrees of how fish species react to handling stress, mortality occurs as a result of catch and release.
- *Size, Age, Timing Selection* Harvest may selectively remove fish based on size, age, distribution or run timing, depending on the gear, timing and location of the fishery. Commercial fishing gear can be size-selective, depending on the type of gear (i.e., gill net vs. troll) or the size of gear (i.e., mesh size). As mentioned in the mixed stock fishery discussion for direct harvest mortality, size selectivity can be a desired result if the gear is designed to harvest a specific size stock or species. However, commercial fishing gear size selectivity can also be undesirable. For example, if a fishery disproportionately harvests the larger individuals in a population, the remaining smaller individuals comprise the effective population (i.e., those individuals that spawn in any given year). If this process is repeated annually, the effect on the adult population is a decreased average size at maturity, which can also modify a stock's age composition. Even when fisheries are not size selective, ocean fisheries harvesting immature fish alter the age structure of the spawning escapement of species with multiple age classes in the spawning population toward younger age classes, and thus exert selective pressure for younger maturation. This happens because fish that would mature at an older age must survive the risk of harvest for more years than fish that mature at younger ages.

Fisheries may also be selective for a particular timing or segment of the run, depending on management practices. For example, a fishery may disproportionately harvest the early portion of a run because of market- or industry-driven needs, or because of the timing of hatchery fish runs. Because run timing is heritable (Garrison and Rosentreter 1981), fisheries may alter run timing traits due to systematic temporal removals from populations over time. Although there is evidence that run timing alterations have occurred in certain stocks (e.g. some Lower Columbia River coho stocks), it is not a forgone outcome for all stocks exposed to fisheries.

Hatchery Management

Hatchery programs have the potential to benefit or harm salmonid population viability by affecting abundance, productivity, distribution, and/or diversity. A number of new studies, including Araki et al. (2008) and Chilcote et al. (2011), support earlier studies that hatchery programs can cause significant risks to salmon population viability including genetic changes that reduce fitness of wild fish, increase risk of disease outbreaks, and/or alter life history traits, and ecological effects—such as increased

[42] Drop off mortality can occur when a fish his hooked but not landed.

competition for food and space or amplified predation—that reduce population productivity and abundance (see review of ecological effects in Kostow (2009) and the Ecological Interactions Workshop 2010 (State of the Salmon 2010). Hatcheries can also impose environmental changes by creating migration barriers that reduce a population's spatial structure by limiting access to historical habitat. Conversely, in some circumstances, hatchery programs can benefit salmonid viability by supplementing natural spawning and thereby increasing natural-origin fish abundance and spatial distribution, by serving as a source population for re-populating unoccupied habitat, and by conserving genetic resources. Reviews of these various effects can be found in Araki et al. (2008), in the WP BiOp (NMFS 2008a), Kostow (2009) and Chilcote et al. (2011).

Releases of hatchery reared Chinook began in 1902 in the McKenzie River, 1918 in the Santiam River, 1920 in the Middle Fork Willamette River, 1939 in the Clackamas River, 1957 in the Molalla River. Currently there are hatchery programs for UWR spring Chinook salmon in all four of the historically most productive populations (core populations), including the McKenzie population that has also been designated a genetic legacy population (for definitions see McElhany et al. 2003). There is also a Chinook production program in the South Santiam basin that has hatchery releases of the South Santiam stock into the Molalla basin. The UWR spring Chinook hatchery programs are managed principally as harvest hatchery programs (see definition of program types in the ODFW's Fish Hatchery Management Policy[43]) for mitigation to replace or compensate lost habitat capacity of naturally produced fish. In the Willamette basin, this mitigation is due mostly to construction of dams and reservoirs for the Willamette River Basin Flood Control Project (NMFS 2008a). Today, hatchery fish continue to dominate UWR Chinook production, a source of concern noted in NOAA Fisheries Northwest Fisheries Science Center Status review update for Pacific salmon and steelhead listed under the Endangered Species Act Pacific Northwest (Ford et al 2010). Specifically, this review update stated in part for the UWR spring Chinook salmon ESU:

> New data collected since the last BRT report have verified the high fraction of hatchery origin fish in all of the populations all in the ESU (even the Clackamas and McKenzie have hatchery fractions above WLC-TRT viability thresholds). The new data have also highlighted the substantial risks associated with pre-spawning mortality. Although regional recovery plans are targeting key limiting factors for future actions, there have been no significant on-the-ground-actions since the last BRT report to resolve the lack of access to historical habitat above dams, nor have there been substantial actions removing hatchery fish from natural spawning grounds.

ODFW estimated that 85-95% of the spring Chinook passing Willamette Falls in 2001 were of hatchery origin (ODFW 2001a). Recent evaluations show that some steps have been taken to provide better protection for wild populations, but more improvements are needed (HSRG 2007). Many UWR Chinook populations are characterized by high proportions of hatchery fish on the spawning grounds. The major concern with these hatchery programs is the negative effect hatchery fish spawning in the natural environment have on productivity and long-term fitness of naturally spawning populations (HSRG 2007).The major concern with these hatchery programs is the negative effect hatchery fish spawning in the natural environment have on productivity and long-term fitness of naturally spawning populations (HSRG 2007).

The available data on stock transfers between UWR spring Chinook populations (Kostow 1995) and some supporting genetic data suggested that the current populations represent a single gene pool (Myers et al. 2006). Release of hatchery reared fish from outside the ESU into the Willamette basin ended in the early 1990's, but it is thought that (with the exception of Clackamas Spring Chinook) the existing hatchery

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[43] As of December 2010: http://www.dfw.state.or.us/fish/nfcp/rogue_river/docs/hatchery_mgmt.pdf

broodstocks were founded from their respective local populations at the time Willamette Project dams were built (NMFS 2008a). In most cases broodstock collection occurred at facilities built near the base of the dams, and presumably a mix of returning natural-origin and hatchery-origin fish were incorporated into the subsequent hatchery broodstock. As natural-origin populations declined, the proportion of natural-origin fish in the broodstock declined as well, so that hatchery-origin fish currently make up the majority fish in the broodstock (NMFS 2008a). NMFS concluded that hatchery Chinook salmon are part of the UWR spring Chinook ESU (NMFS 2004).

In recent years, most of these mitigation harvest programs have incorporated some proportion of natural origin fish into the hatchery brood stock in an effort to enhance the hatchery stock for harvest production goals. During this time a multiagency coordination group developed short and long term visions for hatchery management in the Willamette basin. One of the program elements was to adopt principles of conservation hatchery programs in order to conserve some natural genetic resources for future recovery efforts, namely eventual reintroduction above dams. Because so few natural-origin fish are available for reintroductions, the coordination group supported some level of integration of some natural-origin fish into the broodstock, with the objective of using subsequent generations of hatchery fish for reintroduction purposes. Recent analyses have indicated some concerns with the level of integration, and there have been recommendations for looking at alternatives.

One outcome of the hatchery influence has been that the proportions of UWR Chinook with various life history characteristics are different than the historic populations in the Willamette Basin. Most hatchery juveniles are released as age-1 smolts in the spring, whereas a more continuous migration of naturally produced smolts through the fall and spring periods was observed in the historic populations (Willis et al. 1995, cited in NMFS 2004; see also Schroeder et al. 2007). Hatchery Chinook return at an earlier age than the historic populations. Most of the returns now are age-4 fish instead of age-5 (Willis et al. 1995, cited in NMFS 2004). It is unknown if younger adults is the result of genetic changes as the result of hatchery operations or fisheries, or simply the result of releasing larger smolts than occurred naturally.

Hatchery production of UWR steelhead began in 1930 and persisted until 1999. Non-native summer steelhead programs began as early as 1926, and currently summer steelhead of Skamania stock are raised at most of the rearing facilities in upper Willamette River subbasins, and released as smolts in the North and South Santiam, McKenzie and Middle Fork Willamette subbasins. The summer steelhead program is currently a mitigation program to provide replacement of fisheries lost due to habitat and production loss in the Willamette as well as other lower Columbia basins. Differences in spawn timing among these stocks may limit (but not eliminate) the potential for interbreeding. Genetic analysis indicates a close affinity between winter steelhead populations in the Santiam, Molalla (North Fork), and Calapooia Rivers. Skamania summer-run are genetically distinct from presumptive native steelhead.

The negative effects of releasing large numbers of an out-of-ESU steelhead stock are not limited to the potential effects on genetic diversity, but include ecological impacts as well (see review in Kostow 2009). While most insight regarding ecological effects on steelhead has come from steelhead populations outside the UWR ESU (Chilcote 2003, Kostow et al. 2003, Kostow 2004, Kostow and Zhou 2006), the impacts are likely relevant to the UWR ESU as well. For example, Kostow and Zhou (2006; citing references therein) suggested that because adults hatchery summer steelhead typically spawn earlier than do wild winter steelhead and their offspring emerge earlier, they may have a competitive advantage in occupying choice feeding territories prior to the emergence of winter steelhead. In addition, when large hatchery releases result in the localized carrying capacity to be exceeded-which is presumed to be the case in UWR sub-basins-there is increased potential for density-dependant mortality on wild fish for early life stages. If a significant number of summer steelhead juveniles residualize in the UWR sub-basins, they could compete with native wild steelhead parr, which have a 1-2 year residence time in freshwater. These potential sources of juvenile hatchery steelhead competition were identified as key LFT for the North and South Santiam winter steelhead populations.

Residualized summer steelhead may also prey upon juvenile Chinook salmon, and this has been identified as a secondary LFT in the Santiam populations, as well as the McKenzie population where releases support a sports fishery. Additional information on hatchery programs in the Willamette basin that may impact UWR Chinook and steelhead can be found in the draft HGMPs[44] and recent HSRG reviews[45].

5.3 Threats from Climate Change and Human Population Increases

Climate change and increases in human population in the Willamette basin will likely intensify and broaden the limiting factors already impacting UWR Chinook and steelhead populations. This will likely require increased intensity, persistence, and continued implementation of the recovery actions in this Plan, as well as identifying additional new actions as RME and adaptive management proceed. Success of this plan requires improvement on the status quo for major LFTs, and preventing other potential impacts from becoming LFTs. In this section we summarize some of the broader projected impacts of these emerging threats, and address them within strategies and actions in subsequent Plan chapters.

Climate Change

Although the impacts of climate change are difficult to project at the population scale, climate change will likely make it more difficult to meet the recovery goals for UWR Chinook and steelhead. The UWR ESUs have presumably persisted through past climatic extremes, but this was prior to the recent overlay of human-induced LFTs, and it is unclear how these populations will respond to the future effects of human-induced climate change. For example, the effects of degraded and lost habitat quality and complexity in the estuary and the ESU tributaries—which already limit the viability of all UWR Chinook and steelhead populations—could be amplified through climate change. With the anticipated negative changes in altered hydrology and higher seasonal water temperatures, there will likely be further losses of backwater, sloughs, and other off-channel areas that provide cool water refugia and resting habitat important to salmonid survival. Degraded riparian habitat conditions may exacerbate altered hydrology and water temperatures by reducing stream shading, bank stabilization, aquatic food production, and nutrient and chemical mediation. While the impacts of global climate change are less clear in the ocean environment, early modeling efforts suggest that warmer temperatures are likely to increase ocean stratification, which in the past has coincided with relatively poor ocean habitat for most Pacific Northwest salmon, herring, anchovies, and smelt populations (CIG 2004).

There are many recent efforts to project the effects of climate change on fish and wildlife in the Pacific Northwest using global emission scenarios and regional and global climate change models (ISAB 2007a, CIG[46], OCCRI[47]). The Independent Scientific Advisory Board recently completed a review of climate change impacts on Columbia River basin fish and wildlife (ISAB 2007a). Although the potential ecological responses and management approaches are complex and not precisely predictable, the projected regional trajectories of increased winter flooding, decreased summer and fall streamflows (and the related effects on stream temperature), and elevated temperatures in streams, rivers, and the estuary are likely to compound already degraded habitat conditions. Some observed and projected regional impacts of climate change relevant to Pacific Northwest salmonids are summarized in Table 5-5.

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[44] http://www.dfw.state.or.us/HGMP/final.asp
[45] http://www.hatcheryreform.us/hrp/reports/appendixe/welcome_show.action
[46] http://cses.washington.edu/cig/fpt/fpt.shtml
[47] http://occri.net/

For recovery planning efforts, there is a need to further down-scale these regional projections and to assess them in terms of ESU and population-scale vulnerabilities. The Oregon Climate Change Research Institute (OCCRI) and Climate Leadership Initiative (CLI[48]) recently conducted a downscaling process from global models to assess a range of possible outcomes from climate change in the Willamette basin (CLI & OCCRI 2010[49]). Briefly, these projections show:

1. *Streamflows:* UWR streams are likely to become flashier in the winter and early spring, and of the three models used (PCM, CSIRO, HadCM),
   a. All showed severe increase in winter flow, probably due to increased winter air temperatures
      i. As noted in CLI-NCCSP-USFS (2009), if winter storm intensity increases, the basin will experience higher runoff and more flooding in winter/spring, and "Greater sediment input, debris flow, and landslide risks are likely, especially in areas with road networks, extensive timber harvest, and other intense land uses. While periodic floods are necessary for maintaining stream health because they create and maintain deep pools, clean spawning gravels, and recruit large wood to the stream, floods that are too frequent or intense can cause shortages of woody debris and increase sparseness of wood distribution, scour gravel deposits and dislodge the egg masses of salmonids, or otherwise compromise stream structure and function." Main effects will be on egg and other early life stages, but change in peak discharge may also influence Chinook juvenile migration.
   b. All showed a moderate decrease in historical summer flows, probably influenced by reduction of "effective precipitation" where: 1) higher winter/spring air temperatures will result in less snowpack and earlier snowmelt in upper drainages that supply flow to lower catchments, and 2) higher air temperatures in summer will increase evapo-transpiration of riparian vegetation, decrease moisture content is soils, and increase evaporation in streams. Together these may lead to lower base flows and expansion of the low flow period in spring and fall, and to warmer water temperatures. With higher water temperature and subsequent degradation in other water quality attributes (algal blooms, lower DO), tolerance ranges for UWR ESUs may be exceeded, leading to direct mortality in some cases (or complete avoidance of the area) or indirect mortality associated with spread and stress associated with disease. In addition, expansion of range or increase in metabolic efficiency of warm-water fish may lead to greater predation on juvenile Chinook and steelhead. Main effects will be on late juvenile life stages, particularly for steelhead.
   c. As noted in CLI-NCCSP-USFS (2009), "spring-fed streams and riparian areas will be buffered somewhat from climate change due to mediated shifts in flow and temperature. The McKenzie is likely to remain the best stronghold for fish in the Upper Willamette. The Middle Fork also may see more moderate changes in flow."
2. *Air Temperature*: The three models consistently show an annual average increase in temperature for all seasons under both the B1 (green) and A1b (business as usual) emissions scenarios (5-8 degrees F). The most severe change in temperature is during the late summer months of August and September. The HadCM model shows the greatest increase in temperature of up to 10-15 degrees F in the summer months by the end of the century.
   a. Associated with low summer stream flows, populations of warm-water predaceous fishes may increase, leading to declines in juvenile survival of UWR Chinook and steelhead.

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48 a program with Resource Innovation Group (TRIG) affiliated with the Institute for a Sustainable Environment (ICE) at the University of Oregon

49 http://www.theresourceinnovationgroup.org/climate-preparedness-pubs/

3. *Precipitation:* The PCM1 and HadCM models project slightly less precipitation in summer and winter, with little change during the fall and spring months. The CSIRO model shows a slight increase in precipitation in the winter months. The decrease in precipitation for summer months in the Willamette basin is not shown to be as severe as in other parts of the state. The CLI-NCCSP-USFS (2009) report noted that climate scientists have suggested a potential "shift to extended periods of wet weather followed by extended periods of drought on an approximately inter-decadal schedule." And:
   a. "Such a pattern of precipitation would make it more difficult for stream systems to maintain their structure and function. River systems would be susceptible to severe erosion, loss of riparian cover, and isolation from an effective floodplain. These climate change susceptibilities, in combination with the effects of expanded human development of the floodplain, are likely to severely degrade the natural capacity of the land to store excess water during flood and slowly release it during drought."
4. *Snow Water Equivalent:* Under the A1b scenario, the model projects a severe decrease in snow water equivalent with near disappearance (greater than 80% loss) by the end of the century. As noted above for streamflows, lack of snowpack will influence summer streamflows, with subsequent impacts on the UWR ESUs.

The above effects will likely play out regardless of actions in this Recovery Plan. An RME need is a more detailed risk assessment that can identify management strategies for specific watersheds in the ESUs where there is opportunity to build population resilience to climate change.

Table 5-5. Observed and Projected Impacts of Climate Change in Major Climate/Hydrologic Indicators for the Pacific Northwest (from multiple sources, including: Mote et al. 1999; Miles et al. 2000; Mote 2003; Snover et al. 2003; Steward et al. 2004; Wiley 2004 as cited in CIG, 2004; CLI-NCCSP- USFS 2009).

Indicator	Observed 20th century changes	Projected changes during 21st century
Air Temperature	Region-wide warming of about 1.5°F (1920-2003). 2000-2009 was the warmest decade on record, and each of the last three decades has been much warmer than the decade before[50]	Average Annual Temperature □ 2040: increase of 2-4°F □ 2080: increase of 6-8°F Average Summer Temperature □ 2040: increase of 4-6°F □ 2080: increase of 4-8°F Average Winter Temperature □ 2040: increase of 1-2°F □ 2080: increase of 2-4°F
Precipitation	Region-wide increase in precipitation since 1920.	Mean Annual Precipitation □ By 2040: less in spring, summer, and fall, more in winter □ By 2080: from slight year round decrease to larger shifts that include monsoon patterns in the spring coupled with increased seasonal drought in the summer

[50] http://www.nasa.gov/home/hqnews/2010/jan/HQ_10-017_Warmest_temps.html

Snowpack	Substantial declines of April 1 snowpack (>30%) at most monitoring stations below 6,000 feet. Data collected during the 20th century revealed widespread increases in average annual temperature and precipitation, and decreases in the April 1 snow water equivalent.	Projected decrease in April 1 snowpack for the Cascades Mountains in Washington and Oregon relative to 20th century climate: • 44% by the decade of the 2020s based on +3°F avg. temp change. • 58% by the decade of the 2040s based on +4.5°F avg. temp change. Snowpack is likely to decline in PNW by 60% by 2040, and 80-90% by 2095 from current levels.
Timing of peak spring runoff	Advanced 10-30 days earlier during the last 50 years, with greatest trends in the PNW.	With earlier snowmelt in spring, stream flows will peak earlier but at lower levels than typical flows in recent years, depending on the geology of the particular stream reach. Earlier peak spring runoff is expected
Storms and Flooding		With warmer oceans and more available moisture in the atmosphere, storm events could increase in intensity, resulting in more flooding in all rivers in the Basin
Summer streamflow	Declining in sensitive PNW basins. Example: May-Sept inflows into Chester Morse Lake in the Cedar River watershed (WA) as a fraction of annual flows have decreased 34% since 1946.	Continued and more wide-spread declines.

Future Human Population Growth and Development

As of 2004, an estimated 2.5 million people lived in Oregon counties with stream and river reaches that support UWR Chinook and steelhead (Benton, Clackamas, Lane, Linn, Marion, Multnomah, Polk, Washington and Yamhill counties; State of Oregon DAS Office of Economic Analysis 2004[51]). The certified population estimate for these counties as of July 1, 2010 is 2,677,150 million people (DAS-OEA). The population is expected to increase at about an average rate of 1.24% through 2040, with a projected population of 3.85 million people at the end of this time period (Table 5-6).

Table 5-6. Projected human population estimates for selected Oregon counties. Table uploaded and adapted from website of Office of Economic Analysis, Department of Administrative Services, State of Oregon.

	Total Population Projection						
County	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Oregon	3,843,900	4,095,708	4,359,258	4,626,015	4,891,225	5,154,793	5,425,408
Benton	85,721	88,995	91,982	94,549	96,517	98,235	99,886
Clackamas	391,536	424,648	460,323	497,926	536,123	576,231	620,703
Lane	347,494	365,639	387,574	409,159	430,454	451,038	471,511

[51] http://oregon.gov/DAS/OEA/demographic.shtml

Linn	110,123	115,156	120,465	126,140	132,133	138,717	146,260
Marion	323,128	344,443	367,018	388,898	410,022	429,824	448,671
Multnomah	711,909	735,445	756,390	778,028	800,565	821,768	842,009
Polk	72,845	83,338	95,594	107,118	117,557	127,019	135,937
Washington	542,678	599,377	660,367	723,669	788,162	854,164	920,852
Yamhill	98,932	108,812	119,011	129,850	141,505	153,549	166,776
County Total	2,684,366	2,865,854	3,058,724	3,255,338	3,453,038	3,650,545	3,852,605

In general terms, an increasing human population puts further stress on aquatic resources. Examples include those summarized by the ISAB (2007b) for trends in the Columbia River basin:

- Population growth will increase demand for resources key to fish and wildlife populations: water, land, and forests.
- Increased demand for residential land is accelerating the rate of conversion of forest and agricultural lands.
- Changes in land use will affect water use and management and, ultimately, fish and wildlife habitat.
- The effects of climate change and population growth will combine to increase pressure on fish and wildlife habitats.
- The dominant ongoing pattern of settlement in the Columbia River basin is exurban sprawl which causes loss, degradation, and fragmentation of habitat. It also increases infrastructure costs, social conflict, and harmful interactions among people and wildlife.
- Demands for fresh water from surface and groundwater will increase. Decreases in the snow pack at higher elevations, resulting from climate change, will exacerbate this situation especially during low-flow summer and fall seasons.
- Urbanization will increase the amount of impervious surfaces in watersheds (pavement, roofs etc.), causing an increase in surface runoff during storm events and a reduction base flows due to reduced groundwater recharge.
- Population-related factors external to the Columbia River basin will affect fish and wildlife habitat. These include international trade, shipping, dredging, hazardous material transport, and airborne pollution.

Similar trends are projected to occur in the Willamette basin, and it should be stressed that it is the trajectory of land use development to accommodate population growth that will have the largest influence on LFTs for Chinook and steelhead. For example, Baker et al. (2004; see also related material of the Pacific Northwest Ecosystem Research Consortium[52]) noted that Willamette stakeholders did not see a plausible "futures scenario" where future landscape changes and environmental effects would be of the same magnitude as what occurred between the years 1850-1990. Rather, among three futures scenarios, future landscape changes reflect mostly "a shifting from past resource uses to new uses, rather than a substantial expansion of human use of land and water into relatively intact, natural ecosystems." However, significant differences in environmental attributes could occur at smaller scales among three different futures scenarios (Hulse et al. 2002), and under both a Plan Trend and Development scenario extended out to year 2050, there will be: 1) large increases in urbanized acres, water consumed in dry summers, miles of dry 2^{nd}-4^{th} order streams, and 2) decreases in conifer canopy cover, forested riparian areas, and indices of aquatic biota health.

[52] http://oregonstate.edu/dept/pnw-erc/

A key component of impacts on aquatic resources is the amount of future human population density in urban growth boundaries and in rural-residential areas (Figures 168 and 169 and Table 49 in Hulse et al. 2002). Greater expansion of urban and rural residential development will have a suite of impacts on water quality, fish passage, riparian and aquatic physical habitat, hydrology, and stormwater and wastewater management. Details of these impacts and how they affect watershed health and salmonid recovery in Oregon can be found in the extensive review of the IMST (2010).

5.4 Threats and Associated Limiting Factors for UWR Chinook and Steelhead Populations

The key and secondary LFTs that contribute to the current status of UWR Chinook and steelhead populations at each life stage and geographic location are shown in Tables 5-7 (Chinook) and 5-8 (steelhead), followed by a description of LFT codes in Table 5-9. These tables are intended to help scope the threats affecting all populations in the ESUs. Further details on the geographic locations are in Table 5-4. The subsections that follow (and LFT tables therein) provide population-specific[53] details of the LFTs.

[53] In the population subsections the abbreviation "CHS" represents spring Chinook salmon, and "STW" represents winter steelhead.

Table 5-7. Key and secondary LFTs to the recovery of all populations in the UWR Chinook ESU. Bolded codes are key concerns and non-bolded codes are secondary concerns. Codes are in Table 5-9. The codes for Clackamas Chinook are subordinate to the codes used for this population in the OrLCR Plan; the code usage here is for tracking purposes of the LFTs. Black cells indicate where life stage is not present. Abbreviations for populations are: Clackamas=CM, Molalla=MO, North Santiam=NS, South Santiam=SSA, Calapooia=CA, McKenzie=MK, Middle Fork Willamette= MF.

Threats	Population	Natal Subbasin (Tributaries and lakes within population area)							West-side tributaries	Mainstem Willamette (Above falls)			Estuary (Below Bonneville Dam and Willamette Falls)			Ocean
		Egg / Alevin	Fry	Summer parr	Winter parr	Smolt	Adult	Spawner	Parr	Parr	Smolt	Adult	Parr	Smolt	Adult	Sub-adult
Flood control/ hydropower Management	CM	7i	8a	8a; 9k	8a	**1a**	9k									
	MO															
	NS	**9b**, 7bc	**10d**			**1d**	**2b**, 2k						**5ab,7h,8a,10f** 9j			
	SSA	**9e**, 7d				**1e**	**2c**, 2l			**10d**						
	CA															
	MK	7e, 9g	**10d**			1b	**2d**									
	MF	**9f, 7f,** 7g				**1f**	**2e2m**									
Land Management	CM		8a	9ai	**8a,** 9hi	9hi							**5a** 8a,9ahi			
	MO	7a		**9ah,** 8a, 9i,10b			**8b, 9c**			9hi						
	NS			**9ah,** 8a, 9i			**2f**		8a	**9hi** 8a		9hi				
	SSA						**2g**									
	CA	7a		**9ah,** 8a, 9i,10b			**2h, 8b, 9c**									
	MK			8a, 9ahi						**8a, 9hi**						
	MF															
Other Species	CM												6e			
	MO															
	NS															
	SSA															
	CA															
	MK															
	MF															
Harvest Management	CM														11g	11a
	MO															
	NS															
	SSA															
	CA															
	MK															
	MF															
Hatchery Management	CM							**3a**					4a			
	MO															
	NS		6c													
	SSA															
	CA															
	MK		6cd													
	MF															

Table 5-8. Key and secondary limiting factors to the recovery of all populations in the UWR Steelhead DPS. Bolded codes are key concerns and non-bolded codes are secondary concerns. Codes are in Table 5-9. Abbreviations for populations are: Molalla=MO, North Santiam=NS, South Santiam=SSA, Calapooia=CA.

Threats	Population	Natal Subbasin (Tributaries and lakes within population area)								West-side tributaries	Mainstem Willamette (Above falls)			Estuary (Below Bonneville Dam and Willamette Falls)			Ocean
		Egg / Alevin	Fry	Summer parr	Winter parr	Smolt	Adult	Spawner	Kelt	Parr	Parr	Smolt	Adult	Parr	Smolt	Adult	Adult
Flood control/ hydropower Management	MO																
	NS	**10a,** 7bc, 9d	**10d**			**1d**	**2b**		2i			10d	**10c**		**5ab 7h, 8a, 10f,** 9j		
	SSA	**10e,** 7d, 9e				**1e**	**2c**		2j			10d	**10c**				
	CA											10d	**10c**				
Land Management	MO	7a	9ah, 10b 2a		**8a,** 9hi	9hi					9hi				**5a,** 8a, 9ahi		
	NS		9ah 10b 2a		**8a,** 9hi	9hi					**9hi,** 8a		9hi				
	SSA		9ah, 10b 2a		**8a,** 9hi	9hi											
	CA		9ah, 10b 2a		**8a,** 9hi	9hi		2h									
Other Species	MO														6e		
	NS																
	SSA		**6b**														
	CA																
Harvest Management	MO																
	NS																
	SSA																
	CA																
Hatchery Management	MO														4a		
	NS		**4c**					**3a**									
	NS			**4d**													
	SSA		**4c**														
	SSA			**4d**													
	CA																

Table 5-9. Codes used for summarizing UWR limiting factors in Tables 5-7 and 5-8 and subsection tables below.

Code	Limiting Factor	Specific Threat
1	Habitat access (impaired downstream passage of juveniles at water control facilities, leading to direct and delayed mortality)	a: due to Clackamas subbasin dams
		b: due to McKenzie subbasin dams
		d: due to NS subbasin dams
		e: due to SSA subbasin dams
		f: due to MF Willamette subbasin dams
2	Habitat access (impaired adult access to holding and spawning habitat due to migration barriers)	a: to wadeable streams from road crossings, small dams, and diversion structures
		b: to habitat above NS dams
		c: to habitat above SSA dams
		d: to habitat above McKenzie dams
		e: to habitat above MF Willamette dams
		h: to habitat above small Calapooia dams
2	Habitat access (impaired downstream passage of STW kelts at water control facilities, leading to direct and delayed mortality)	i: due to NS subbasin dams.
		j: due to SSA subbasin dams
2	Habitat access (lack of spawning opportunity due to pre-spawning mortality impacts associated with handling stresses at sorting facilities and altered hydrology/WQ below dams.	k: crowding below NS dams.
		l: crowding below SSA dams.
		m: crowding and high water temperatures below Middle Fork Willamette dams.
3	Population traits (impaired productivity and diversity)	a: hatchery fish interbreeding with wild fish on the spawning grounds.
4	Competition (due to hatchery programs)	a: out-of-basin competition due to high density of juvenile hatchery fish in the estuary from composite Columbia basin hatchery releases
		c: in-basin competition with naturally produced progeny of hatchery summer steelhead
		d: in-basin competition with residualized hatchery summer steelhead smolts
5	Food web (impaired growth and survival from changes to estuarine food web)	a: reduced macrodetrital inputs due to 1) Columbia Basin hydropower habitat effects (reservoirs, revetments, disposal of contaminated dredge material), and 2) floodplain development
		b: increased microdetrital inputs due Columbia Basin hydropower and flood control reservoirs
6	Predation (multiple sources)	b: (by native and non-native fish species that are not associated with hatchery programs). Documented abundance of largemouth bass in Green Peter reservoir. Emerging concern of pikeminnow, centrarchid, and walleye impacts in other reservoirs and warm water reaches
		c: (by non-ESU/DPS hatchery species-smolts). Hatchery summer steelhead releases within subbasins
		d: (by hatchery rainbow trout). Hatchery rainbow trout programs within subbasins
		e: (birds in estuary). Land use practices that create favorable conditions in estuary for Caspian terns and cormorants to prey on salmonid juveniles
7	Physical habitat quality	a: excessive fine sediment in natal basin due to non-flood control land

Code	Limiting Factor	Specific Threat
	(multiple sources)	use practices, leading to impaired incubation gravel.

Table 5-9. Continued.

Code	Limiting Factor	Specific Threat
7	Physical habitat quality (flood control/hydropower sources)	b: flood control operations that reduce peak flows, leading to streambed coarsening below North Santiam dams.
		c: impaired gravel recruitment leading to lack of incubation gravel below North Santiam flood control facilities
		d: flood control operations that reduce peak flows, leading to streambed coarsening below South Santiam dams.
		e: impaired gravel recruitment leading to lack of incubation gravel below McKenzie flood control facilities
		f: impaired gravel and wood recruitment leading to lack of incubation gravel below Middle Fork Willamette flood control facilities
		g: flood control operations that reduce peak flows, leading to streambed coarsening below Middle Fork Willamette dams.
		h: impaired fine sediment/sand recruitment and routing in the estuary due to trapping of sediments behind flood control/hydropower facilities .
		i: impaired gravel recruitment leading to lack of incubation gravel below Clackamas flood control/hydro facilities.
8	Physical habitat quality (impaired habitat complexity and diversity)	a: land use practices including stream cleaning, straightening and channelization, revetments, riparian area degradation, lack of large wood recruitment, and/or loss of floodplain connectivity and access to off-channel habitat.
		b: land use practices (non-hydro) resulting in loss of summer holding pools of sufficient depth and structure, aggravated by human harassment issues: contributing to high pre-spawn mortality, loss of off-channel and side channel areas for resting and feeding as a consequence of floodplain development and channelization and loss of seasonal and shallow rearing habitat due to dredging, filling and placement of culverts in streams..
9	Water quality/quantity (effects on temperature within subbasins)	a: high summer water temperatures due to water and land use practices that impair riparian condition shading function, or practices that reduce summer streamflows (e.g., water withdrawals for agricultural, industrial, or municipal uses: leading to reduced growth and survival of juveniles.
		b: elevated fall water temperature below NS flood control facilities due to flow alterations: leading to premature hatching/emergence of CHS produced below dams.
		c: elevated water temperatures throughout the adult migration and holding window due to water land use practices that impair riparian condition shading function, or practices that reduce streamflows (e.g., water withdrawals for agricultural, industrial, or municipal uses, high temperatures and exposure to contaminants in urban areas such as the lower Willamette River.) contributing to poor adult condition and high pre-spawn mortality.
		d: decreased winter/spring water temperatures below NS flood control facilities due to flow alterations: impeding hatching/emergence of STW produced below dam.
		e: elevated fall water temperature below SSA flood control facilities due to flow alterations: leading to premature hatching/emergence of CHS produced below dams.

Code	Limiting Factor	Specific Threat
		k: elevated spring and summer water temperatures in the Clackamas subbasin due to reservoir heating at large hydroelectric facilities.
9	Water quality (input of toxins)	h: Non-point sourcing of inputs of agricultural chemicals used throughout the Columbia and Willamette river basins
9	Water quality (input of toxins)	i: Point and non-point sourcing of runoff and lack of treatment from urban, industrial, rural and agricultural practices, including presence of legacy contaminants in sediments downstream of industrial and urban areas.
9	Water quality (effects on temperature outside of subbasins)	j: elevated spring water temperatures in the estuary due to reservoir heating at large Columbia mainstem hydro facilities.
10	Hydrograph/water quantity (altered hydrology below dams)	a: Elevated flows during fall and winter from operations of North Santiam flood control/hydropower dams, and subsequent dewatering of steelhead redds below dams.
10	Hydrograph/water quantity (altered hydrology below dams)	c: reduced mainstem Willamette flows due to spring reservoir filling at subbasin flood control facilities: leading to increased water temperature and subsequent disease vulnerability.
10	Hydrograph/water quantity (altered hydrology below dams)	d: reduced occurrence of peak flows that maintain and create habitat; resulting in decreased channel complexity and habitat diversity in lower subbasins and mainstem Willamette River.
10	Hydrograph/water quantity (altered hydrology below dams)	e: elevated flows during fall and winter from operations of South Santiam flood control/hydropower dams, and subsequent dewatering of steelhead redds below dams
10	Hydrograph/water quantity (altered hydrology below dams)	f: operations at Columbia Basin hydropower dams that modulate flow and sourcing of materials, leading to degraded estuarine conditions such as impaired access to off-channel habitat, creation or maintenance of estuarine habitat, altered plume dynamics, and changes in the food web structure and function.
10	Hydrograph/water quantity (insufficient stream flows and floodplain storage from land use practices)	b: water withdrawals leading to insufficient stream flows, resulting in reduced habitat availability and impaired water quality.
11	Population traits	a: Mortality from targeted fishery
11	Population traits	g: Mortality due to gill net bycatch

5.4.1 Factors and Threats Limiting Viability of Clackamas Chinook

The following descriptions of the LFTs are specific to the Clackamas Chinook salmon population. Table 5-10 summarizes the key and secondary LFTs to recovery of the population at different life stages and locations, and the subsequent LFT descriptions in text are organized in a similar fashion. The LFTs for Clackamas spring Chinook were identified as part of the development of the OrLCR Plan (ODFW & NMFS 2010).

Table 5-10. The key and secondary LFTs to the recovery of the Clackamas Chinook salmon population. The LFTs are organized by limiting factor (column 1), within which the general threat categories are nested (column 2). Life stages are organized by three general life history modes (row 1), geographic areas where those modes are expressed (row 2), and specific life stage within that geographic area where the LFT is having an impact (row 3). Bolded codes are key concerns and non-bolded codes are secondary concerns. Codes are further defined in Table 5-9. Stippled cells indicate geographic areas where the population does not occur or life stage is not expressed (e. g. kelts for Chinook salmon).

Clackamas Spring Chinook		Rearing and Downstream Migration											Marine Foraging	Upstream Migration and Spawning		
		Natal Subbasin						Mainstem Willamette		West-side Tribs	Estuary		Ocean	Estuary	Mainstem Willamette	Natal Subbasin
Limiting Factor	**General Threat Category**	**Egg / Alevin**	**Fry**	**Summer Parr**	**Winter Parr**	**Smolt**	**Kelt**	**Parr**	**Smolt**	**Parr**	**Parr**	**Smolt**	**sub-adult/ Adult**	**Adult**	**Adult**	**Adult and Spawner**
Habitat Access	Flood Control/ Hydropower					**1a**										
Physical Habitat Quality	Flood Control/ Hydropower	7i	8a								**5ab,7h,8a**					
	Land Use		8a		**8a**						**5a,** 8a					
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower			9k							**10f,** 9j					9k
	Land Use			9ai	9hi						9ahi					
Predation	Land Use / Introductions										6e					
	Hatchery Management															
Competition	Land Use / Introductions															
	Hatchery Management										4a					
Population Traits	Hatchery Management															3a
	Harvest												11a	11g		

Habitat Access

Impaired downstream passage (1a). [Code 4b in the OrLCR Plan.].

Flood Control/Hydropower Management. *<u>Key threat</u>: CHS smolts.*

For juvenile Chinook salmon produced above the Portland General Electric (PGE) hydropower facilities, impaired downstream passage past these facilities the is a key concern for the Clackamas spring Chinook population. Mortality of juveniles migrating downstream occurs at North Fork Dam, Faraday Powerhouse and River Mill Dam. In a DEIS for the Clackamas Hydro Project, it was estimated the current average mortality for smolts passing through the hydro complex was 24.6% for Chinook (FERC 2006).

Physical Habitat Quality

Impaired gravel recruitment (7i). [Code 6d in the OrLCR Plan.].

Flood Control/Hydropower Management. Secondary threat: CHS eggs-alevins[54]

Impaired gravel recruitment behind dams affects Chinook spawning habitat quality in the Clackamas River. A geomorphic analysis of the Clackamas River downstream of River Mill Dam shows that gravel recruitment is impaired in the two-mile reach below River Mill Dam (Wampler and Grant 2003). Sediment trapping by the dams has resulted in coarsening of the grain size, channel incision and erosion of margin deposits.

Impaired habitat complexity and diversity of off-channel habitats (8a). [Code 6e in the OrLCR Plan.].

Flood Control/Hydropower Management. Secondary threat: CHS multiple juvenile freshwater life stages (subbasin). Key threat: juveniles (estuary).

Subbasin: Degraded rearing and migration habitat conditions in the lower Clackamas River subbasin resulting from development and operations of the PGE hydroelectric facilities pose a secondary concern to juvenile stages of the Clackamas spring Chinook population. It also reduced physical habitat complexity and diversity in the subbasin, in part by reducing the amount of large wood delivered to the lower subbasin. Project development and operations also inundated historical spawning and rearing habitats in the upper subbasin.

Estuary: In the Columbia River estuary, impaired physical habitat quality is due in part to altered flows related to hydroelectric development in the Columbia River Basin, and it presents a key threat to juvenile Clackamas spring Chinook. Altered flows changed estuarine habitat and plume conditions, and impaired access to off-channel habitat. Changes in the hydrograph have altered the natural pattern of flows over the seasons, causing inadequate flow, scouring flow, or other flow conditions. These changes affected habitat-forming processes and contributed to the loss of peripheral wetland, off-channel habitat and side channel habitat in the Columbia River estuary, including the lower Willamette River.

Land Use Management. Key threat: CHS winter parr (subbasin). Secondary threat: CHS fry (subbasin); CHS parr and smolts (estuary)

Subbasin: Impaired physical habitat quality due to stream cleaning, straightening and channelization, diking, wetland filling, and lack of large wood recruitment is a key concern for Clackamas spring Chinook winter parr and a secondary concern for fry. Changes in riparian condition, loss of large wood in tributary streams and the Clackamas River, and modified in-channel and side channel habitats limit Chinook production. The straightening and restricting of the stream channels has decreased channel complexity and connectivity to side channels and other off-channel areas that historically provided important overwintering habitat for juvenile Chinook. Several roads along streams in the upper Clackamas subbasin restrict and impinge on channel dynamics and also impact habitat quality (NPCC 2004). In the lower Clackamas subbasin, diking and channelization have

[54] The Planning Team for the OrLCR Plan identified this LFT as a concern for spring Chinook spawners in the Clackamas system. The Planning Team for the UWR Plan considers it a concern for spring Chinook eggs and alevins.

restricted the stream channel and reduced connectivity between the river and the floodplain (NPCC 2004).

Estuary: Degraded habitat quality in the lower Willamette River also impacts the population. Loss of habitat diversity and key habitat has resulted from channelization, the loss of wood and other structure, and elimination of much of the shallow water habitat. The loss of this historical habitat diversity and complexity in the lower Willamette River has reduced the amount of juvenile rearing habitat available in the reach for Clackamas Chinook (NPCC 2004).

In the lower Columbia River estuary, including the lower Willamette River, historically complex habitats have also been modified. Historically the estuary contained rich habitat for salmonid growth and survival, including a close proximity to high-energy areas with ample food availability and sufficient refuge habitat. Today many once important habitat areas in the estuary have been affected by land and water management activities. Complex habitats have been modified through channelization, diking, development and other practices. Jetties, pile dikes, tide gates, docks, breakwaters, bulkheads, revetments, seawalls, groins, ramps and other structures have changed circulation patterns, sediment deposition, sediment erosion, and habitat formation in the estuary (Williams and Thom 2001).

Together, habitat alteration through dredging, disposal of sand/gravel, wetland filling, instream and overwater structures, dikes and navigational structures have significantly altered estuary size/function, and reduced connectivity with peripheral wetland and side channel habitat. As a result of these changes, the surface area of the estuary has decreased by approximately 20% over the past 200 years (Fresh et al. 2005). This loss of access to historical spawning and rearing habitats has restricted the populations to sometimes sub-optimal habitat.

Impaired food web. Reduced macrodetrital input in the estuary due to Columbia Basin hydropower reservoir, and disposal of dredge material and other land use (5a). [Code 3a in the OrLCR Plan.]

Flood Control/Hydropower and Land Use Management. <u>Key threat</u>: CHS juveniles (estuary)

Reduced macrodetrital-based input in the Columbia River estuary affects the viability of the Clackamas Chinook population. Historically, the estuarine food web was based primarily on a large macrodetrital component, derived from course plant materials that originated from the floodplain and other zones in the in the estuary. As such, the food web was broad-based, seasonally dynamic, and distributed throughout the estuary. The basal features of the food web are much different today, primarily due to changes in flow patterns, loss of wetland and side channel habitat that reduced floodplain inputs, combined with channel alterations that changed saltwater intrusion patterns and interrupted nutrient cycles. Today, detrital sources from emergent wetlands in the estuary are approximately 84% less than they were historically (Bottom et al. 2005), and the shift from a macrodetritus-based source to a microdetritus-based source has lowered the productivity of the estuary.

Impaired food web. Increased microdetrital input due to Columbia Basin hydropower reservoirs (5b). [Code 3b in the OrLCR Plan.]

Flood Control/Hydropower. <u>Key threat</u>: CHS juveniles (estuary)

The estuary's current food web is microdetrital-based, made up of decaying phytoplankton delivered from upstream reservoirs. The substitution of this microdetrital-based food web for the historic macrodetrital-based web reduces Chinook productivity in the estuary. Unlike the historic macrodetritus-based food web, which was distributed evenly throughout the estuary, the contemporary microdetrital food web is concentrated within the estuarine turbidity maximum, an area in the middle region of the Columbia River estuary where circulation traps higher levels of suspended particulate material (Bottom et al. 2005). The estuarine turbidity maximum is thought to contain bacteria that attach to detritus. Together, these represent the primary food source in the estuary today (LCREP 2004).

Impaired sediment/sand routing (7h). [Code 6c in the OrLCR Plan.]

Flood Control/Hydropower. Key threat: CHS juveniles (estuary)

Changes in hydrology have impaired the routing and recruitment of fine sediment and sands. This change has contributed to impaired physical habitat quality in the estuary; and therefore constitutes a key impact on Clackamas Chinook. The force of historical spring freshets in the Columbia River moved sand into the estuary where it helped form shallow-water habitats that are thought vital for juvenile salmonids (LCREP 2006). Today, due to changes in hydrology and sequestering of sediment behind hydropower dams, spring freshet flows have been altered and sand discharge into the Columbia River estuary has been reduced to 70% of nineteenth-century levels (Jay and Kukulka 2002). The magnitude of change in sand transport contributed to changes in habitat forming processes. It also likely reduced turbidity, leaving juvenile fish more exposed to avian and fish predators.

Water Quality / Quantity / Hydrograph

Water quality. Elevated summer water temperature from land use practices (9a). [Same code in the OrLCR Plan.]

Land Use Management. Secondary threat: CHS

Subbasin: High summer water temperatures are considered a secondary concern for Clackamas spring Chinook. EDT results identify summer water temperature in the Clackamas subbasin as limiting summer rearing for juvenile spring Chinook (NPCC 2004). The high water temperatures are primarily the result of decreased riparian forest in the tributaries and the mainstem Clackamas River, ponding in reservoirs behind the hydroelectric dams, and other upriver factors. Riparian and upslope conditions in the lower Clackamas subbasin have only a minor impact on the elevated temperatures conditions (NPCC 2004).

Estuary: In the Columbia River estuary, land use practices that degraded riparian conditions or reduced streamflows have contributed to elevated water temperatures. In conjunction with water withdrawals, elevated stream temperatures often exist because of a lack of intact, functional and contiguous riparian management zones and sufficient streamside buffers. Channel widening may also be a contributing factor.

Water quality. Elevated spring and summer water temperatures in the Clackamas subbasin due to reservoir heating at large hydroelectric facilities (9k). [Code 9b in the OrLCR Plan.]

Flood Control/Hydropower. Secondary threat: CHS summer parr and adults

Water impoundment in reservoirs above Clackamas hydropower dams results in solar heating and elevated river water temperatures below these hydropower facilities. The warmer water temperatures in the lower Clackamas River limit juvenile spring Chinook summer rearing (NPCC 2004). High temperatures are also a concern for spring Chinook adults in the lower subbasin as they migrate into and hold over summer in this area.

Water quality. Elevated water temperatures in the estuary due to reservoir heating at large *hydropower reservoirs in the Columbia Basin (9j). [Code 9b in the OrLCR Plan.]*

Flood Control/Hydropower. Secondary threat: CHS juveniles

Elevated water temperatures in the estuary due to reservoir heating in the Columbia Basin pose a secondary threat to Clackamas spring Chinook. Flow regulation and reservoir construction on the Columbia have caused average water temperatures to increase. Water quality measurements at Bonneville Dam indicate that periods of increased temperatures are lasting longer than they did historically (National Research Council 2004). Current average and maximum values of Columbia River water temperatures are well above 20° C, which approaches the upper limits of thermal tolerance for cold-water fishes such as salmon (National Research Council 2004). Altered water temperatures can affect migration of Chinook destined to headwater holding and spawning areas. Cool temperatures in the winter can delay migration, warm summer temperatures can increase susceptibility to disease.

Water quality. Toxins from urban and industrial sources (9i). [Code 9d in the OrLCR Plan.]

Land Use Management. Secondary threat: CHS juveniles in subbasin and estuary

Toxic contaminants from urban and industrial practices reduce habitat quality for spring Chinook parr and smolts. Toxic contaminants are a problem in the lower Willamette River and other sites of intense urban or industrial development. An intensive study of sediments in Portland Harbor (the stretch of the Willamette River from Sauvie Island to the Fremont Bridge) has reported pesticides, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbon (PAHs), and other chemicals at levels that exceed State and Federal sediment quality screening levels, and are harmful to the ecosystem.[55]

The Columbia River downstream of Bonneville Dam is the most urbanized stretch in the entire basin. In a study by Loge et al. (2005), cumulative delayed disease-induced mortalities were estimated at 3 percent and 18 percent for juvenile Chinook residing in the Columbia River estuary for 30 to 120 days, respectively, with about 50 percent of that mortality estimated to be due to effects of toxic contaminants such as PCBs and PAHs. Generally studies have shown that PCB and PAH concentrations in salmon and their prey in the lower Columbia and lower Willamette are comparable to those in organisms in other moderately to highly urbanized areas (Fresh et al. 2005; LCREP 2007; Johnson et al. 2007), and in some cases are above estimated threshold levels for toxic effects (et al. 2002, 2006, 2008). Trace metals, PCBs, dioxins, PAHs, and other compounds have been detected in this reach of the estuary (Fresh et al. 2005), and the U.S. Environmental Protection Agency has identified several PCB and DDT hot spots within the estuary, including near Longview, West Sand Island, the Astoria Bridge, and Vancouver (Fresh et al. 2005; Hayslip et al. 2006). Copper, used in brake pads for motor vehicles and often found in stormwater samples, has also been measured in the estuary at concentrations shown to interfere with the olfactory function in salmon (Baldwin et al. 2003; Sandahl et al. 2007; LCREP 2007). The Portland and Vancouver sewage treatment plants are large sources of effluent in this area (Fresh et al. 2005). Contaminants from industrial point sources and urban stormwater runoff in the area also affect water quality (USEPA 2009). Some contaminants are also transported downstream to the estuary from areas above Bonneville Dam and Willamette Falls..

Water quality. Toxins from agricultural pesticide sources (9h). [Code 9c in the OrLCR Plan.]

Land Use Management. Secondary threat: CHS juveniles in subbasin and estuary

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[55] http://yosemite.epa.gov/r10/cleanup.nsf/sites/ptldharbor.

Contaminants from agricultural practices found throughout the Columbia River estuary pose a threat to Clackamas spring Chinook. The U.S. Geological Survey's National Stream Quality Accounting Network program reported that a wide range of commonly used pesticides have been detected at sampling sites near Bonneville Dam and at the confluence of the Willamette and Columbia rivers (LCREP 2007a,b; Fresh et al. 2005). Detected water-soluble pesticides include simazine, atrazine, chlorpyrifos, metolachlor, diazinon, and carbaryl. Short-term exposure to these types of pesticides at environmentally relevant concentrations has been associated with disruption of olfactory function in salmonids; leading to difficulty in homing, predator avoidance, and finding prey (Scholz et al. 2000; Sandahl et al. 2002, 2005; Tierney et al. 2008). Moreover, mixtures of some of these pesticides (e.g., malathion and diazinon or chlorpyriphos) may be acutely lethal to salmonids (Laetz et al. 2009). Certain trace metals, such as lead and arsenic, have also been introduced to the environment through pesticides, such as lead arsenate, which is used as an insecticide for apples (Fresh et al. 2005). Additionally, a number of chlorinated pesticides, including dichlorodiphenyltrichloroethanes (DDTs), chlordanes, and endosulfans, are still present in soils and sediments in the Columbia Basin, even though they were banned in the United States in the 1970s (USEPA 2009). These compounds have been observed in tissues and stomach contents of juvenile Chinook salmon from the lower Columbia River and estuary and, in some cases, DDTs have accumulated in salmon tissues to concentrations above estimated toxic effects thresholds (Beckvar et al. 2005; Johnson et al. 2007)

Hydrology/water quantity. Altered hydrology from Columbia Basin hydroelectric operations (10f). [Code 5b in the OrLCR Plan.]

Flood Control/Hydropower. Key threat: CHS

Management of the Columbia River hydropower system alters the timing and magnitude of spring freshets, and thereby contributes to impairment of habitat quality and access in the estuary. Reduction of maximum flow levels, along with deposit of dredged material and diking, has all but eliminated overbank flows in the Columbia River (Bottom et al. 2001). The loss of overbank flows has restricted access to off-channel areas that historically contained seasonal wetlands and forested backwaters, and has also reduced large woody debris recruitment to the estuary and contributed to a change in food web structure and function. Artificial regulation of flow, especially rapid diurnal flow fluctuations, can strand juveniles in shallow water areas.

Predation

Predation by birds in the estuary due to land use practices (6e). [Code 8b in the OrLCR Plan.]

Land Use Management. Secondary threat: CHS juveniles

Modification of estuarine habitats has increased the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species in the Columbia River estuary (LCREP 2006; Fresh et al. 2005). For example, new islands formed through the disposal of dredged materials have attracted terns away from traditional habitats, especially those that are degraded. The new islands are often well-positioned for terns preying on migrating salmonids. 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. For this reason, the USACE began reducing the area available for tern nesting in 1999, and under the 2008 FCRPS RPA (action 45), has further reduced available area (to 1.5 to 2 acres by 2010). The USACE is also examining the feasibility of reducing predation levels of double-crested cormorants (RPA action 46), which consume a large number of juvenile salmonids (approximately 3.6 million juveniles) from their East Sand Island nesting grounds (Collis and Roby 2006).

Competition

Competition with hatchery fish in the estuary (4a). [Code 1a in the OrLCR Plan.]

Hatchery Management. Secondary Threat: CHS

Competition with hatchery fish from all Columbia River hatcheries for limited habitat and food supplies in the Columbia River estuary affects productivity of the Clackamas spring Chinook population. In recent years, approximately 1.7 million adult salmon and steelhead have returned annually to the Columbia River. To achieve these returns, an estimated 200 million juveniles are produced each year, 50-95% of which are of hatchery origin, depending on the species (LCREP 2006; CBFWA 1990; Genovese and Emmett 1997 as cited in Bottom et al. 2005). Hatchery fish are often released within a short period of time, causing large pulses of hatchery fish that ultimately compete with naturally produced fish for limited habitat and associated resources in the estuary at key times. This can result in stressors that translate into reduced salmonid survival (LCREP 2006). Hatchery fish are often larger than naturally produced counterparts, and may have a competitive advantage. This competition may result in density-dependent mortality for natural origin fish, limiting the number that can enter the plume. The intensity and magnitude of competition, however, has not been quantitatively documented and depends in part on when hatchery and natural juvenile salmonids enter the estuary and how long they stay.

Population Traits

Loss of population traits due to mortality from targeted fisheries (11a). [Code 7a in the OrLCR Plan.]

Harvest Management. Secondary threat: CHS sub-adults (ocean, estuary)

Incidental or direct mortality from targeted ocean troll fisheries poses a secondary threat to Clackamas spring Chinook. The spring Chinook population is exposed to ocean fisheries off the coast of Washington and as far north as Alaska. The harvest impact on the wild component population from ocean and mainstem Columbia fisheries, as well as those that occur in the Clackamas, has averaged about 25% in recent years[56].

Loss of population trait due to indirect mortality from gill net bycatch (11g). [Code 7b in the OrLCR Plan.]

Harvest Management. Secondary threat: CHS adults (estuary)

Incidental catch and mortality from gill net fisheries targeting other stocks in the Columbia River estuary also threatens the viability of Clackamas spring Chinook. The gill net fishery targets hatchery produced spring Chinook, but incidentally catches wild spring Chinook.

Loss of population traits due to hatchery fish interbreeding with wild fish on spawning grounds (3a). [Code 7c in the OrLCR Plan.]

Hatchery Management. Secondary threat: CHS adults (subbasin)

[56] Limiting factors and threats for this population were identified during the planning process for the OrLCR Plan. Harvest was identified as a key concern for a population if the estimated average harvest rate was 35% or higher, and as a secondary concern if it was between 10-35%. As this impact is currently estimated at 25%, targeted fishery and bycatch mortality was identified as secondary concern.

Hatchery fish interbreeding with wild fish on natural spawning grounds can lead to genetic introgression and other attributes that compromise genetic diversity and other population traits, and presents is a key concern for Clackamas spring Chinook. Hatchery fish comprise an estimated 42% (average) of the spring Chinook on natural spawning areas in the Clackamas basin[57].

[57] Limiting factors and threats for this population were identified during the planning process for the OrLCR Plan. Hatchery strays are identified as a key concern for a population if the estimated percentage of hatchery fish on local spawning grounds has likely averaged 30% or higher, and as a secondary concern if the proportion averaged between 10-30%.

5.4.2 Factors and Threats Limiting Viability of Molalla Chinook and Steelhead

The following descriptions of the LFTs are specific to the Molalla Chinook salmon and steelhead populations. Tables 5-11 and 5-12 summarize the key and secondary LFTs to recovery of the populations at different life stages and locations, and subsequent LFT descriptions are organized in a similar fashion. Harvest is not considered a key or secondary threat at any life stage of Mollala Chinook or steelhead populations.

Table 5-11. The key and secondary LFTs to the recovery of the Molalla Chinook salmon population. See caption in Table 5-10 for explanation table organization, LFT bolding, cell shading and cell patterning. Codes are further defined in Table 5-9.

Molalla Spring Chinook		**Rearing and Downstream Migration**											**Marine Foraging**	**Upstream Migration and Spawning**		
		Natal Subbasin						**Mainstem Willamette**		**West-side Tribs**	**Estuary**		**Ocean**	**Estuary**	**Mainstem Willamette**	**Natal Subbasin**
Limiting Factor	**General Threat Category**	**Egg / Alevin**	**Fry**	**Summer Parr**	**Winter Parr**	**Smolt**	**Kelt**	**Parr**	**Smolt**	**Parr**	**Parr**	**Smolt**	**sub-adult/ Adult**	**Adult**	**Adult**	**Adult and Spawner**
Habitat Access	Flood Control/ Hydropower															
Physical Habitat Quality	Flood Control/ Hydropower										**5ab,7h,8a**					
	Land Use	7a	8a		**8a**						**5a,** 8a					**8b**
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower										**10f,** 9j					
	Land Use			**9ah,** 9i, 10b	9hi						9ahi				9hi	**9c**
Predation	Land Use / Introductions										6e					
	Hatchery Management															
Competition	Land Use / Introductions															
	Hatchery Management										4a					
Population Traits	Hatchery Management															**3a**
	Harvest															

Table 5-12. The key and secondary LFTs to the recovery of the Molalla steelhead population. See caption in Table 5-10 for explanation table organization, LFT bolding, cell shading and cell patterning. Codes are further defined in Table 5-9.

Molalla Winter Steelhead		Rearing and Downstream Migration											Marine Foraging	Upstream Migration and Spawning		
		Natal Subbasin						Mainstem Willamette		West-side Tribs	Estuary		Ocean	Estuary	Mainstem Willamette	Natal Subbasin
Limiting Factor	**General Threat Category**	**Egg / Alevin**	**Fry**	**Summer Parr**	**Winter Parr**	**Smolt**	**Kelt**	**Parr**	**Smolt**	**Parr**	**Parr**	**Smolt**	**sub-adult/ Adult**	**Adult**	**Adult**	**Adult and Spawner**
Habitat Access	Flood Control/ Hydropower															
Physical Habitat Quality	Flood Control/ Hydropower											**5ab,7h 8a**				
	Land Use	7a	2a		**8a,** 2a	2a						**5a,** 8a				2a
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower											**10f,** 9j				
	Land Use		9ah, 10b		9hi			9hi				9ahi			9hi	
Predation	Land Use / Introductions											6e				
	Hatchery Management															
Competition	Land Use / Introductions															
	Hatchery Management											4a				
Population Traits	Hatchery Management															**3a**
	Harvest															

Habitat Access

Habitat access. Impaired access to wadeable streams due to barriers (2a).

Land Use Management. Secondary threat: STW multiple life stages

Small dams, irrigation diversions, road crossings and other passage impediments related to land use restrict juvenile and adult steelhead access to habitat on wadeable-sized tributaries.

Physical Habitat Quality

Physical habitat quality. Excessive fine sediment (7a)

Land Use Management. Secondary threat: CHS, STW

Subbasin channels in the lower Molalla River, particularly near the city of Molalla (RM 20), and in some tributaries have been simplified through revetments, roads, riprap and other actions that restrict channel movement. High erosion and destabilized stream banks release excess sediment, causing turbid water and silt deposits that harm aquatic life and violate water quality standards.

Impaired habitat complexity and diversity, off-channel habitats (8a)

Land Use Management. <u>Key threat</u>: CHS, STW winter parr; <u>Secondary threat</u>: CHS fry, summer parr; CHS, STW (estuary)

Subbasin: Habitat degradation is considered the primary factor limiting future production and recovery of the Chinook population in the Molalla River. Impaired physical habitat degrades rearing potential for the winter parr life stage of both species. Aquatic habitat in the forested upper Molalla/Pudding subbasin remains closer to the historical baseline, with the highest proportion of functioning riparian areas, the largest amounts of large wood in the river and tributary channels, and higher quality aquatic habitats.

Historical and, in some place continued, wood removal from streams and riparian harvest has reduced large wood in the channels, though riparian areas in the forested upper subbasin have more conifer trees than in the lower subbasin. Reduced wood in stream channels limits pool formation, thus reducing hiding areas for adult fish and restricting the quality and quantity of juvenile rearing habitat. There has also been an extensive loss of wetlands throughout the subbasin. Loss of connectivity to floodplain and wetland habitats has affected juvenile rearing and refuge habitat, particularly in the lower subbasin. Backwater habitats, including pool margins, side channels and alcoves, are below historical levels (WRI 2004).

Channels in the lower Molalla River, particularly near the city of Molalla (RM 20), and in some tributaries have been simplified through revetments, roads, riprap and other actions that restrict channel movement. High erosion and destabilized stream banks release excess sediment, causing turbid water and silt deposits that harm aquatic life and is a contributing source to the exceedence of water quality standards. Revetments have also simplified channels throughout the lower Pudding River and tributaries. Actions to stabilize the lower river through the placement of riprap along banks (and other actions) and limited large wood in the channel have also interacted to reduce the quantity and quality of backwater habitats (WRI 2004).

Estuary: The limiting factors in the estuary are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Flood Control/Hydropower Management. <u>Key threat</u>: CHS and STW juveniles (estuary).

The limiting factors in the estuary associated with flood control/hydropower are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired food web. Reduced macrodetrital input in the estuary due to Columbia Basin hydropower reservoir, and disposal of dredge material and other land use (5a).

Flood Control/Hydropower and Land Use Management. <u>Key threat</u>: CHS and STW juveniles (estuary)

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired food web. Increased microdetrital input due to Columbia Basin hydropower reservoirs (5b).

Flood Control/Hydropower. <u>Key threat</u>: CHS and STW juveniles (estuary)

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired fine sediment and sand recruitment and routing (7h).

Flood Control/Hydropower. Key threat: CHS and STW juveniles (estuary)

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Loss of summer holding pools (8b)

Land Use Management. Key threat: CHS adults

Loss of holding pools, which provided cover and relief from high water temperatures, increases pre-spawning mortality of adult Chinook. Loss of wetland, floodplain and off-channel habitats has affected the quantity and quality of adult holding areas. Habitat degradation has also reduced availability of suitable Chinook spawning areas in the Molalla.

Water Quality / Quantity / Hydrograph

Water quality. Elevated summer water temperature from land use practices. (9a)

Land Use Management. Key threat: CHS juveniles (subbasin); Secondary Threat: STW juveniles (subbasin and estuary) and CHS juveniles (estuary)

Subbasin: Elevated water temperatures from land use practices decrease survival and/or growth of juvenile Chinook and steelhead. High water temperatures are common in the lower Molalla subbasin and are aggravated by loss of riparian cover, reduced wetland areas, channel simplification and increased impervious surfaces (WRI 2004). The stretch of the Molalla River from the mouth to RM 48.2 is included on the State 303(d) list for water temperature impairment (ODEQ 2006).

Water temperatures also exceed water quality criteria throughout the Pudding drainage. The Pudding River from the mouth to RM 61.7 is included on the State 303(d) list for water temperature impairment (ODEQ 2006). Water temperatures are elevated in many of the tributaries, particularly in the lower subbasin. In the Pudding River, low summertime flows contribute to concentrating nonpoint-source runoff (toxics and nutrients) and aggravate naturally higher water temperatures. Nutrient and toxic runoff, along with erosion of sediment containing legacy pesticides and background concentrations of iron, from agricultural and urban areas is also an issue in the Pudding drainage (WRI 2004).

Estuary: Effects from elevated water temperatures in the Columbia River estuary are the same as those discussed in for Clackamas Chinook in Section 5.4.1.

Water quality. Elevated water temperature from land uses, leading to prespawning mortality (9c)

Land Use Management. Key threat: CHS adults

Elevated water temperatures during the late spring and early summer associated with LFTs 8a (habitat modification) and 10b (insufficient stream flows) contribute to poor adult condition and increase pre-spawning mortality of adult Chinook in the Molalla River system.

Water quality. Toxins from agricultural pesticide sources (9h).

Land Use Management. Key threat: CHS summer parr; Secondary threat: CHS and STW juveniles in subbasin, juveniles and adults in the mainstem Willamette, and juveniles in the estuary

Threats in the estuary are the same as those described for Clackamas Chinook in Section 5.4.1. Several members of the Planning Team indicated that UWR populations were exposed to these toxins within the subbasin and to some extent in the mainstem Willamette River as well. Several subbasin stream reaches are listed as 303 (d) streams for pesticides (see Table 4-2 in the Molalla/Pudding Subbasin TMDL report, ODEQ 2008[58]), and past monitoring has found a suite of pesticides and other pollutants in surface waters (Wentz et al. 1998[59]).

Water quality. Toxins from urban and industrial sources (9i).

Land Use Management. Secondary threat: CHS and STW juveniles in subbasin, juveniles and adults in the mainstem Willamette, and juveniles in the estuary

Threats in the estuary are the same as those described for Clackamas Chinook in Section 5.4.1. Although the subbasins and upper mainstem Willamette River have less dense urbanization and industrial development than the Portland metro area, UWR Chinook and steelhead are exposed to some extent to some or all of these toxins in the subbasin and mainstem Willamette during rearing and migration .

Hydrograph/water quantity. Insufficient stream flows (10b)

Land Use Management. .Secondary threat: CHS and STW juveniles

Naturally low summertime flows in the lower Pudding drainage are aggravated by water withdrawals, channelization of tributaries, and modification of runoff patterns as a result of agriculture, impervious surfaces, and urban/residential development. In addition, a loss of storage capacity in floodplains and wetlands, particularly in the Pudding drainage, has accelerated runoff and increased peak flows. Small diversions, ditches, and drainage tiling in the lower subbasin have reduced storage capacity, contributing to flashy peak flows and lower flows during the summer and early fall (WRI 2004).

Water quality. Elevated water temperatures in the estuary due to reservoir heating at large hydropower reservoirs in the Columbia Basin (9j).

Flood Control/Hydropower. Secondary threat: CHS and STW juveniles

Threats in the estuary are the same as those described for Clackamas Chinook in Section 5.4.1.

Hydrology/water quantity. Altered hydrology in the estuary (10f).

Flood Control/Hydropower. Key threat: CHS and STW juveniles

Predation

Predation by birds in the estuary due to land use practices (6e).

Land Use Management. Secondary threat: CHS and STW juveniles

The limiting factors in the estuary are the same as those described for Clackamas Chinook in Section 5.4.1.

Competition

Competition with hatchery fish in the estuary (4a).

Hatchery Management. Secondary Threat: CHS and STW juveniles

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[58] http://www.deq.state.or.us/wq/TMDLs/docs/willamettebasin/MolallaPudding/MoPudChapter4Pesticides.pdf
[59] http://pubs.usgs.gov/circ/circ1161/circ1161.pdf

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Population Traits

Loss of population traits due to hatchery fish interbreeding with wild fish on spawning grounds (3a).

Hatchery Management. Key threat: CHS and STW adults (subbasin)

Hatchery fish interbreeding with wild Molalla populations presents a significant risk of genetic introgression and associated loss in VSP attributes. About 100,000 Chinook smolts from South Santiam Hatchery are released annually into the Molalla. These fish represent about 90% of the naturally spawning adults. Few redds have been observed from natural or hatchery fish. There is current no hatchery steelhead releases in the basin, but there is a potential risk from out-of-ESU summer steelhead (broodstock program from the South Santiam) straying into the subbasin.

5.4.3 Factors and Threats Limiting Viability of North Santiam Chinook and Steelhead

The following descriptions of the LFTs are specific to the North Santiam Chinook salmon and steelhead populations. Tables 5-13 and 5-14 summarize the key and secondary LFTs to recovery of the populations at different life stages and locations, and subsequent LFT descriptions are organized in a similar fashion. Harvest is not considered a key or secondary threat at any life stage of North Santiam Chinook or steelhead populations.

Table 5-13. The key and secondary LFTs to the recovery of the North Santiam Chinook salmon population. See caption in Table 5-10 for explanation table organization, LFT bolding, cell shading and cell patterning. Codes are further defined in Table 5-9.

North Santiam Spring Chinook		Rearing and Downstream Migration											Marine Foraging	Upstream Migration and Spawning		
		Natal Subbasin						Mainstem Willamette		West-side Tribs	Estuary		Ocean	Estuary	Mainstem Willamette	Natal Subbasin
Limiting Factor	**General Threat Category**	**Egg / Alevin**	**Fry**	**Summer Parr**	**Winter Parr**	**Smolt**	**Kelt**	**Parr**	**Smolt**	**Parr**	**Parr**	**Smolt**	**sub-adult/ Adult**	**Adult**	**Adult**	**Adult and Spawner**
Habitat Access	Flood Control/ Hydropower					**1d**										**2b,** 2k
Physical Habitat Quality	Flood Control/ Hydropower	7bc									**5ab,7h,8a**					
	Land Use		8a		**8a**			8a			**5a,** 8a					
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower	**9b**	**10d**					**10d**			**10f,** 9j					
	Land Use			**9ah,** 9i	9hi			**9hi**			9ahi				9hi	**2f**
Predation	Land Use / Introductions										6e					
	Hatchery Management		6c													
Competition	Land Use / Introductions															
	Hatchery Management										4a					
Population Traits	Hatchery Management															**3a**
	Harvest															

Table 5-14. The key and secondary LFTs to the recovery of the North Santiam steelhead population. See caption in Table 5-10 for explanation table organization, LFT bolding, cell shading and cell patterning. Codes are further defined in Table 5-9.

North Santiam Winter Steelhead		Rearing and Downstream Migration											Marine Foraging	Upstream Migration and Spawning		
		Natal Subbasin						Mainstem Willamette		West-side Tribs	Estuary		Ocean	Estuary	Mainstem Willamette	Natal Subbasin
Limiting Factor	General Threat Category	Egg / Alevin	Fry	Summer Parr	Winter Parr	Smolt	Kelt	Parr	Smolt	Parr	Parr	Smolt	sub-adult/ Adult	Adult	Adult	Adult and Spawner
Habitat Access	Flood Control/ Hydropower					**1d**	2i									**2b**
Physical Habitat Quality	Flood Control/ Hydropower	7bc										**5ab,7h 8a**				
	Land Use	7a	2a		**8a,** 2a	2a		8a				**5a,** 8a				2a
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower	**10a**, 9d	**10d**						10d			**10f,** 9j			**10c**, 10d	
	Land Use		9ah, 10b		9hi			9hi				9ahi			9hi	
Predation	Land Use / Introductions											6b?, 6e				
	Hatchery Management															
Competition	Land Use / Introductions															
	Hatchery Management		**4c**	**4cd**								4a				
Population Traits	Hatchery Management															**3a**
	Harvest															

Habitat Access

Impaired downstream passage due to North Santiam subbasin dams (1d).

Flood Control/Hydropower Management. Key threat: CHS and STW smolts.

Migration delay and direct mortality of Chinook and steelhead smolts results from the lack of downstream passage provisions at the North Santiam dams. Lack of defined and prolonged flows can not only obscure principal passage routes through reservoirs, but also influence migration behavior of fish below these projects. Any juveniles produced above these facilities must first find attraction flows at the face of the dams, then pass through available routes. Direct and delayed mortality occurs with passage over spillways, through turbines, or through or other project structures not designed for fish passage.

Impaired downstream passage of STW kelts at North Santiam dams (2i).

Flood Control/Hydropower Management. Secondary threat: STW

Mortality of steelhead kelts occurs during downstream passage through turbines or because they are not able to locate downstream passage routes. Many of the same issues regarding juveniles above barriers apply to kelts.

Impaired adult access to habitat above North Santiam dams (2b).

Flood Control/Hydropower Management. Key threat: CHS, STW

Detroit and Big Cliff dams are complete barriers to upstream adult migration, and block access to an estimated 71% of the historical production area for Chinook and 55–65% of historical spawning habitat for winter steelhead. Non-volitional upstream access can be partially achieved if natural origin fish are safely trapped and hauled from the Minto facility to habitats above Detroit dam. The current Minto facility cannot achieve this.

Impaired adult access to habitat above Upper and Lower Bennett dams (2f).

Flood Control/Hydropower Management. Key threat: CHS

Upper Bennett Dam (RM 31.5) and lower Bennett Dam (RM 29) impair adult spring Chinook access to habitat upstream of the dams.

Impaired adult access leading to pre-spawning mortality (2k).

Flood Control/Hydropower Management. Secondary threat: CHS

Water temperatures in the river below Big Cliff dam are cooler in the summer from pre-project levels (see NMFS 2008a, section 4.6.3.3.1), potentially delaying the upstream movement of Chinook adults to the extent that they are not able to cope with other significant sources of stress. As spring Chinook attempt to migrate to the upper subbasin, they experience high pre-spawn mortality associated with crowding, sorting, delay, and stress at the outdated Minto trapping facility.

Physical Habitat Quality

Streambed coarsening due to reduced peak flows (7b).

Flood Control/Hydropower Management. Secondary threat: CHS and STW eggs and alevins

Flood control operations at Big Cliff and Detroit dams have reduced the frequency and magnitude of peak flows, and are not sufficient to create and maintain channel complexity and to provide nutrients, organic matter, and sediment inputs from floodplain areas (WRI 2004). Modification of the flow regime has changed delivery and transport of large wood (particularly the formation of large jams), and reduced and modified the recruitment and deposition of gravels and small cobbles. This has led to reduced pool frequency and depth, and reduced flow refugia for juvenile fish.

Impaired gravel recruitment due to flood control facilities (7c).

Flood Control/Hydropower Management. Secondary threat: CHS and STW eggs and alevins

Modification of the flow regime downstream of Big Cliff Dam has impaired gravel recruitment and deposition in the lower river, and together with gravel entrapment above dams, has resulted in reduced quantity and quality of spawning and incubation substrates in the lower mainstem of the North Santiam River.

Excessive fine sediment leading to impaired incubation gravels (7a).

Land Use Management. Secondary threat: STW eggs and alevins

High erosion and destabilized stream banks from past and current land uses have released excess sediment, causing turbid water and silt deposits that settle in spawning beds and harm winter steelhead eggs and alevins.

Impaired access to wadeable streams due to barriers (2a).

Land Use Management. Secondary threat: STW juveniles and adults

Road crossings and other land use related passage impediments restrict steelhead access to spawning and rearing habitat on wadeable-sized tributaries. Partial barriers include unscreened diversions, Santiam Water Control District power and irrigation canals, road culverts, the Salem ditch, and Sidney ditch (WRI 2004). Habitat conditions may further exclude winter steelhead from some lower tributaries (McElhany et al. 2004).

Physical habitat quality. Impaired habitat complexity/diversity, off-channel habitats (8a).

Land Use Management. Key threat: CHS and STW winter parr (subbasin); Secondary threat: CHS fry and summer parr (subbasin); CHS and STW parr-smolt (mainstem Willamette and Westside tributaries); CHS and STW juveniles (estuary)

Subbasin: Impaired physical habitat in the North Santiam drainage has significantly degraded rearing potential for Chinook and steelhead during the winter parr life stage. The lower portion of the subbasin contains only 25% of the original extent of floodplain forest, and there has been significant loss of wetland, floodplain, and off-channel habitats and associated habitat complexity. The floodplain is not inundated frequently, and reduced over-bank flow and side channel connectivity limit rearing and refuge habitat (WRI 2004).

Reaches of the North Santiam River below Detroit and Big Cliff dams have limited supplies of large wood. Reduced recruitment of large wood has reduced the formation of pools and side channels, and the capture of spawning gravels. It has also limited the creation of new gravel bars, resulting in a decrease in cool water rearing habitats. Limited wood supplies reduce hiding areas for adult fish, and restrict the quality and quantity of juvenile rearing habitat (WRI 2004).

The mainstem Willamette River and Westside tributaries also support juvenile life stages of winter steelhead and spring Chinook throughout the entire year. Habitat degradation in these areas affects rearing potential and migration characteristics for North Santiam Chinook and steelhead parr and smolts.

Estuary: In the Columbia River estuary, many once important habitat areas have been affected by land and water management activities. Along the lower Columbia, complex habitats have been modified through channelization, diking, development and other practices. Physical habitat quality in the lower Willamette River has also been reduced through land use practices. Loss of habitat diversity and key habitat has resulted from channelization, the loss of wood and other structure, and elimination of much of the shallow water habitat (McConnaha 2002). The limiting factors in the estuary are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Flood Control/Hydropower Management. Key threat: CHS and STW juveniles

The limiting factors in the estuary are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired food web. Reduced macrodetrital input in the estuary due to Columbia Basin hydropower reservoir, and disposal of dredge material and other land use (5a).

Flood Control/Hydropower and Land Use Management. Key threat: CHS and STW juveniles

(estuary)

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired food web. Increased microdetrital input due to Columbia Basin hydropower reservoirs (5b).

Flood Control/Hydropower. Key threat: CHS and STW juveniles (estuary)

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired fine sediment and sand recruitment and routing (7h).

Flood Control/Hydropower. Key threat: CHS and STW juveniles (estuary)

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water Quality / Quantity / Hydrograph

Water quality. Elevated water temperatures due to flow alterations at dams (9b).

Flood Control/Hydropower. Key threat: CHS eggs and alevins

Operations at Detroit and Big Cliff dams have altered water temperature patterns. Water temperatures in the river below the dams are warmer in the fall and winter than they were historically. This shortens the period of egg incubation, and results in premature hatching and emergence for fish produced below the dams.

Altered hydrology; elevated fall flows below dam (10a).

Flood Control/Hydropower. Key threat: STW eggs and alevins

Operations at Detroit and Big Cliff dams have changed flow regimes in the North Santiam River below Big Cliff dam. Increased flows in the fall from Detroit and Big Cliff dams may allow winter steelhead to spawn in areas that are then dewatered during active flood control operations (WRI 2004). This poses a risk to early life stages.

Decreased water temperatures due to dam operations (9d).

Flood Control/Hydropower. Secondary threat: STW eggs and alevins

Operations at Detroit and Big Cliff dams have altered water temperature patterns. Cooler temperatures in the spring and early summer are thought to impede hatching and delay the emergence of steelhead fry (NMFS 2008a) thereby reducing development or growth (WRI 2004).

Altered hydrology; reduced peak flow (10d).

Flood Control/Hydropower. Key threat: CHS juveniles (tributaries and mainstem Willamette), STW juveniles (tributaries); Secondary threat: STW adults (mainstem Willamette)

Operations at Detroit and Big Cliff dams have changed flow regimes in the North Santiam River, degrading habitat conditions for juvenile spring Chinook and steelhead. Reduced magnitude and occurrence of peak flows reduce channel movement that is important for recruitment of gravel and large wood, and maintaining varying seral stages of riparian vegetation. This in turn reduces the maintenance and formation of channel complexity and diversity of fish habitat. Lower peak flows also reduces the functioning of scouring to form pools. These effects extend to the mainstem Willamette River, where flood control (and reduced peak flows) omits the dynamic hydrologic conditions needed to support quality rearing habitat.

Water quality. Elevated water temperature from land uses (9a).

Land Use Management. Key threat: CHS (subbasin), Secondary threat: STW subbasin and estuary); CHS (estuary)

Effects from elevated water temperatures in the Columbia River estuary are the same as those discussed in for Clackamas Chinook in Section 5.4.1. The elevated water temperatures particularly decrease survival and/or growth of Chinook summer parr and steelhead fry and summer parr.

Water quality. Toxins from agricultural pesticide sources (9h).

Land Use Management. Key threat: CHS summer parr (subbasin and mainstem Willamette); Secondary threat: CHS and STW juveniles in subbasin, juveniles and adults in the mainstem Willamette, and juveniles in the estuary

Threats in the estuary are the same as those described for Clackamas Chinook in Section 5.4.1. Several members of the Planning Team indicated that UWR populations were exposed to these toxins within the subbasin and to some extent in the mainstem Willamette River as well.

Water quality. Toxins from urban and industrial sources (9i).

Land Use Management. Key threat: CHS parr (subbasin and mainstem Willamette); Secondary threat: CHS and STW juveniles in subbasin, juveniles and adults in the mainstem Willamette, and juveniles in the estuary

Threats in the estuary are the same as those described for Clackamas Chinook in Section 5.4.1. Although the subbasins and upper mainstem Willamette River have less dense urbanization and industrial development than the Portland metro area, UWR Chinook and steelhead are exposed to some extent to some or all of these toxins in the subbasin and mainstem Willamette.

Hydrograph/water quantity. Insufficient stream flows (10b).

Land Use Management. Secondary threat: STW fry-summer parr

Substantial water appropriations and withdrawals from the North Santiam River occur at and below the community of Stayton. During low flow months (July through October), domestic water use, combined with irrigation withdrawals in the lower elevations of the watershed, may significantly reduce stream flows. In 1990, approximately 55% of the population of Marion County received its water supply from the North Santiam River. The communities of Idanha, Gates, Mill City, Stayton, Salem, Turner and Jefferson all divert their supplies from the lower or middle reach of the river (or in the case of Jefferson, just below the confluence of the North and South Santiam Rivers) (Snyder et al. 2002). Above Stayton, appropriated water in the North Santiam River watershed represents only a small fraction of average flows, therefore surface water withdrawals are generally believed to have little or no effect on current in-stream habitats in the middle reach (Snyder et al. 2002).

Hydrology/water quantity. Altered hydrology (10f).

Flood Control/Hydropower. Key threat: CHS and STW juveniles

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water quality. Elevated water temperatures due to reservoir heating (9j).

Flood Control/Hydropower. Secondary threat: CHS and STW juveniles

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Hydrograph/water quantity. Reduced flow in mainstem Willamette during spring reservoir filling (10c).

Flood Control/Hydropower. Key threat: STW adults

Reduced flows in the Willamette River during spring reservoir filling result in increased water temperatures that lead to increased disease vulnerability.

Predation

Predation by birds in the estuary due to land use practices (6e).

Land Use Management. Secondary threat: CHS and STW juveniles

The limiting factors in the estuary are the same as those described for Clackamas Chinook in Section 5.4.1.

Predation by non ESU-DPS hatchery fish species (6c).

Hatchery Management. Secondary threat: CHS juveniles

Hatchery summer steelhead smolts released in the subbasin can prey on North Santiam Chinook fry and parr.

Competition

Competition with hatchery fish in the estuary (4a).

Hatchery Management. Secondary threat: CHS and STW juveniles

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Competition with naturally produced progeny of hatchery summer steelhead (4c).

Hatchery Management. Secondary threat: STW

Natural production resulting from hatchery releases of non-native South Santiam stock summer steelhead is a risk to the viability of the North Santiam steelhead population (NMFS 2004). This hatchery stock originated from Skamania stock and is not part of the UWR steelhead DPS. Releases of thousands of hatchery smolts annually result in competition with juvenile UWR North Santiam steelhead. While most adult summer steelhead in the basin are harvested by anglers or removed at the Minto trap, ODFW has observed summer steelhead spawning in the mainstem North Santiam River, and Rock, Mad, Elkhorn and Sinker creeks. The North Santiam River had the highest densities of summer steelhead redds observed in any of the indigenous steelhead populations in the DPS. Studies in the Clackamas River have shown adverse effects from non-native Skamania summer steelhead on native winter steelhead (Chilcote 2003, Kostow and Zhou 2006). One ecological factor that may impact juvenile winter steelhead is the earlier emergence of summer steelhead, which may impart a competitive disadvantage to native fish if choice feeding territories are already occupied by summer steelhead (Kostow and Zhou 2006).

Competition with residualized hatchery summer steelhead smolts (4d).

Hatchery Management. Secondary threat: STW

Releases of non-native South Santiam stock summer steelhead also results in competition between juvenile North Santiam steelhead and residual hatchery summer steelhead smolts. See discussion above for 4c.

Population Traits

Loss of population traits due to hatchery fish interbreeding with wild fish on spawning grounds (3a).

Hatchery Management. Key threat: CHS and STW

Hatchery fish breeding with natural origin spawners represents a key threat to the genetic characteristics of the wild Chinook and steelhead populations.

Chinook. Hatchery operations on the North Santiam River began nearly 100 years ago. Today, hatchery fish account for approximately 90% of the natural spawners, due in part to low natural production.

Steelhead. Releases of hatchery produced of native North Santiam steelhead smolts in the North Santiam River system ended in 1998; however, the legacy of past hatchery releases is unknown. ODFW continues to release thousands of hatchery produced South Santiam stock summer steelhead smolts annually. This hatchery stock originated from Skamania stock and is not part of the UWR DPS. Impact from genetic introgression with summer steelhead is unknown.

5.4.4 Factors and Threats Limiting Viability of South Santiam Chinook and Steelhead

The following descriptions of the LFTs are specific to the South Santiam Chinook salmon and steelhead populations. Tables 5-15 and 5-16 summarize the key and secondary LFTs to recovery of the populations at different life stages and locations, and subsequent LFT descriptions are organized in a similar fashion. Harvest is not considered a key or secondary threat at any life stage of South Santiam Chinook or steelhead populations.

Table 5-15. The key and secondary LFTs to the recovery of the South Santiam Chinook salmon population. See caption in Table 5-10 for explanation table organization, LFT bolding, cell shading and cell patterning. Codes are further defined in Table 5-9.

South Santiam Spring Chinook		Rearing and Downstream Migration											Marine Foraging	Upstream Migration and Spawning		
		Natal Subbasin						Mainstem Willamette		West-side Tribs	Estuary		Ocean	Estuary	Mainstem Willamette	Natal Subbasin
Limiting Factor	**General Threat Category**	**Egg / Alevin**	**Fry**	**Summer Parr**	**Winter Parr**	**Smolt**	**Kelt**	**Parr**	**Smolt**	**Parr**	**Parr**	**Smolt**	**sub-adult/ Adult**	**Adult**	**Adult**	**Adult and Spawner**
Habitat Access	Flood Control/ Hydropower					**1e**										**2c,** 2l
Physical Habitat Quality	Flood Control/ Hydropower	7d									**5ab,7h,8a**					
	Land Use		8a		**8a**			8a			**5a,** 8a					
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower	**9e**	**10d**					**10d**			**10f,** 9j					
	Land Use			**9ah,** 9i	9hi			**9hi**			9ahi				9hi	**2g**
Predation	Land Use / Introductions										6e					
	Hatchery Management		6c													
Competition	Land Use / Introductions															
	Hatchery Management										4a					
Population Traits	Hatchery Management															**3a**
	Harvest															

Table 5-16. The key and secondary LFTs to the recovery of the South Santiam steelhead population. See caption in Table 5-10 for explanation table organization, LFT bolding, cell shading and cell patterning. Codes are further defined in Table 5-9.

South Santiam Winter Steelhead		Rearing and Downstream Migration											Marine Foraging	Upstream Migration and Spawning		
		Natal Subbasin						Mainstem Willamette		West-side Tribs	Estuary		Ocean	Estuary	Mainstem Willamette	Natal Subbasin
Limiting Factor	General Threat Category	Egg / Alevin	Fry	Summer Parr	Winter Parr	Smolt	Kelt	Parr	Smolt	Parr	Parr	Smolt	sub-adult/ Adult	Adult	Adult	Adult and Spawner
Habitat Access	Flood Control/ Hydropower					**1e**	2j									**2c**
Physical Habitat Quality	Flood Control/ Hydropower	7d										**5ab,7h 8a**				
	Land Use	7a	2a		**8a,** 2a	2a						**5a,** 8a				2ah
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower	**10a**, 9d	**10d**						10d			**10f,** 9j			**10c**, 10d	
	Land Use		9ah, 10b		9hi			9hi				9ahi			9hi	
Predation	Land Use / Introductions		**6b**									6e				
	Hatchery Management															
Competition	Land Use / Introductions															
	Hatchery Management		**4c**	**4cd**								4a				
Population Traits	Hatchery Management															**3a**
	Harvest															

Habitat Access

Impaired downstream passage at South Santiam dams (1e).

Flood Control/Hydropower Management. Key threat: CHS, STW smolts

Mortality of Chinook and steelhead juveniles occurs during downstream passage through turbines and other outlets at South Santiam dams or because they are not able to locate downstream passage routes. Fish are not currently outplanted above Green Peter dam because of poor passage survival and related problems with predation.

Impaired access to wadeable streams due to barriers (2a).

Land Use Management. Secondary threat: STW fry and summer parr

Small dams, irrigation diversions, road crossings and other land use related passage impediments restrict steelhead access to habitat on wadeable-sized tributaries. A number of irrigation diversions and push-up dams pose migration barriers to adult Chinook in the lower tributaries of Crabtree and Thomas creeks (E&S 2000). Numerous partial and complete fish passage barriers at culverts on tributary streams limit juvenile upstream movement into rearing and refuge habitat.

Impaired adult access to habitat above South Santiam dams (2c).

Flood Control/Hydropower Management. Key threat: CHS, STW adults

Green Peter and Foster dams block or limit access to an estimated 85% of the historical production area for Chinook and steelhead. Both dams have poorly performing passage provisions and current access is provided with experimental trap-and-haul methods.

Impaired adult access to habitat above Lebanon Dam (2g).

Land Use Management. Key threat: CHS adults

The eight-foot high Lebanon Dam at RM 21 impairs adult Chinook passage. The dam is equipped with several new fish ladders that allow passage of adult fish, but the dam may still delay some migration or injure adult fish seeking the entrances.

Impaired downstream passage of kelts at South Santiam dams (2j).

Flood Control/Hydropower Management. Secondary threat: STW kelts

Mortality of steelhead kelts occurs during downstream passage through turbines or because they are not able to locate downstream passage facilities.

Impaired adult access; pre-spawning mortality (2l).

Flood Control/Hydropower Management. Secondary threat: CHS adults

South Santiam spring Chinook are subject to pre-spawning mortality due to crowding below South Santiam dams.

Physical Habitat Quality

Impaired food web. Reduced macrodetrital input in the estuary due to Columbia Basin hydropower reservoirs, and disposal of dredge material (5a).

Flood Control/Hydropower and Land Use Management. Key threat: CHS, STW parr and smolts

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired food web. Increased microdetrital input in the estuary due to Columbia Basin hydropower reservoirs (5b).

Flood Control/Hydropower Management. Key threat: CHS, STW juveniles

The estuary's current food web is microdetrital-based, made up of decaying phytoplankton delivered from upstream reservoirs. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Excessive fine sediment (7a).

Land Use Management. Secondary threat: STW eggs/alevin

High erosion and destabilized stream banks from past and current land uses have released excess sediment, causing turbid water and silt deposits that settle in spawning beds and harm winter steelhead eggs and alevins.

Streambed coarsening due to reduced peak flows (7d).

Flood Control/Hydropower Management. Secondary threat: CHS, STW eggs/alevin

Changes in the frequency and magnitude of high flow events downstream of Green Peter and Foster dams have caused a reduction of channel complexity and diversity of downstream rearing habitat. The frequency of large magnitude flows is not sufficient to create and maintain channel complexity, or to provide nutrient, organic matter, and sediment inputs from floodplain areas. Loss of frequent floodplain inundation has reduced overbank flow and side-channel connectivity, nutrient exchange, sediment exchange, and flood refugia for fish. Reduced pool frequency, depth, and cover have affected the quality of adult habitat in the river and tributaries. The dams also block transport of large wood from 50% of the subbasin (USACE 2001). Limited wood in the river and tributaries has affected the quality of pools and backwater habitats (WRI 2004).

Impaired sediment/sand routing (7h).

Flood Control/Hydropower Management. Key threat: CHS and STW juveniles

Impaired physical habitat quality in the estuary due to changes in sediment and sand routing has a key impact on South Santiam Chinook and steelhead. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired habitat complexity/diversity, off-channel habitats (8a).

Land Use Management. Key threat: CHS, STW winter parr (subbasin); Secondary threat: CHS fry and summer parr (subbasin); CHS and STW parr-smolt (mainstem Willamette and Westside tributaries); CHS and STW juveniles (estuary)

Subbasin: Impaired physical habitat has significantly degraded rearing potential for Chinook and steelhead during the winter parr life stage in the South Santiam Basin. Past management of riparian areas and stream cleaning practices have led to reduced large wood in streams. Mature riparian forests now make up a very small proportion of the floodplain and riparian vegetation along the river and tributaries in the lower basin, particularly in areas where there is the largest amount of agricultural use. Riparian conditions are better in the upper subbasin than in the lower, but proportions of mature and old-growth coniferous forests are reduced (USACE 2001, cited in WRI 2004).

The mainstem Willamette River and South Santiam basin supports both winter steelhead and spring Chinook at various life stages throughout the entire year. Habitat degradation in the mainstem Willamette and South Santiam affects rearing potential and migration characteristics for South Santiam Chinook and steelhead parr and smolts. Juveniles of both species also use Westside tributaries for rearing, and habitat degradation in these drainages can limit this use.

Estuary: In the Columbia River estuary, many once important habitat areas have been affected by land and water management activities. Along the lower Columbia, complex habitats have been modified through channelization, diking, development and other practices. Physical habitat quality in the lower Willamette River has also been reduced through land use practices. The limiting factors in the estuary are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Flood Control/Hydropower Management. Key threat: CHS, STW winter parr; Secondary threat: CHS fry, summer parr

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water Quality / Quantity / Hydrograph

Water Quality. Elevated water temperature from land uses (9a).

Land Use Management. Key threat: CHS (subbasin); Secondary threat: STW (tributaries and estuary); CHS (estuary)

Temperatures exceed water quality criteria in the South Santiam River and in many tributaries. These elevated water temperatures decrease survival and/or growth of Chinook and steelhead juveniles in the river system. High water temperatures in the lower subbasin are aggravated by low streamflows, as well as land use practices that result in the loss of riparian cover, reduced wetland areas, and channel simplification (E&S 2000). Water temperatures are generally lower in the forested upper subbasin.

Effects from elevated water temperatures in the Columbia River estuary are the same as those discussed in for Clackamas Chinook in Section 5.4.1.

Water Quality. Elevated water temperatures due to flow alterations at dams (9e).

Flood Control/Hydropower Management. Key threat: CHS eggs/alevin; Secondary threat: STW eggs/alevin

Altered flow regimes downstream of Green Peter and Foster dams have changed water temperature patterns. Compared to historical conditions, water temperatures in the river below the dams are cooler in the summer and warmer in the fall and winter, which alters the timing of spawning, and affects the period of egg incubation (USACE 2001, cited in WRI 2004). Maximum temperatures for incubation and emergence have been exceeded in the lower South Santiam River, and cause premature hatching and emergence, especially for Chinook. Water temperatures in the South Santiam River exceed water quality criteria for summer maximums for juvenile rearing and migration, and have also exceeded water quality criteria for summer maximum adult migration (WRI 2004).

Water Quality. Toxins from agricultural sources (9h).

Land Use Management. Key Threat: CHS summer parr in subbasin, parr and smolts in mainstem Willamette); Secondary threat: CHS, STW juveniles in subbasin, juveniles and adults in mainstem Willamette, juveniles in estuary

Contaminants from agricultural practices found throughout the Columbia River estuary pose a threat to South Santiam Chinook and steelhead. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water Quality. Toxins from urban and industrial sources (9i).

Land Use Management. Secondary threat: CHS, STW

Toxic contaminants from urban and industrial practices reduce habitat quality for Chinook parr and smolts, and steelhead smolts from the South Santiam River system. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water Quality. Elevated water temperatures due to reservoir heating (9j).

Flood Control/Hydropower Management. Secondary threat: CHS parr and smolts, STW smolts

Elevated water temperatures in the estuary due to reservoir heating in Columbia Basin pose a secondary threat to South Santiam Chinook and steelhead. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Hydrology/water quantity. Altered hydrology; elevated flows (10e10a).

Flood Control/Hydropower Management. Key threat: STW eggs and alevin

Flow fluctuations due to operations at Green Peter and Foster dams can elevate flows during the winter steelhead spawning period and reduce flows during egg incubation, allowing the dewatering of steelhead redds.

Hydrograph/water quantity. Insufficient stream flows (10b).

Land Use Management. Secondary threat: STW fry-summer parr

Water withdrawals for irrigation, domestic and industrial water uses contribute to low flow conditions in the South Santiam River and its tributaries, particularly in late summer and early fall. The loss of streamflow affects steelhead productivity by reducing rearing habitat availability and quality for fry and summer parr.

Hydrology/water quantity. Reduced flow in mainstem Willamette during spring reservoir filling (10c).

Flood Control/Hydropower Management. Key threat: STW adults

Reduced flows in the Willamette River during spring reservoir filling result in increased water temperatures that lead to increased disease.

Hydrology/water quantity. Altered hydrology; reduced peak flow (10d).

Flood Control/Hydropower Management. Key threat: CHS (fry and parr in tributaries and smolts in mainstem Willamette), STW (fry and parr in tributaries); Secondary threat: STW smolts (mainstem Willamette)

Operations at Green Peter and Foster dams have changed the flow regime in the South Santiam River, degrading habitat conditions for juvenile spring Chinook and steelhead. Reduced peak flow decreases channel complexity and diversity of downstream rearing habitat. Reduced peak flows in the mainstem Willamette River due to flood control and hydro operations cause a reduction of channel complexity and diversity of rearing habitat for Chinook and steelhead smolts from the South Santiam system.

Hydrology/water quantity. Altered hydrology (10f).

Flood Control/Hydropower Management. Key threat: CHS parr and smolts, STW smolts

Management of the Columbia River hydro system alters the timing and magnitude of spring freshets, and impairs estuarine habitat quality and access. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Predation

Predation by non-native fish species (6b).

Land Use Management, Hatchery Management, and Species Introductions. Key threat: STW juveniles in subbasin;

Non-native largemouth bass are present in Green Peter Reservoir and are thought to prey on juvenile Chinook and steelhead that are progeny of outplanted fish.

Predation by non ESU-DPS fish species (6c).

Hatchery Management. Secondary threat: CHS juveniles

Hatchery summer steelhead smolts prey on South Santiam Chinook fry and parr.

Predation by birds in the estuary (6e).

Land Use Management. Secondary threat: CHS, STW juveniles

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Competition

Competition with hatchery fish in the estuary (4a).

Hatchery Management. Secondary threat: CHS, STW juveniles

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Competition with naturally produced progeny of hatchery summer steelhead (4c).

Hatchery Management. Secondary threat: STW

The naturally produced progeny of non-native summer steelhead released in the subbasin are thought to compete with juvenile South Santiam steelhead for habitat and food (NMFS 2004). This hatchery stock was introduced into the Willamette Basin from Skamania stock and is not part of the UWR steelhead DPS. Not all of the adult summer steelhead are harvested by anglers or removed at the Foster trap, and some summer steelhead have been observed spawning in the mainstem South Santiam River, Wiley, Crabtree, and Thomas Creeks. Studies in the Clackamas River have shown adverse effects from non-native Skamania summer steelhead on native (Chilcote 2003, Kostow and Zhou 2006). One ecological factor that may impact juvenile winter steelhead is the earlier emergence of summer steelhead, which may impart a competitive disadvantage to native fish if choice feeding territories are already occupied by summer steelhead (Kostow and Zhou 2006).

Competition with residualized hatchery summer steelhead smolts (4d).

Hatchery Management. Secondary threat: STW

Releases of non-native summer steelhead in the basin also results in competition between juvenile South Santiam steelhead and residual hatchery summer steelhead smolts. See discussion above for 4c.

Population Traits

Loss of Population traits due to hatchery fish interbreeding with wild fish on spawning grounds (3a).

Hatchery Management. Key threat: CHS and STW

Hatchery fish breeding with natural origin spawners continues to present a key threat to the genetic characteristics of the wild Chinook and steelhead populations.

Chinook: The large number of hatchery fish on natural spawning beds compared to the number of natural-origin spawning fish is a major concern for South Santiam Chinook. In recent years the proportion of naturally spawning Chinook in the South Santiam that are of hatchery origin has been over 80% (ODFW 2005a). The contribution of natural-origin fish to the broodstock is thought to be small (McElhany et al. 2007).

The proportions of Chinook with various life history characteristics are different than the historic populations in the Willamette Basin. Most hatchery produced juveniles are released as age-1 smolts in the spring, whereas a more continuous migration of naturally produced smolts through the fall and spring periods was observed in the historic populations (Willis et al. 1995, cited in NMFS 2004). Hatchery Chinook return at an earlier age than the historic populations. Most of the returns now are age-4 fish instead of age-5 (Willis et al. 1995, cited in NMFS 2004). It is unknown if the return of younger adults is the result of genetic changes due to hatchery operations or fisheries, or simply the result of releasing larger smolts than occurred naturally.

Steelhead: Hatchery releases of North Santiam steelhead were discontinued in the South Santiam in 1986. ODFW released North Santiam hatchery stock steelhead from 1979 through 1986 as part of a research study to improve downstream passage of smolts at Foster and Green Peter dams. The proportion of hatchery-reared fish that currently spawn naturally in the South Santiam River is believed to be less than 5% (Chilcote 1997); prior to 1989 it was more than 40% (ODFW 2005a). The legacy of past hatchery operations in combination with the continued release of summer-run steelhead presents risks to the viability of the steelhead population.

5.4.5 Factors and Threats Limiting Viability of Calapooia Chinook and Steelhead

The following descriptions of the LFTs are specific to the Calapooia Chinook salmon and steelhead populations. Tables 5-17 and 5-18 summarize the key and secondary LFTs to recovery of the populations at different life stages and locations, and subsequent LFT descriptions are organized in a similar fashion. Harvest is not considered a key or secondary threat at any life stage of Calapooia Chinook or steelhead populations.

Table 5-17. The key and secondary LFTs to the recovery of the Calapooia Chinook salmon population. See caption in Table 5-10 for explanation table organization, LFT bolding, cell shading and cell patterning. Codes are further defined in Table 5-9.

Calapooia Spring Chinook		Rearing and Downstream Migration											Marine Foraging	Upstream Migration and Spawning		
		Natal Subbasin						Mainstem Willamette		West-side Tribs	Estuary		Ocean	Estuary	Mainstem Willamette	Natal Subbasin
Limiting Factor	**General Threat Category**	**Egg / Alevin**	**Fry**	**Summer Parr**	**Winter Parr**	**Smolt**	**Kelt**	**Parr**	**Smolt**	**Parr**	**Parr**	**Smolt**	**sub-adult/ Adult**	**Adult**	**Adult**	**Adult and Spawner**
Habitat Access	Flood Control/ Hydropower															
Physical Habitat Quality	Flood Control/ Hydropower										**5ab,7h,8a**					
	Land Use	7a	8a		**8a**			8a			**5a,** 8a					**2h,8b**
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower							**10d**			**10f,** 9j					
	Land Use			**9ah,** 9i, 10b	9hi			**9hi**			9ahi				9hi	**9c**
Predation	Land Use / Introductions										6e					
	Hatchery Management															
Competition	Land Use / Introductions															
	Hatchery Management										4a					
Population Traits	Hatchery Management															**3a**
	Harvest															

Table 5-18 The key and secondary LFTs to the recovery of the Calapooia steelhead population. See caption in Table 5-10 for explanation table organization, LFT bolding, cell shading and cell patterning. Codes are further defined in Table 5-9.

Calapooia Winter Steelhead		Rearing and Downstream Migration											Marine Foraging	Upstream Migration and Spawning		
		Natal Subbasin						Mainstem Willamette		West-side Tribs	Estuary		Ocean	Estuary	Mainstem Willamette	Natal Subbasin
Limiting Factor	**General Threat Category**	**Egg / Alevin**	**Fry**	**Summer Parr**	**Winter Parr**	**Smolt**	**Kelt**	**Parr**	**Smolt**	**Parr**	**Parr**	**Smolt**	**sub-adult/ Adult**	**Adult**	**Adult**	**Adult and Spawner**
Habitat Access	Flood Control/ Hydropower															
Physical Habitat Quality	Flood Control/ Hydropower											**5ab,7h 8a**				
	Land Use	7a	2a		**8a,** 2a	2a						**5a,** 8a				2ah
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower								10d			**10f,** 9j			**10c**, 10d	
	Land Use		9ah, 10b		9hi			9hi				9ahi			9hi	
Predation	Land Use / Introductions											6e				
	Hatchery Management															
Competition	Land Use / Introductions															
	Hatchery Management											4a				
Population Traits	Hatchery Management															**3a**
	Harvest															

Habitat Access

Impaired access to wadeable streams due to barriers (2a).

Land Use Management. Secondary threat: STW multiple life stages

Numerous unscreened small diversions impair steelhead access to historical habitat within the Calapooia subbasin (WRI 2004). Land management practices also restrict access to off-channel areas and the floodplain.

Impaired adult access to habitat above Calapooia dams (2h).

Land Use Management. Key threat: CHS adults; Secondary threat: STW adults

Fish passage barriers are an issue throughout the subbasin. Currently, access is blocked to more than half of the stream length historically accessible to Chinook. Several dams and diversions limit upstream migration. The dams and diversions within the Thompson's Mill complex (RM 19.5 to 28.5) have the greatest impact on fish passage. While Sodom Dam is equipped with a fish ladder, migrating Chinook are delayed at the base of the dam, which subjects them to additional stress and possible harassment and poaching (Runyon et al. 2004).

Physical Habitat Quality

Impaired food web. Reduced macrodetrital input in the estuary due to Columbia Basin hydropower reservoir, and disposal of dredge material and other land use (5a).

Flood Control/Hydropower and Land Use Management. Key threat: CHS, STW juveniles (estuary)

Reduced macrodetrital-based input in the Columbia River estuary affects viability of Calapooia Chinook and steelhead populations. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired food web. Increased microdetrital input due to Columbia Basin hydropower reservoirs (5b).

Flood Control/Hydropower Management. Key threat: CHS, STW juveniles (estuary)

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Physical habitat quality. Excessive fine sediment (7a)

Land Use Management. Secondary threat: CHS, STW eggs and alevin

High erosion and destabilized stream banks from past and current land uses have released excess sediment, causing turbid water and silt deposits that settle in spawning beds and harm winter steelhead eggs and alevins.

Physical habitat quality. Impaired sediment/sand routing (7h).

Flood Control/Hydropower Management. Key threat: CHS, STW parr and smolts

Impaired physical habitat quality in the estuary due to changes in sediment and sand routing has a key impact on Calapooia Chinook and steelhead. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired habitat complexity and diversity, off-channel habitats (8a)

Land Use Management. Key threat: CHS, STW winter parr; Secondary threat: CHS fry, summer parr (subbasin), parr and smolts (mainstem Willamette, West-side tributaries); CHS, STW juveniles (estuary)

Subbasin: Modifications to key habitats and the natural processes that form and maintain them affect viability of Calapooia Chinook and steelhead. Impaired physical habitat conditions particularly reduce rearing potential for the populations during the winter parr life stage. Habitat quality has declined through changes in interactions between stream systems and their floodplain that have reduced the delivery and transport of large wood, modified gravel deposition, reduced the frequency and depth of pools, minimized hiding cover for adult and juvenile fish, and reduced spawning areas. Flow alteration, channel confinement and in-stream barriers have reduced access to off-channel habitats essential for juvenile rearing and winter refuge and decreased connectivity between habitats throughout the watershed and the dynamic processes needed to form and maintain habitat diversity (WRI 2004).

The mainstem Willamette River and Calapooia subbasin support both winter steelhead and spring Chinook at various life stages throughout the entire year. Habitat degradation in the mainstem

Willamette and Calapooia affects rearing potential and migration characteristics for Calapooia Chinook and steelhead parr and smolts. Juveniles of both species also use Westside tributaries for rearing, and habitat degradation in these drainages can limit this use.

Estuary: In the Columbia River estuary, many once important habitat areas have been affected by land and water management activities. Along the lower Columbia, complex habitats have been modified through channelization, diking, development and other practices. Physical habitat quality in the lower Willamette River has also been reduced through land use practices. The limiting factors in the estuary are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Flood Control/Hydropower Management. <u>Key threat</u>: CHS and STW juveniles (estuary).

The limiting factors in the estuary associated with flood control/hydropower are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Loss of summer holding pools (8b)

Land Use Management. <u>Key threat</u>: CHS adults

Loss of holding pools increases pre-spawning mortality of adult Chinook; a survey of 27 female carcasses in the Calapooia in 2003 found 100% pre-spawning mortality (Schroeder and Kenaston 2004).

<u>Water Quality / Quantity / Hydrograph</u>

Water quality. Elevated summer water temperature from land use practices (9a)

Land Use Management. <u>Key threat</u>: CHS summer parr (subbasin); <u>Secondary threat</u>: STW fry and summer parr (subbasin); CHS, STW juveniles (estuary)

Subbasin: Naturally low flows in the Calapooia basin are aggravated by water withdrawals, which increase water temperatures. Water temperatures exceed State criteria in the Calapooia River and some tributaries, particularly in the lower subbasin. In general, water temperatures are lower in the forested upper subbasin than in the lower subbasin (Runyon et al. 2004).

Estuary: Effects from elevated water temperatures in the Columbia River estuary are the same as those discussed in for Clackamas Chinook in Section 5.4.1.

Water quality. Elevated water temperature from land uses, leading to pre-spawning mortality (9c)

Land Use Management<u>. Key threat:</u> CHS adults

Elevated water temperatures decrease survival and/or growth of juvenile Chinook, and increase pre-spawning mortality of adult Chinook.

Water quality. Toxins from agricultural pesticide sources (9h).

Land Use Management. <u>Key threat</u>: CHS summer parr (subbasin),CHS parr and smolts (mainstem Willamette); <u>Secondary threat</u>: CHS and STW juveniles in subbasin, STW juveniles and CHS and STW adults in mainstem Willamette, and CHS and STW juveniles in estuary

Contaminants from agricultural practices found throughout the Columbia River estuary pose a threat to Calapooia Chinook and steelhead. The limiting factors are the same as those discussed for

Clackamas Chinook in Section 5.4.1.

Water quality. Toxins from urban and industrial sources (9i).

Land Use Management. Key threat: CHS parr and smolts (mainstem Willamette); Secondary threat: CHS and STW juveniles in subbasin, STW juveniles and CHS and STW adults in the mainstem Willamette, and CHS and STW juveniles in the estuary

Toxic contaminants from urban and industrial practices reduce habitat quality for Chinook parr and smolts, and steelhead smolts from the Calapooia River system. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water quality. Elevated water temperatures in the estuary due to reservoir heating at large hydropower reservoirs in the Columbia Basin (9j).

Flood Control/Hydropower Management. Secondary threat: CHS and STW juveniles

Elevated water temperatures in the estuary due to reservoir heating in Columbia Basin pose a secondary threat to Calapooia Chinook and steelhead. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Hydrograph/water quantity. Insufficient stream flows (10b)

Land Use Management. .Secondary threat: CHS and STW juveniles

Insufficient streamflow restricts steelhead in the Calapooia basin during fry and summer parr life stages. The low flows result primarily from water withdrawals and because of land use practices that have accelerated runoff and increased peak flows. These practices include channelization of tributaries in the lower subbasin; modification of runoff patterns as a result of agriculture, impervious surfaces, and residential development; and loss of storage capacity in floodplains and wetlands (WRI 2004). Water withdrawals from the Calapooia include operational rights for Thompson Mill and municipal water for the City of Brownville.

Hydrograph/water quantity. Reduced flow in mainstem Willamette during spring reservoir filling (10c).

Flood Control/Hydropower Management. Key threat: STW

Reduced flows in the Willamette River during spring reservoir filling result in increased water temperatures that lead to increased disease.

Hydrograph/water quantity. Altered hydrology; reduced peak flow in mainstem Willamette River (10d).

Flood Control/Hydropower Management. Key threat: CHS juveniles; Secondary threat: STW juveniles and adults

Reduced peak flows in the mainstem Willamette River due to flood control and hydro operations cause a reduction of channel complexity and diversity of rearing habitat for Chinook and steelhead smolts from the Calapooia system.

Hydrology/water quantity. Altered hydrology in the estuary (10f).

Flood Control/Hydropower. Key threat: CHS and STW juveniles

Management of the Columbia River hydro system alters the timing and magnitude of spring freshets, and impairs estuarine habitat quality and access. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Predation

Predation by birds in the estuary due to land use practices (6e).

Land Use Management. Secondary threat: CHS and STW juveniles

Modification of estuarine habitats has increased the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species in the Columbia River estuary (LCREP 2006; Fresh et al. 2005). The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Competition

Competition with hatchery fish in the estuary (4a).

Hatchery Management. Secondary Threat: CHS and STW juveniles

Competition with hatchery fish from all Columbia River hatcheries for limited habitat and food supplies in the Columbia River estuary affects productivity of Calapooia Chinook and steelhead populations. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Population Traits

Loss of population traits due to hatchery fish interbreeding with wild fish on spawning grounds (3a).

Hatchery Management. Key threat: CHS and STW adults (subbasin)

Hatchery fish interbreeding with wild Molalla populations presents a significant risk of genetic introgression and associated loss in VSP attributes. About 100,000 Chinook smolts from South Santiam Hatchery are released annually into the Molalla. These fish represent about 90% of the naturally spawning adults. Few redds have been observed from natural or hatchery fish. There is current no hatchery steelhead releases in the basin, but there is a potential risk from out-of-ESU summer steelhead (broodstock program from the South Santiam) straying into the subbasin.

5.4.6 Factors and Threats Limiting Viability of McKenzie Chinook

The following descriptions of the LFTs are specific to the McKenzie Chinook salmon population. Table 5-19 summarizes the key and secondary LFTs to recovery of the population at different life stages and locations, and subsequent LFT descriptions are organized in a similar fashion.

Table 5-19. The key and secondary LFTs to the recovery of the McKenzie Chinook salmon population. See caption in Table 5-10 for explanation table organization, LFT bolding, cell shading and cell patterning. Codes are further defined in Table 5-9.

McKenzie Spring Chinook		Rearing and Downstream Migration											Marine Foraging	Upstream Migration and Spawning		
		Natal Subbasin						Mainstem Willamette		West-side Tribs	Estuary		Ocean	Estuary	Mainstem Willamette	Natal Subbasin
Limiting Factor	**General Threat Category**	**Egg / Alevin**	**Fry**	**Summer Parr**	**Winter Parr**	**Smolt**	**Kelt**	**Parr**	**Smolt**	**Parr**	**Parr**	**Smolt**	**sub-adult/ Adult**	**Adult**	**Adult**	**Adult and Spawner**
Habitat Access	Flood Control/ Hydropower					**1b**										**2d**
Physical Habitat Quality	Flood Control/ Hydropower	7e									**5ab,7h,8a**					
	Land Use		8a		**8a**			8a	**8a**		**5a,** 8a					
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower	9g	**10d**					**10d**			**10f,** 9j					
	Land Use			9ahi	9hi			**9hi**			9ahi				9hi	
Predation	Land Use / Introductions										6e					
	Hatchery Management		6cd													
Competition	Land Use / Introductions															
	Hatchery Management										4a					
Population Traits	Hatchery Management															**3a**
	Harvest															

<u>Habitat Access</u>

Impaired downstream passage at McKenzie dams (1b).

Flood Control/Hydropower Management. <u>Key threat</u>: CHS smolts

Mortality of Chinook and steelhead juveniles occurs during downstream passage through turbines at McKenzie dams or because they are not able to locate downstream passage routes.

Impaired adult access to habitat above McKenzie dams (2d).

Flood Control/Hydropower Management. <u>Key threat</u>: CHS adults

Construction of Cougar Dam on the South Fork blocked fish access to a significant amount of historically productive Chinook habitat above the dam. Blue River Dam was built without fish passage facilities, but only two miles of Chinook spawning habitat was lost because a falls already limited distribution. EWEB's Trail Bridge Dam blocks access to the uppermost three miles of the mainstem McKenzie River and a portion of the Smith River.

Physical Habitat Quality

Impaired food web. Reduced macrodetrital input in the estuary due to Columbia Basin hydropower reservoirs, and disposal of dredge material (5a).

Flood Control/Hydropower and Land Use Management. Key threat: CHS parr and smolts

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired food web. Increased microdetrital input in the estuary due to Columbia Basin hydropower reservoirs (5b).

Flood Control/Hydropower Management. Key threat: CHS juveniles

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired gravel recruitment due to McKenzie flood control facilities (7e)

Flood Control/Hydropower Management. Secondary threat: CHS eggs/alevin

Reduced peak flows in the McKenzie Basin due to flood control operations cause a reduction of channel complexity and diversity of rearing habitat for juvenile Chinook. The dams also capture large wood that historically created complex habitat conditions. Trail Bridge Dam and, to a greater extent, Cougar Dam and Blue River Dam, intercept large wood and sediment from 35% of the McKenzie's headwaters (WRI 2004). Together, reductions in the peak flows and reduced delivery of large wood in the channel have also resulted in fewer side channels and other backwater features, and reduce recruitment of gravel and other substrates. The mainstem McKenzie below Deerhorn Park (RM 32) has lost most of its islands and side channels (WRI 2004).

Impaired sediment/sand routing (7h).

Flood Control/Hydropower Management. Key threat: CHS juveniles

Impaired physical habitat quality in the estuary due to changes in sediment and sand routing has a key impact on McKenzie Chinook. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired habitat complexity/diversity, off-channel habitats (8a).

Land Use Management. Key threat: CHS winter parr(subbasin), smolts (mainstem Willamette and Westside tributaries; Secondary threat: CHS fry and summer parr (subbasin); CHS parr (mainstem Willamette); CHS juveniles (estuary)

Subbasin: Altered habitat diversity (loss of channel confinement, riparian function, wood in the channel, and other attributes) has affected all of the Chinook life stages in the geographic areas, with larger impacts in the Blue River watershed, lower McKenzie River, lower subbasin tributaries, and Mohawk watershed (WRI 2004). Impacts have particularly degraded rearing potential for Chinook juveniles during the winter parr life stage.

The mainstem Willamette River and McKenzie basin supports spring Chinook at various life stages throughout the entire year. Habitat degradation in the mainstem Willamette and McKenzie affects rearing potential and migration characteristics for McKenzie Chinook parr and smolts. Juveniles also use Westside tributaries for rearing, and habitat degradation in these drainages can limit this use.

Estuary: In the Columbia River estuary, many once important habitat areas have been affected by land and water management activities. Along the lower Columbia, complex habitats have been modified through channelization, diking, development and other practices. Physical habitat quality in the lower Willamette River has also been reduced through land use practices. The limiting factors in the estuary are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Flood Control/Hydropower Management. Key threat: CHS juveniles.

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water Quality / Quantity / Hydrograph

Water Quality. Elevated water temperature from land uses (9a).

Land Use Management. Secondary threat: CHS summer parr in subbasin and CHS juveniles in estuary

Elevated water temperatures from past and/or present land management practices decrease survival and/or growth for McKenzie Chinook summer parr.

Effects from elevated water temperatures in the Columbia River estuary are the same as those discussed in for Clackamas Chinook in Section 5.4.1.

Water Quality. Elevated water temperatures due to flow alterations at dams (9g).

Flood Control/Hydropower Management. Secondary threat: CHS eggs/alevin

Elevated water temperatures below McKenzie hydropower/flood control dams result in premature hatching and emergence of Chinook. A temperature control tower has been operational at Cougar Dam since 2005. Evaluation of that facility relative to emergence timing and other effects is ongoing as described and proposed in the WP BiOp (NMFS 2008a; RPA 5.4).

Water Quality. Toxins from agricultural sources (9h).

Land Use Management. Key Threat: CHS parr and smolts in mainstem Willamette; Secondary threat: CHS juveniles in subbasin and estuary, adults in mainstem Willamette

Contaminants from agricultural practices found throughout the Columbia River estuary pose a threat to McKenzie Chinook. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water Quality. Toxins from urban and industrial sources (9i).

Land Use Management. Key threat: CHS parr and smolts in mainstem Willamette; Secondary threat: CHS juveniles in subbasin and estuary, adults in mainstem Willamette

Toxic contaminants from urban and industrial practices reduce habitat quality for Chinook parr and smolts from the McKenzie River system and in the Willamette River. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water Quality. Elevated water temperatures due to reservoir heating (9j).

Flood Control/Hydropower Management. Secondary threat: CHS parr and smolts

Elevated water temperatures in the estuary due to reservoir heating in Columbia Basin pose a secondary threat to McKenzie Chinook. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Hydrology/water quantity. Altered hydrology; reduced peak flow (10d).

Flood Control/Hydropower Management. Key threat: CHS fry and parr in subbasin, CHS parr and smolt in mainstem Willamette

Peak flows have been greatly diminished by Cougar and Blue River dams. Average annual peak flows after the dams were completed in 1968 are only 60% of the average annual peak flows that occurred before dam construction (Alsea Geospatial et al. 2000). Reduced peak flows cause a reduction of channel complexity and diversity of rearing habitat for juvenile Chinook.

Hydrology/water quantity. Altered hydrology (10f).

Flood Control/Hydropower Management. Key threat: CHS parr and smolts

Management of the Columbia River hydro system alters the timing and magnitude of spring freshets, and impairs estuarine habitat quality and access. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Predation

Predation by non ESU-DPS fish species (6c).

Hatchery Management. Secondary threat: CHS juveniles

Hatchery steelhead smolts prey on Chinook fry and summer parr.

Predation by rainbow trout (6d).

Hatchery Management. Secondary threat: CHS juveniles

Hatchery rainbow trout prey on Chinook fry and summer parr.

Predation by birds in the estuary (6e).

Land Use Management. Secondary threat: CHS juveniles

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Competition

Competition with hatchery fish in the estuary (4a).

Hatchery Management. Secondary threat: CHS juveniles

Competition with hatchery fish from all Columbia River hatcheries for limited habitat and food supplies in the Columbia River estuary affects productivity of McKenzie Chinook. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Population Traits

Loss of Population traits due to hatchery fish interbreeding with wild fish on spawning grounds (3a).

Hatchery Management. Key threat: CHS spawners

The risk of genetic introgression from interbreeding with hatchery Chinook represents a key threat to the McKenzie Chinook population. The McKenzie Hatchery Chinook program increases the number of natural spawners below and above Leaburg Dam. From 2001 to 2004, hatchery fish comprised 30 to 34% of the natural spawners above Leaburg Dam (Schroeder et al. 2007). Below Leaburg Dam, hatchery fish comprised more than 70% of the natural spawners in 2003 (Firman et al. 2004, cited in NMFS 2004). It is believed the high level of hatchery fish on the spawning grounds in recent years is representative of what occurred over the last few decades. The hatchery program also outplants adults above Cougar and Trail Bridge dams.

5.4.7 Factors and Threats Limiting Viability of Middle Fork Willamette Chinook

The following descriptions of the LFTs are specific to the McKenzie Chinook salmon population. Table 5-20 summarizes the key and secondary LFTs to recovery of the population at different life stages and locations, and subsequent LFT descriptions are organized in a similar fashion.

Table 5-20. The key and secondary LFTs to the recovery of the Middle Fork Willamette Chinook salmon population. See caption in Table 5-10 for explanation table organization, LFT bolding, cell shading and cell patterning. Codes are further defined in Table 5-9.

Middle Fork Willamette Spring Chinook		Rearing and Downstream Migration											Marine Foraging	Upstream Migration and Spawning		
		Natal Subbasin						Mainstem Willamette		West-side Tribs	Estuary		Ocean	Estuary	Mainstem Willamette	Natal Subbasin
Limiting Factor	**General Threat Category**	**Egg / Alevin**	**Fry**	**Summer Parr**	**Winter Parr**	**Smolt**	**Kelt**	**Parr**	**Smolt**	**Parr**	**Parr**	**Smolt**	**sub-adult/ Adult**	**Adult**	**Adult**	**Adult and Spawner**
Habitat Access	Flood Control/ Hydropower					**1f**										**2me**
Physical Habitat Quality	Flood Control/ Hydropower	7fg									**5ab,7h,8a**					
	Land Use		8a		**8a**			8a	**8a**		**5a,** 8a					
Water Quality / Quantity / Hydrograph	Flood Control/ Hydropower	**9f**	**10d**					**10d**			**10f,** 9j					
	Land Use			9ahi	9hi			**9hi**			9ahi				9hi	
Predation	Land Use / Introductions										6e					
	Hatchery Management															
Competition	Land Use / Introductions															
	Hatchery Management										4a					
Population Traits	Hatchery Management															**3a**
	Harvest															

<u>Habitat Access</u>

Impaired downstream passage at Middle Fork Willamette dams (1f).

Flood Control/Hydropower Management. <u>Key threat</u>: CHS smolts

Chinook smolts die while passing through turbines or because they are unable to locate downstream passage at dams and become trapped in the reservoirs.

Impaired adult access to habitat above Middle Fork Willamette dams (2e).

Flood Control/Hydropower Management. Key threat: CHS adults

Dexter, Lookout Point and Hills Creek dams were built without upstream fish passage facilities and block access by adults to an estimated 80% of the historical production area for Chinook (USACE 2001, cited in WRI 2004). ODFW began trucking adult Chinook trapped at Dexter Dam to above Hills Creek Reservoir in 1993 and later expanded the program to include areas above Lookout Point Reservoir.

Fall Creek Dam is also a barrier to fish movement. A trapping facility is in place but upstream migrants may experience abrasion, mechanical injury, and stress, and experience delay in migration and disease when water temperatures are above maximum (WRI 2004).

Impaired adult access and altered hydrology (2m).

Flood Control/Hydropower Management. Key threat: CHS adults

Prespawning mortality occurs due to crowding and high water temperatures below Middle Fork Willamette dams.

Physical Habitat Quality

Impaired food web. Reduced macrodetrital input in the estuary due to Columbia Basin hydropower reservoirs, and disposal of dredge material (5a).

Flood Control/Hydropower and Land Use Management. Key threat: CHS parr and smolts

Reduced macrodetrital-based input in the Columbia River estuary affects viability of the Middle Fork Willamette Chinook population. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired food web. Increased microdetrital input in the estuary due to Columbia Basin hydropower reservoirs (5b).

Flood Control/Hydropower Management. Key threat: CHS juveniles

The estuary's current food web is microdetrital-based, made up of decaying phytoplankton delivered from upstream reservoirs. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired gravel and large wood recruitment due to Middle Fork Willamette flood control facilities (7f).

Flood Control/Hydropower Management. Secondary threat: CHS eggs/alevin

The physical presence of Dexter, Lookout Point, Hills Creek and Fall Creek dams reduce transport and delivery of large wood and gravel to downstream reaches. Because the dams capture material in their reservoirs, delivery of large wood to the lower Middle Fork Willamette River is blocked from 90% of the subbasin (USACE 2001, cited in WRI 2004). Loss of gravel recruitment has reduced suitable spawning areas. In addition, the effect of flow management limits the erosional sourcing and distribution of these materials from floodplain reaches below these facilities.

Streambed coarsening due to reduced peak flows (7g).

Flood Control/Hydropower Management. Secondary threat: CHS eggs/alevin

Flood control operations reduce peak flows, and the resulting frequency of large magnitude flows is not sufficient to create and maintain channel complexity and to provide nutrients, organic matter, and sediment inputs from floodplain areas (WRI 2004). Resulting losses in abundance and distribution of gravels, small cobbles, and large wood (particularly in large jams) have reduced habitat for juvenile rearing.

Impaired sediment/sand routing (7h).

Flood Control/Hydropower Management. Key threat: CHS juveniles

Impaired physical habitat quality in the estuary due to changes in sediment and sand routing has a key impact on Middle Fork Willamette Chinook. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Impaired habitat complexity/diversity, off-channel habitats (8a).

Land Use Management. Key threat: CHS winter parr (tributaries), CHS parr, smolts (mainstem Willamette); Secondary threat: CHS fry and summer parr (subbasin); CHS parr (mainstem Willamette); CHS juveniles (estuary)

Subbasin: Loss of habitat complexity and diversity in the Middle Fork Willamette River system has a key effect on the Middle Fork Willamette Chinook population during the winter parr life stage. The historical removal of large wood from tributary streams and degradation of riparian vegetation have interacted to reduce the quantity and distribution of large wood in the river and tributaries. Limited wood in the river and tributary channels limits the formation of pools, thus reducing the quality and quantity of juvenile rearing habitat (WRI 2004).

Loss of connectivity to historical floodplains also reduces habitat quality for Chinook. Revetments line half of the lower eight miles of the Middle Fork Willamette, which limits habitat complexity. Lower river reaches have lost sinuosity, side-channel length, alcoves, and gravel bars.

The lower subbasin contains only a small fraction of the original floodplain forest. Remaining floodplain forests are interspersed with areas of farmland, pastureland, highways, residences and other development. Roads next to stream channels have increased channel confinement and reduced riparian vegetation and canopy cover. As a result of these land alterations, riparian vegetation within 100 feet of the small tributaries of the lower Middle Fork Willamette is generally in poor condition. Changes in riparian canopy cover have increased summer high water temperatures on some tributary streams (WRI 2004).

The mainstem Willamette River and Middle Fork Willamette basin supports spring Chinook at various life stages throughout the entire year. Habitat degradation in the mainstem Willamette and Middle Fork affects rearing potential and migration characteristics for Middle Fork Willamette Chinook parr and smolts. Juveniles also use Westside tributaries for rearing, and habitat degradation in these drainages can limit this use.

Estuary: In the Columbia River estuary, many once important habitat areas have been affected by land and water management activities. Along the lower Columbia, complex habitats have been modified through channelization, diking, development and other practices. Physical habitat quality in the lower Willamette River has also been reduced through land use practices. The limiting factors in the estuary are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Flood Control/Hydropower Management. Key threat: CHS juveniles.

The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

<u>Water Quality / Quantity / Hydrograph</u>

Water Quality. Elevated water temperature from land uses (9a).

Land Use Management. <u>Secondary threat</u>: CHS summer parr in subbasin and CHS juveniles in estuary

Reduced habitat quality, including changes in riparian canopy cover, contributes to increased water temperatures in some Middle Fork Willamette tributaries. Maximum temperatures for adult Chinook migration have been exceeded in the Middle Fork Willamette River and Fall Creek below the dams, the upper Middle Fork Willamette River above Hills Creek Reservoir, Salt Creek, the North Fork of the Middle Fork Willamette, Lost Creek, Fall Creek above Fall Creek Dam, and other tributaries.

Water quality. Elevated water temperatures due to flow alterations at dams (9f).

Flood Control/Hydropower Management. <u>Key threat</u>: CH eggs/alevin

Reduced flows below the Middle Fork Willamette dams during spring result in increased water temperatures in the mainstem Willamette. Premature hatching of eggs and emergence of Chinook fry due to high water temperatures below the dams in the fall are key impacts on population viability.

Water Quality. Toxins from agricultural sources (9h).

Land Use Management. <u>Key Threat</u>: CHS parr and smolts in mainstem Willamette; <u>Secondary threat</u>: CHS juveniles in subbasin and estuary, adults in mainstem Willamette

Contaminants from agricultural practices found throughout the Columbia River estuary pose a threat to Middle Fork Willamette Chinook. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water Quality. Toxins from urban and industrial sources (9i).

Land Use Management. <u>Key threat:</u> CHS parr and smolts in mainstem Willamette; <u>Secondary threat</u>: CHS juveniles in subbasin and estuary, adults in mainstem Willamette

Toxic contaminants from urban and industrial practices reduce habitat quality for Chinook parr and smolts. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Water Quality. Elevated water temperatures due to reservoir heating (9j).

Flood Control/Hydropower Management. <u>Secondary threat</u>: CHS parr and smolts

Elevated water temperatures in the estuary due to reservoir heating in Columbia Basin pose a secondary threat to Middle Fork Willamette Chinook. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Hydrology/water quantity. Altered hydrology; reduced peak flow (10d).

Flood Control/Hydropower Management. <u>Key threat</u>: CHS fry and parr in subbasin, CHS parr and smolt in mainstem Willamette

Dam operations alter downstream flow regimes. Elevated flows to draft the reservoirs in preparation for flood control season occur in the fall during spawning. Reduced flows after drawdown if the fall is dry or during flood control operations can dewater redds. Flow fluctuations can occur at rates rapid enough to entrap and strand juvenile anadromous fish (WRI 2004).

Hydrology/water quantity. Altered hydrology (10f).

Flood Control/Hydropower Management. Key threat: CHS parr and smolts

Management of the Columbia River hydro system alters the timing and magnitude of spring freshets, and impairs estuarine habitat quality and access. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Predation

Predation by non-native fish species (6b).

Land Use Management, Hatchery Management, and Species Introductions. CHS juveniles in the estuary

In the estuary this threat is the same as described for Clackamas Chinook in Section 5.4.1.

Predation by birds in the estuary (6e).

Land Use Management. Secondary threat: CHS juveniles

Modification of estuarine habitats has increased the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species in the Columbia River estuary (LCREP 2006; Fresh et al. 2005). The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Competition

Competition with hatchery fish in the estuary (4a).

Hatchery Management. Secondary threat: CHS juveniles

Competition with hatchery fish from all Columbia River hatcheries for limited habitat and food supplies in the Columbia River estuary affects productivity of Middle Fork Willamette Chinook. The limiting factors are the same as those discussed for Clackamas Chinook in Section 5.4.1.

Population Traits

Loss of Population traits due to hatchery fish interbreeding with wild fish on spawning grounds (3a).

Hatchery Management. Key threat: CHS spawners

The small number of naturally-produced Chinook in the Middle Fork Willamette (the population was considered extirpated by ODFW) coupled with the preponderance of hatchery fish in the naturally spawning population represents a key concern to the population's viability. The Willamette Hatchery Chinook program increases the number of spawners downstream and upstream of Dexter Dam and in Fall Creek. Interbreeding between hatchery Chinook and natural origin spawners alters the genetic characteristics of the wild population.

Chapter 6: Delisting Goals, Criteria and Scenarios

Chapter 6 describes scenarios in which the desired status of individual Chinook salmon and steelhead populations combine to achieve the desired status (delisting goals) of the ESU and DPS, and an approach to achieving the desired status through threat reductions. The chapter outlines a set of threat reduction options (scenarios) that illustrate how to achieve these population goals. As noted in Chapter 3, this Plan recommends recovery goals that are believed to be consistent with ESA delisting. As noted in Chapter 3, this Plan has two broad recovery goals, and therefore different levels of desired status:

1. an ESU-level desired status that is consistent with ESA delisting of an ESU (see details of NMFS delisting framework and criteria in Chapter 1).
    a. Tiered within this desired status for the ESUs, this Plan also identifies desired statuses for individual populations within the context of this broader ESU delisting goal, as described in this chapter.
2. a level of desired status for individual populations that is consistent with the State of Oregon's vision of broad sense recovery. A description of Oregon's broad sense recovery vision and approach is described in Chapter 10 of this Plan

In the first section of this chapter we describe an ESU-level desired status scenario, consistent with viability criteria for a viable ESU (see Chapter 3 regarding delisting criteria in an ESA framework for each ESU). Since a viable ESU can consist of different combinations of populations at different risk levels, this section also identifies one example of how the desired status for individual populations could combine to meet the desired status scenario for the ESU. We also assume that achieving some combination of viable populations (as outlined by the WLC-TRT viability criteria; McElhany et al. 2003) would meet the biological criteria for an ESU to be evaluated within the context of an ESU delisting decision. Given that the population extinction risk analyses were based on biological criteria and summarized in units of extinction risk based on the VSP parameters (Chapter 4), a population's desired status was also defined in terms of extinction risk. For the threat criteria it was assumed that the Limiting Factors and Threats assessment (Chapter 5) characterized sufficiently the factors impeding viable populations.

In the second section of this chapter, two independent approaches are used to analyze population-level demographic parameters within an extinction risk framework. The first approach used the conservation gaps developed in Chapter 4 to establish some VSP recovery targets, and applied some threat reduction scenarios to portray ways to functionally achieve a desired status for a population. The analyses did this by combining the LFT organizational framework (Chapter 5 LFTs) with classes of key actions (Chapter 7) that address specific LFTs. The major objective of these population-specific threat reduction scenarios was to conceptualize how a suite of actions addressing LFTs could recover a population to a desired status that is founded on VSP criteria. The scenarios help scope the likelihood of actually achieving desired status for a population, based on an understanding of the types of actions (and their relationships) that would reduce the impact of specific LFTs.

The second approach used an analytical platform from the Species Life-cycle Analysis Modules (SLAM, developed by NOAA's Northwest Fisheries Science Center - NWFSC) to provide a more explicit analysis of life stage demographic parameters. SLAM was used in this Plan as a provisional cross test of the threat reduction scenario analyses, where improvements in limiting factors are modeled with population dynamics in explicit life stages to produce levels of extinction risk. This analysis is designed to add to the "weight of evidence" that the overall approach to achieving desired status for populations is sound.

6.1 Scenario Options for Meeting Biological Delisting Goals and Criteria

The WLC-TRT viability criteria for a viable ESU and DPS as outlined in Chapter 3 and detailed in the WLC-TRT report (McElhany et al. 2003) provided the framework for how to meet the desired status of the ESU/DPS, by considering the desired risk statuses for individual populations. Therefore the desired status for individual populations in the following population sections represents a desired status for a population within the broader ESU and DPS viability context and delisting goals. Table 6-1 presents some options/combinations of UWR population statuses (expressed as risk classes and scores; see Chapter 4) that could be used to meet an ESU/DPS-level desired status of biological viability for the Chinook salmon ESU and steelhead DPS

Chinook

The desired status of each UWR Chinook population for ESU desired status (meeting ESU biological viability goals) is shown under "ESU Scenario 1" in Table 6-1. Although some of the other ESU scenarios were discussed with the Planning and Stakeholder teams, Scenario 1 represented the most balanced approach given limitations in some populations. The approach in this Plan to achieve ESU delisting of UWR Chinook salmon is to recover the McKenzie (core and genetic legacy population) and the Clackamas populations to an extinction risk status of very low risk (beyond minimal viability thresholds), to recover the North Santiam and Middle Fork Willamette populations (core populations) to an extinction risk status of low risk, to recover the South Santiam population to moderate risk, and improve the status of the remaining populations from very high risk to high risk.

Steelhead

The desired status of each UWR steelhead populations for DPS viability goals is shown under "ESU/DPS Scenario 1" in Table 6-1. The most current PVA simulations of biological viability criteria indicated this DPS as viable, and for DPS delisting purposes it is assumed that what remains is to address the threats criteria. This Plan's approach to ESU delisting of UWR steelhead is to assure no population has a higher extinction risk than currently, and to maintain or improve all core populations and one non-core population to a viable level. To the extent that actions that benefit UWR Chinook salmon will also increase the viable abundance/productivity and spatial structure parameters for steelhead, it s projected that most or all steelhead populations could achieve a very low risk level.

Table 6-1. A summary of different combinations of population-level desired statuses (expressed as extinction risk classes and scores based on VSP criteria; see Chapter 4 for scoring thresholds), to meet ESU/DPS **-level desired status based on** ESU/DPS **viability criteria (see Chapter 3 for the ESU delisting criteria).** ESU/DPS **scenario 1 (shaded) was chosen as the** ESU/DPS **-level desired status goal for this Plan. * indicates core population, and ** indicates genetic legacy population.**

		ESU Scenario Options for meeting UWR ESU viability criteria				
Population	Current Extinction Risk-all VSP factors (score)	1	2	3	4	5
Chinook						
Clackamas*	Moderate (2)	Very Low (4)	VL (4)	VL (4)	VL (4)	VL (4)
Molalla	Very High (0)	High (1)	H (1)	H (1)	VH (0)	VH (0)
North Santiam*	Very High (0)	L (3)	L (3)	L (3)	L (3)	L (3)
South Santiam	Very High (0)	M (2)	L (3)	L (3)	L (3)	H (1)
Calapooia	Very High (0)	H (1)	H (1)	H (1)	VH (0)	H (1)
McKenzie**	Low (3)	VL (4)	VL (4)	VL (4)	VL (4)	VL (4)
MF Willamette*	Very High (0)	L (3)	L (3)	M	L (3)	L (3)
N of viable Pops.	1	4	5	4	5	4
ESU Average Score	0.71	2.57	2.71	2.43	2.43	2.29
N of Viable Core pops.	1	4	4	3	4	4
Steelhead						
Molalla	L (3)	VL (4)	L (3)			
North Santiam*	L (3)	VL (4)	L (3)			
South Santiam*	L (3)	VL (4)	VL (4)			
Calapooia	M (2)	M (2)	L (3)			
N of viable Pops.	3	3	4			
DPS Average Score	2.75	3.5	3.25			
N of Viable Core pops.	2	2	2			

6.2 Threat Reduction Scenarios for Meeting Goals and Criteria

This section describes the development by ODFW of the population-level threat reduction and VSP scenarios that illustrate how to achieve the population-level desired statuses that were chosen under ESU-level desired status Scenario 1 in the previous section. This section also describes how scenario projections were evaluated with another viability model.

6.2.1 Methods

This section, along with Section 6.3, describes the technical approaches ODFW used to create the recovery scenarios that form the overall game plan for recovery of the UWR Chinook salmon ESU and steelhead DPS. We describe the specific scenarios in Section 6.2.2

To provide a logical framework for how threat reductions are manifested into different levels of reduced extinction risk, we partitioned the broad threats identified in Chapter 5 into sub-categories for which there was a reasonable assumption we could assign some index of current impact on abundance and productivity (A/P). The broad threats identified in Chapter 5 each had multiple limiting factors, had overlapping impacts on life history stages, and had potential cumulative and interactive effects on population viability. In addition, for many populations there were no life-stage specific data, and there was uncertainty of unknown magnitude for many population parameters and threat rates. Given these limitations, the threat categories chosen for our Scenario Analysis do not match the threat categories identified in Chapter 5. We refined this threat characterization by making sub-categories within a threat category, based on a significant life-stage or geographic area where an LFT was thought to have the most impact, and how it roughly corresponded to the entities that would implement actions to address a limiting factor. We ended up with ten sub-categories (Table 6-2), which to each was assigned estimates of current mortality rates, which was our index of current impact on A/P. Table 6-3 shows how the Chapter 5 threat categories were encompassed by the threat subcategories used for the threat reduction scenarios.

Table 6-2. Partitioning of Chapter 5 broad threat categories into subcategories for finer resolution of impact rates and to refine the association with threat reductions.

Broad Threat Categories	Threat Subcategories
Flood Control/Hydropower Management	Spawner Access Juvenile Passage Spawner Habitat Juvenile Habitat
Land Management	Freshwater Habitat Estuary Habitat
Other Species Management	Other Species-predation
Harvest Management	Harvest
Hatchery Management	Juveniles- competition Spawners

Table 6-3. The relation of Chapter 6 threat categories used for the Scenario Analysis to the threat categories used in Chapter 5. Chapter 6 subcategories are in capital letters and unique fill colors within the table. Black cells indicate that the threat for that life stage cannot exist or was not identified as a threat in Chapter 5.

		Life Stage									
	Threat Categories in Chapter 5	Egg / Alevin	Fry	Summer Parr	Winter Parr	Out of Basin Parr	Smolt	Sub adult	Adult	Spawner	Kelt
Natal Subbasins	Harvest Management									HARVEST	
	Flood Control/Hydro Management	JUVENILE HABITAT CONDITIONS							SPAWNER HABITAT CONDITIONS		PASSAGE
			JUVENILE PASSAGE							SPAWNER ACCESS	
	Hatchery Management		HATCHERY-juvenile competition							HATCHERY-genetics	
			OTHER SPECIES-fish predation								
	Land Management (Non Hydro)	FRESHWATER HABITAT							FW HABITAT		
	Other Species		OTHER SPECIES-fish predation								
West Side Tributaries	Harvest Management										
	Flood Control/Hydro Management										
	Hatchery Management										
	Land Management (Non Hydro)	FRESHWATER HABITAT							FW HABITAT		
	Other Species										
Mainstem Willamette (above Will. Falls)	Harvest Management								HARVEST		
	Flood Control/Hydro Management		JUVENILE HABITAT CONDITIONS-out of basin effects								
	Hatchery Management										
	Land Management (Non Hydro)	FRESHWATER HABITAT							FW HABITAT		
	Other Species										
Estuary	Harvest Management								HARVEST		
	Flood Control/Hydro Management					JUVENILE HABITAT CONDITIONS-out of basin effects					
	Hatchery Management					HATCHERY-juvenile competition					
	Land Management (Non Hydro)					ESTUARY HABITAT					
						OTHER SPECIES-bird and fish predation					
	Other Species										
Ocean	Harvest Management							HARVEST			
	Flood Control/Hydro Management										
	Hatchery Management										
	Land Use Management (Non Hydro)										
	Other Species										

In Chapter 4, abundance targets and conservation gaps at different extinction risk level were defined with a CATAS model, and those targets were used in threat reduction scenarios to help evaluate the extent to how much the threats should be reduced to meet these VSP targets. CATAS simulations established the increases in adult abundance for a population to achieve particular extinction risk levels (e.g., high, medium, low, or very low), therefore the conservation gap is the difference between a population's current modeled abundance and the abundance needed to achieve a desired level of extinction risk. Although CATAS functions to decrease extinction risk with increases in survival, conversely, closing conservation gaps to achieve desired risk levels for each population can be accomplished with mortality reductions.

We have extended the currency of a conservation gap and the VSP principles to the threat reduction scenarios below, where scenarios are essentially an heuristic approach to show how the threats could be reduced in a systematic fashion, based on professional opinion. This coupling of addressing the biological *and* threats criteria discussed in Chapter 3 is referred to as the "Scenario Analysis". The major objective of these population-specific threat reduction scenarios was to formulate how a suite of actions addressing LFTs could recover a population to a desired status that is founded on VSP criteria. The scenarios help scope the likelihood of actually achieving desired status for a population, based on an understanding of the types of actions that would reduce the impact of specific LFTs. Note that the simplicity of this approach and the treatment of threats are based on assumptions that all of the threats are density independent and act in some way on separate life stages or sequential groups of fish. In this analysis, we have accepted these simplifying assumptions in order to set some guidance for how to implement actions necessary to achieve desired statuses. We have tested the basic validity of this approach by using a more complicated model (SLAM, below) that allows for density dependence and life stage-specific mortality to compare the results of the Scenario Analysis.

The Scenario Analysis provides simple quantification of mortality influencing the A/P VSP criteria by LFT category, allowing a rapid assessment of different threat reduction hypotheses for achieving different extinction risk levels. For spatial structure and diversity VSP parameters there are no analogous PVA-derived numerical goals for different risk level conservation gaps. For the diversity parameter it was assumed that many diversity elements are partially determined by abundance, and the dominant threat to diversity is the impact of hatchery strays on genetic diversity. We concur with the WLC-TRT that viable populations would have low hatchery genetic influence, and based on the guidelines for the porportion of hathery fish spawning with wild fish (pHOS) in McElhany et al. (2007) we have adopted the following levels for the pHOS: If the overall desired status goal for a population is low risk or very low risk, then in addition to meeting the abundance and productivity targets for this designation, the diversity target is achieving an average pHOS of ≤10%, regardless of their spawn timing. Likewise, if the recovery goal risk category for a population is 'moderate' then the target average pHOS is ≤ 30%. Chapter 8 outlines the RME approach for assessing the proportion of naturally spawning hatchery fish (pHOS) in the future.

It was assumed that spatial structure attributes would be improved to viable levels principally by fish passage actions that resulted in significant access to and production within previously blocked habitat. It was also assumed that if the abundance and productivity risk level goals were met, they would augment the spatial connnectivity of a population to the extent that spatial structure risk is aligned with those of abundance and productivity.

The UWR Planning Team evaluated 1) the approach for assigning impact (mortality) rates within the ten threat subcategories, 2) what current impact rate to assign to each subcategory, and 3) what would be the assumptions regarding feasible reductions in those rates. Ultimately the evaluation process was constrained by uncertainty in impact rates for some of the subcategories, and what would be feasible improvements in some of the freshwater habitat impacts. The consensus of the Team was that the scenarios should be used to scope how reducing a few large impacts, using a range of impact values, would "close" a conservation gap. These adjustments were made and when feasible habitat impact reductions were considered, it resulted in very few scenario options. These options were presented to the Stakeholder Team to illustrate societal tradeoffs in threat reductions. The results are the threat reduction scenarios and choices below, which illustrate options for reducing anthropogenic threats to ESA-listed salmonids across several threat categories to achieve a desired risk class for individual populations, based on achieving a viable ESU.

A comprehensive evaluation of population status should also include an examination of the threats facing the population with an emphasis on future environmental conditions. As noted in Lindley et al. (2007), natural climate variability can have a large influence on whether viability criteria are being met. For example, the viability criteria we have proposed may not be protective enough if unfavorable climatic conditions persist over long periods. In addition, poor climatic conditions may mask actual improvements in the LFTs, and could curb the future efforts of implementers and the larger society. Conversely, prolonged periods of favorable climatic conditions may lead to greater population health and the achievement of A/P viability criteria, when in fact, serious problems remain with some LFTs. Therefore, understanding future climatic trends and conditions is necessary to address the stationarity assumption inherent in a biological factor analysis. This assumption would be violated if future environmental conditions were different from the recent past (where "environment" is defined broadly to include anything affecting salmonids). In developing the scenario analysis we did not conduct an assessment of likely future environmental conditions and their projected impacts on population biological status. Instead, we largely relied on the stationarity assumption[60], but made some precautionary adjustments to the abundance conservation gaps as a way of providing a buffer for these likely future impacts. For example, although there is uncertainty regarding the magnitude of the future effects of climate change and human population growth on these salmonid populations, we assume it will be negative. Therefore for each population we have provisionally embedded a conservation buffer in the scenarios by increasing the conservation gap mean abundances by 20%[61].

We reiterate that there is a fair amount of uncertainty in each mortality rate estimate assigned, as well as in the associated "conservation gaps" obtained from CATAS. In many cases values used in analyses were derived without strong empirical data, there is the potential for inaccurate assumptions, the potential for qualitative opinions to propagate uncertainty, and the potential for inter-related analyses to compound uncertainty. RME (Chapter 8) applied within an adaptive management framework (Chapter 9) will be used to reduce uncertainty and refine recovery actions as appropriate in the future. As noted earlier, in practical terms the adaptive management component of this Plan with review of regular population status updates allows evaluation of such potential future threats in a timely manner and subsequent revisions of recovery actions as needed.

Developing a Total Cumulative Mortality Expression and Assigning Current Impact Rates to Freshwater Habitat

The first step in developing threat reduction scenarios for the Scenario Analysis was to assign a current impact for each threat subcategory in Table 6-2. We chose to aggregate and characterize the subcategory

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[60] A "stationarity assumption" is that the recent past is a reasonable predictor of future fish performance

[61] The 20% increase in the abundance goal for each conservation gap was chosen as a temporary approach to address population growth and climate change. It is currently not possible to accurately estimate the level of productivity loss, if any, that steelhead populations will experience due to these factors. The 20% increase was added to ensure that an increasing trend in population health would occur at the initial implementation of the recovery Plan and allow for the science related to identifying the impacts of these factors to evolve. Once a more accurate estimate of the impacts of population growth and climate change can be made, it will be possible to adjust the scenario goals in the Recovery Plan.

impacts as mortality estimates. The cumulative mortality of the subcategory threats represents an anthropogenic mortality rate that is used to calculate the difference between a population's modeled current abundance (from stock-recruitment simulations; Chapter 4) and an estimate of abundance prior to European-derived impacts (historical abundance). With impact rates established for each threat category, reductions in them were evaluated to achieve the CATAS-derived abundance targets for a desired status risk level.

We used the following expression to represent a cumulative mortality impact from different mortality sources.

TCM = 1-((1-SAM)x(1-JHM)x(1-SHM)x(1-FWHM)x(1-EHM)x(1-OSM)x(1-HM)x(1-JCM)x(1-HFM))[62]

where: TCM = total cumulative mortality = current abundance/historic abundance

SAM = mortality associated with spawner access

SHM = mortality associated with spawner habitat conditions

JHM = mortality associated with juvenile habitat conditions due to flood control/hydro

FWHM = mortality associated with freshwater habitat conditions (non flood control/hydro)

EHM = mortality associated with estuary habitat conditions

OSM = mortality associated with other species

HM = mortality associated with harvest

JCM= mortality associated with juvenile competition

HFM = mortality associated with hatchery fish

We obtained estimates of historical abundance for the ESU and DPS from NMFS status reviews and the WLC-TRT documents. To obtain estimates of the historical abundance of individual Chinook populations we multiplied the Mattson's (1948) relative proportions of fish migrating over Willamette Falls and the WLC TRT's estimate for the ESU. For steelhead we used Howells et al. (1985) estimate of relative proportions and multiplied those by the WLC-TRT ESU estimate of historical run size. These steps apportioned the ESU/DPS abundance estimate between populations.

We were able to develop reasonable impact estimates of all the variables except the JHM and FWHM terms (see details below). Because we had little or no information on the current impact of freshwater habitat alterations, we assigned the current freshwater habitat impact as the remaining difference between the current modeled abundance and historical abundance after the other threat category impacts were removed (likewise, because of the lack of habitat-based data for most populations, a modeled approach was not used to determine whether specific habitat-based actions would provide the desired improvements in this area. Instead, professional judgment was used in this area to assess whether the proposed type, location, and amount of actions would achieve the desired statuses). The main assumption of this approach is that the difference in abundance from historic to current conditions is equal to the cumulative impact of all the threat subcategories. For example, a population with a current abundance that is 40% of historic abundance has lost 60% of its historic abundance. This 60% loss represents a cumulative impact to the survival of the population across all threat subcategories. The TCM equation was used to explore some test values for these two terms simultaneously. However, in the end, there was no clear basis to assign different values to these terms so the JHM and FWHM were assigned the same value, and both were used as separate terms in the TCM calculation. By equally adjusting these values in

62 For the TCM equation there is no term for current mortality impact from lack of downstream passage (JPM in following tables). It was assumed that lack of spawner access above large flood control/hydropower projects precluded production of naturally produced juveniles, and that total above-barrier mortality was included in the spawner access category. Therefore the Juvenile Passage Mortality term (JPM) was combined with SAM in the TCM equation.

the TCM equation so that that TCM matched the current modeled abundance, we thereby obtained estimates of mortality associated with these freshwater habitat threats under current conditions (Table 6-4).

Table 6-4. Estimates for UWR Chinook and steelhead current and historical abundances, total cumulative mortality, estimated mortality rates, and calculated threat rates. Estimates include population current abundances based on modeled baseline (current) conditions (from Chapter 4), historic abundances, total cumulative mortality under current baseline conditions (current abundance / historic abundance), and estimates of mortality rates for threat subcategories based on analyses of available data ("known"). The calculated threat rate for freshwater habitat is partitioned between tributary habitat impacts due to flood control/hydropower on juvenile life stages, and tributary and mainstem Willamette River habitat impacts due to other land management impacts. See equation above for detail of acronyms.

				"Known" Mortality (threat) Rate									Calculated Threat Rate	
				Flood Control/Hydro			Land Use	Other Species	Harvest	Hatchery			
Population	Current Modeled Abundance	Historic Abundance	TCM (Cumulative Mortality)	SAM	Juvenile Passage	SHM	EHM (Juveniles)	OSM (adults and Juveniles)	HM (Adults)	JCM	HFM	JHM	FWHM
Chinook													
Clackamas	1,371	27,673	0.95	0.27	---	---	0.10	0.12	0.25	---	0.33	---	0.83
Molalla	0	13,750	1.0	0.00	---	0.00	0.10	0.16	0.25	0.05	0.95	0.00	1.00
N Santiam	0	56,100	1.0	0.71	---	0.60	0.10	0.17	0.25	0.05	0.90	0.97	0.97
S Santiam	1	37,400	>0.99	0.85	---	0.30	0.10	0.17	0.25	0.05	0.90	0.95	0.95
Calapooia	0	9,500	1.0	0.00	---	0.00	0.10	0.16	0.25	0.05	0.95	0.0	1.00
McKenzie	4,885	110,000	0.96	0.25	---	0.10	0.10	0.18	0.25	0.05	0.35	0.56	0.56
MF Will.	0	57,750	1.0	0.95	---	0.80	0.10	0.16	0.25	0.05	0.95	0.87	0.87
Steelhead													
Molalla	2,443	77,000	0.97	0.00	---	0.00	0.10	0.16	0.16	0.05	0.19	0.00	0.94
N Santiam	3,671	75,240	0.95	0.48	---	0.00	0.10	0.17	0.16	0.05	0.14	0.57	0.57
S Santiam	2,701	50,160	0.95	0.18	---	0.00	0.10	0.17	0.16	0.05	0.04	0.66	0.66
Calapooia	415	17,600	0.98	0.00	---	0.00	0.10	0.16	0.16	0.05	0.19	0.00	0.96

As an initial cross check for this approach to determining the impact of anthropogenic alterations to freshwater habitat, we compared our McKenzie River Chinook estimates to those estimated by summarizing the current and historic habitat potential in a draft Ecosystem Diagnosis and Treatment (EDT) analysis, reported in a draft Willamette Subbasin Plan (NPCC 2004). Preliminary EDT from that report noted that the current habitat potential is estimated about 18% of that under the reference (historic) habitat conditions. For purposes here it was assumed this also represents an 82% habitat mortality impact due to human influence. In the Scenario Analysis using the TCM equation above, we entered our best assumptions about other sources of mortality and the current abundance estimates, then solved the equation to find the estimated mortality impacts for JHM and FWHM, which were 56% for the McKenzie. Multiplicatively combining these two sources yielded a total freshwater habitat impact of 80%, a very close approximation to the EDT result (Table 6-5; 98% agreement). In addition, our comparison to EDT for Clackamas yielded a 92% agreement. In the absence of a more comprehensive method to determine freshwater impact rates, it is acknowledged there is potentially large uncertainty surrounding the impact of freshwater habitat conditions. One concern that emerged in light of comments received is that the process described above can produce a result that the JHM and FWHM multipliers (0.97) overshadow other potential sources of mortality. This could lead to the potentially erroneous conclusion that eliminating one or more of the other sources of mortality would have no significant beneficial effect on survival. For this reason, it is important to underscore the potential for misinterpretation of these model results.

Table 6-5. Comparison of mortality rates attributable to anthropogenic impacts on freshwater habitat as estimated by our Scenario Analysis and EDT.

Population	Current Threat Estimate	EDT estimate	Percent Agreement
Clackamas Chinook	84%	77%	92%
McKenzie Chinook	80%	82%	98%

Assigning Current Impact Rates with Mortality Estimates

The impact rates under current conditions for each threat subcategory and population were based on the information below.

Flood Control/Hydropower Management

Subcategory: Spawner Access

For populations where spawner access to historic habitat was limited by large flood control/hydropower facilities, we assumed the proportion of historic habitat blocked by these projects bore a 1:1 relationship with loss of production capacity, which by extension could be used as a mortality estimate for the flood control/hydropower impact for this life stage. Thus if a facility blocked 70% of the historic spawning habitat, we assumed a 70% mortality rate associated with lack of spawning access. We assumed that by providing access to these habitats the *loss of capacity* impact would be reduced by actions addressing pre-spawning mortality associated with providing spawner access, and by actions to reduce mortality of juveniles as they migrate downstream in the flood control/hydro system. Table 6-6 summarizes some estimates of the amount of freshwater habitat lost due to blockage by flood control/hydropower facilities for populations. For the current mortality rate for Chinook for this subcategory, we used the percent of historic production lost from dams as reported it the WP BiOp (NMFS 2008a; but see footnotes in Table 6-6 for modifiers to these estimates). For steelhead there were no pre-dam estimates of historic production lost, so we used the estimates based on the intrinsic potential method (IP) in Table 6-6.

Table 6-6. **Estimates of % historically available habitat (intrinsic potential, IP) blocked by mainstem hydro/flood control facilities, estimate of historic production lost, and estimate of current potential spawning habitat conditions. Numbers in parentheses for McKenzie and MF Willamette are IP proportions corrected for proportion of historic production. Bolded values are those used in analyses.**

	Intrinsic Potential (IP) Method		TRT Viability Report (2003)	WP BiOp (NMFS 2008a)	R2 Resource Consultants (2008, Table 6)
Population	% of Total IP above mainstem hydro/flood control facility	% of Total IP available above mainstem hydro/flood control facility with reservoir correction	% inaccessible habitat	% historic production lost from dams	Current Potential % Spawning Habitat above Dams
Chinook					
North Santiam *above Big Cliff*	43%	39%	42%[1]	**71%[2]**	72%
South Santiam *above Foster*	14%[8]	11%[8]	40%[1]	**85%[3]**	66%
McKenzie	19%[4]	16%	25%	**25%[5]**	Not assessed
above Leaburg	51%				
above Blue River	7%	5% (8%)			
above Cougar	9%	8% (12%)			
above Trail Bridge (including Smith Res)	4%	3% (5%)			
MF Willamette	71%	64%[7]	56%	**95%[6]**	94%
Falls Creek	17%	15% (22%)			
above Dexter (including Hills Creek)	56%	49% (73%)			
above Dexter (not including Hills Creek)	33%	29%			
Steelhead					
North Santiam *above Big Cliff*	**48%**	44%	46%[1]	No estimate	39%
South Santiam *above Foster*	**18%[8]**	15%	17%	No estimate	63%

[1] citing ODFW (2005) report
[2] citing Mattson (1948)
[3] direct from Mattson (1948)
[4] does not include Leaburg; includes Blue River, Cougar, and Trail Bridge Dams
[5] WP BiOp (NMFS 2008a) cites ODFW (2005) as 16% of historic habitat is blocked by dams, whereas Maher (2005) estimated a 25% loss.
[6] includes Fall Creek Dam as inaccessible
[7] above Falls Creek and Dexter total
[8] assumes Foster Dam is not an IP barrier

Subcategory: Juvenile Passage

For the Scenario Analysis we did not include an estimate of current mortality impact from lack of downstream passage. Rather, we assumed that lack of spawner access above large flood control/hydropower projects precluded production of naturally produced juveniles, and that total above-barrier mortality was included in the spawner access category. Under a threat reduction scenario where spawner access was restored and habitat above a dam was fully seeded, we factored in a range of juvenile passage survival estimates.

Subcategory: Spawner Habitat Conditions

This threat subcategory principally addressed pre-spawning mortality of Chinook salmon. In subbasins with flood control/hydropower facilities, a combination of factors may be contributing to this mortality. One likely factor is due to stress associated with large numbers of hatchery fish that comprise a large portion of the run. Their presence in high numbers might lead to crowding in limited holding areas or contribute to disease transmission. In addition, the effect of dam operations that produce cooler spring/summer water temperatures below dams may delay upstream migrations and contribute to this mortality. In subbasins without flood control/hydro facilities and without larger numbers of hatchery fish (Molalla and Calapooia populations), it was assumed pre-spawning impacts were principally a result of high summer water temperatures (resulting from lack of riparian shading and other land use effects) combined with a lack of deep holding pools, and harassment/poaching issues. Because of this, the pre-spawning threat for the Molalla and Calapooia basins were included in the freshwater land management category below.

As an estimate of this threat under current conditions, we used pre-spawn mortality estimates collected by ODFW over the last several years. There is a high amount of uncertainty associated with the pre-spawn mortality data (see details in Schroeder et al. 2007), but provisionally we have estimated current conditions in Table 6-7.

Table 6-7. Estimates of pre-spawning mortality of UWR Chinook salmon, used to model the current impact of this mortality source in subbasins with flood control/hydro facilities and large hatchery programs. It is assumed a principle cause of this mortality is flood control/hydro related effects on water quality and fish crowding below the facilities. Other potential contributors to pre-spawning mortality include crowding by large numbers of hatchery-origin fish, disease, parasites, toxic bioaccumulation, and loss of health due to being caught and released and attacked by pinnipeds.

Chinook Population	% Pre-spawn Mortality below dams
North Santiam	60%
South Santiam	30%
McKenzie	10%
Middle Fork Willamette	80%

Subcategory: Juvenile Habitat Conditions

Estimates for flood control/hydropower related habitat impacts (and in the following subcategory under Land Management: Freshwater Habitat) were not available for any of the populations, so we used a provisional back-calculation method to assign an impact for this subcategory. (See the *Total Cumulative Mortality and Assigning Current Impact Rates to Freshwater Habitat* subheading).

Land Management

Subcategory: Freshwater Habitat

We assumed that much of the impact due to the freshwater habitat threat was not related to flood control/hydro effects on habitat quality, but rather other land management practices that impact both adult and juvenile life stages in natal tributaries, and principally rearing habitat in the Willamette River mainstem and some Westside tributaries of the Willamette. Both juvenile and adult life stages are impacted by this freshwater habitat threat (see LFT assessment Chapter 5). There was no clear approach to assign impact estimates to this subcategory so we relied on a provisional back-calculation method to assign an impact for this subcategory (See the *Total Cumulative Mortality and Assigning Current Impact Rates to Freshwater Habitat* subheading).

Subcategory: Estuary Habitat

Based on information presented in Estuary Recovery Module (NMFS 2008b), the mortality rate for coho and steelhead passing through the Columbia River estuary was assumed to be 40% for yearly outmigrants, (coho, steelhead, and spring Chinook) and 50% for subyearling migrants (fall Chinook and chum salmon). This estimate includes both natural and human related sources of mortality. Since the focus of recovery efforts is on impacts caused by humans, mortality that occurred under pristine conditions was separated from the additional mortality associated with human impacts. We adapted the approach of Magnuson and Hilborn (2003), wherein the estuarine habitat condition in Oregon and Washington were classified in terms of the percentage of the estuary not impacted by human activity. For fall Chinook (an ocean type or sub-yearling species that spends less than a full year rearing in freshwater), Magnuson and Hilborn (2003) found a relationship between estuary survival rate and proportion of the estuary that was still in a natural state. This relationship predicted that an estuary with no natural habitat left would have a fall Chinook survival rate of only 30% relative to fall Chinook migrating through an estuary with no human impacts. This equates to 70% of the fall Chinook mortality resulting from human impacts in degraded estuaries.

The same study looked at coho (a stream type or yearling species) and found no relationship between the amount of an estuary in natural condition and survival rate. In interpreting these results for application to the Columbia estuary it was assumed that: 1) estuary habitat for the Columbia is more degraded than most estuaries examined by Magnuson and Hilborn (2003) and therefore could be viewed as having essentially no remaining natural areas; and 2) the impact of poor estuary habitat on coho probably exists, but perhaps below the level statistically detectable in the Magnuson and Hilborn (2003) study. Based on these assumptions we concluded that 70% of the mortality estimated for sub-yearling species for the Columbia was likely human related. For steelhead, and yearling Chinook we simply split the difference between the 70% impact rate and 0% to come up with a provisional estimate of 35% of the total mortality to be apportioned to human related impacts.

The human related mortality due to estuary habitat was estimated by:

$$1)\quad TEM = M_{total} * F_{human}$$

Where TEM = total estuary mortality due to human related factors, M_{total} = total natural and human mortality rate, by species, as reported in the Estuary Module and F_{human} = fraction of total mortality that was human related as described above. Solving for Equation 1 results in an estuarine mortality rate due to human related impacts of 0.35 * 0.40 = 0.14 for steelhead and spring Chinook.

However, it was necessary to make an additional adjustment to these values because the total estuary mortality impacts reported in Estuary Module (i.e., 40% for yearlings and 50% for sub-yearlings) included the effects of predation on juveniles. Based on other studies as sources for the total impact of each predator class (Ward et al. 1995, Friesen and Ward 1999, Roby et al.

1998, LCFRB 2004, USACE 2005 and 2007b, USFWS 2005, Collis et al. 2007), we adjusted these rates downward to partition out the fraction of the impact that is of human origin. To do this we used the same fractions as for the habitat calculation (i.e., 0.35 for yearlings). Finally, these adjusted predation impacts were removed from the human related estuary habitat impacts using a multiplicative formula rather than a simpler, but incorrect mathematical approach of subtracting the predation impact. The net results of this removal are the final estimates for human related impacts for estuary habitat for steelhead and spring Chinook of 0.1.

Other Species

The principal impact on UWR Chinook and steelhead from other species is predation. In the estuary the predation impacts were basically a combination of the adjusted predation impacts that were partitioned out from the estuary habitat impact described for the subcategory "Estuary Habitat" above. Sources of predation are principally from terns, cormorants, and pikeminnow and the mortality impacts caused by pinniped predation. For pinnipeds, we assumed all of the mortality that occurred at Willamette Falls was human related, whereas for pinniped predation downstream from Willamette Falls we assumed that 50% of the estimated impact rate was natural and 50% related to changes due to humans. We assumed the predation impact due to migrating past Willamette Falls was equal to the impact of migrating past Bonneville Dam, so we applied the same base predation rate estimate as we used for the Hood River Chinook population in the Lower Columbia River Recovery Plan (~.16). We also assumed that some populations above Willamette Falls had additional freshwater predation due to anthropogenic influences, based on those identified in the Limiting Factors and Threats process. Since we had no estimates for these freshwater predation impacts, we multiplied the base estuary rate by factors between 5-20% (depending on population) to derive a freshwater predation term that could be added to the total predation equation. We combined these various sources of mortality in a multiplicative rather than additive fashion. To accomplish this, mortality rates were converted to survival rates (1 – mortality rate). These survival rates were then all multiplied times each other and the result subtracted from 1 to yield the combined predation impact rate. Table 6-8 summarizes the current predation rates used in this Plan.

Table 6-8. Estimated predation rates on UWR Chinook and steelhead used in Scenario Analysis to index the impact of the "Other Species" subcategory.

	Predation Mortality Rate	
Population	Chinook	Steelhead
Populations below Willamette Falls		
Clackamas	0.12	
Populations above Willamette Falls		
Mollala[1]	0.16	0.16
North Santiam[2]	0.17	0.17
South Santiam[2]	0.17	0.17
Calapooia[1]	0.16	0.16
McKenzie[3]	0.18	
Middle Fork Willamette[1]	0.16	

[1] Molalla and Calapooia CHS and STW, and MF Willamette CHS-rates are the same the Hood CHS population (0.16).

[2] North and South Santiam CHS and STW-freshwater rate is 10% of estuarine base rate of 0.16, due to summer steelhead predation in the natal subbasins

[3] McKenzie CHS-freshwater rate is 20% of estuarine base rate of 0.16, due to summer steelhead and rainbow trout predation in the natal subbasin

Harvest

Harvest rates are based on those described and used in Chapter 4 for CATAS. Impact rates for UWR Chinook are thought to average ~25%, and for steelhead, 16[63]%. These rates reflect both freshwater and marine harvest impacts.

Hatchery

Hatchery impacts were divided into those that influenced juvenile competition (estuary and freshwater natal streams), and those resulting from genetic concerns due to interbreeding.

Subcategory: Juvenile Competition

Because we had no direct estimate of this impact we assumed it was some proportion of the estuary habitat impact. We have provisionally assigned a value of 5% impact, which is half of the estuary habitat impact. This rate was applied to all populations.

Subcategory: Adults

The productivity of naturally reproducing populations, expressed as the number of offspring produced per spawner, has been found to be less in those populations where the long-term average incidence of hatchery spawners is high. This relationship, initially described by Chilcote (2003) for steelhead and Nickelson (2003) for coho, has recently been supported by Chilcote et al. (2011) for a wider range of populations, including Chinook. The universal feature of this relationship is an inverse relationship between the mean proportion of hatchery fish in natural spawning populations and overall population productivity. Note that the mechanisms behind this relationship merit further investigation, including fitness of various offspring, genotypic and phenotypic responses, hatchery stock origin, hatchery domestication level, amplification of the relationship through time, variance due to spatial or temporal separation of hatchery and wild spawners, and other responses and factors.

Although most of the loss in productivity in UWR Chinook and steelhead populations has been due to habitat degradation, the presence of large numbers of hatchery fish on natural spawning grounds is an additional productivity impact. In general, with a higher proportion of *potential* spawners being hatchery fish, there is greater chance that wild:hathery and hatchery:hatchery pairings can occur, with subsequent reduction in progeny survival (e.g., less productivity). Poor productivity can lower a population's ability to rebound from periods of adverse environmental conditions and its ability to persist over the long term. Therefore, extinction risk is generally higher in those populations where hatchery fish represent an additional productivity impact. Conversely, reducing the proportion of hatchery fish on natural spawning grounds should reduce this source of productivity loss, and by extension, lessen the extinction risk. However, projecting how much of a conservation benefit would occur with a given reduction in the proportion of hatchery spawners is a complicated problem. Our evaluation of this question suggests that the relationship is sensitive to both the density of spawners relative to habitat carrying capacity and to base level of hatchery spawners. Essentially the effect on extinction risk is both density (spawners) and frequency (hatchery fish) dependent.

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[63] With implementation of the steelhead FMEP, estimates in recent years are <10%. The 16% estimate was used in CATAS simulations, reflecting a longer period in the data record.

NMFS and ODFW considered multiple comments on the treatment of hatcheries in the Proposed Plan and also reviewed the most recent scientific reports and articles. NMFS and ODFW agree that there is ample evidence in the scientific literature to suggest the impacts of hatchery programs should be considered a major threat to recovery. One recent article written by NMFS and ODFW scientists explains:

> "We found a negative relationship between the reproductive performance in natural, anadromous populations of steelhead trout (*Oncorhynchus mykiss*), coho salmon (*O. kisutch*), and Chinook salmon (*O. tshawytscha*), and the proportion of hatchery fish in the spawning population…. In most cases, measures that minimize the interactions between wild and hatchery fish will be the best long-term conservation strategy for wild populations (Chilcote et al 2011)."

The estimates of adult hatchery impact rates for each population were based on the pHOS estimates used in Chapter 4, which were based on available data from coded wire tag (CWT) and spawner surveys.

Some Threat Reduction Caveats and Sequencing Threat Reductions

Review of the magnitude of the mortality rates under current conditions (Table 6-4 above) indicated that improvements in the Flood Control/Hydro sub category threats and Land Use FW Habitat sub category threat and hatchery threat reductions would provide the largest benefits in closing conservation gaps. However, these rates do not reflect their *relative* magnitude under current conditions or their *relative* contribution under recovery scenarios (scenario tables below). Several attempts were made to extract relative importance estimates from the TCM equation, to help show which threats reductions would have the greatest benefits. As a first step in evaluating relative importance for threat reduction options, the Planning Team helped define maximum feasible reductions in the other subcategories, where actions and mortality reductions had already been defined. With these reductions in place, we then evaluated additional threat reductions in flood control/hydro, freshwater habitat impacts, and hatchery impacts to examine how much each of them contributed to meet both abundance viability goals for the ESU/DPS (population delisting scenarios), and maximum mortality reduction thought to be feasible for broad sense recovery goals for a population.

The gains in survival characterized in the desired status scenarios served as a scoping tool for determining how and where efforts and resources could best be allocated to achieve desired status. Actions that address those limiting factors with the broader threat categories that require the most improvement should have a higher priority than actions that address a limiting factor where it is understood that only a modest improvement is needed. Within a threat category, actions in areas that are believed to result in a significant improvement in survival (conversely a reduction in mortality) should be prioritized before those actions in areas that are believed to result in a marginal improvement. A couple of caveats when reviewing the scenario tables below: 1) the approach greatly simplifies the population dynamics that underlie the inter-relation among the threats and limiting factors (for example, decreases in the hatchery threat, mostly represented by reductions in pHOS, are not independent of decreases in flood control threats); and 2) the threat reduction percentages do not reflect the actual difficulty (in terms of cost and technical and social feasibility) in making survival gains. For example, although the scenarios indicate large mortality reductions are needed in the hatchery threat category, the there is disagreement among scientists about how much pHOS reduction actions will benefit natural production until flood control and land use threats are reduced significantly.

Flood Control/Hydropower Management

Subcategories: Spawner Access and Juvenile Passage

Threat reduction targets for mortality associated with Flood Control/Hydro will most likely be implemented through actions identified in the WP BiOp (NMFS 2008a). The WP BiOp did not set targets for improvement in adult or juvenile fish passage, but did outline some measures ("reasonable prudent alternatives; RPA's) that addressed passage, flows, and habitat improvements. We used the Scenario Analysis to explore a range of mortality reductions from WP BiOp actions that would contribute to the desired delisting status. Embedded in the adult passage improvements were reductions in hatchery pHOS above dams, where we assumed pHOS could be maintained at ≤ 5%.

As a first step to examining the magnitude of impact reductions from lack of access and passage, we assumed that reaches inundated by reservoirs were not recoverable for spawning, and that an estimate of the proportion of historic intrinsic potential presently in reservoirs represented a lower range limit for feasible impact rate reduction. This adjustment basically reduces somewhat the carrying capacity benefits of providing access above dams, and therefore the % of recoverable production above the dams (see column 5 in Table 6-10). For example, ~11% of the intrinsic historic production in the Middle Fork Willamette is now in reservoirs, and therefore about 84% of total historic intrinsic potential would be available for production with adult access actions above Lookout Pt., Falls Creek, and Hills Creek dams. Even if enough adults can be transported above the dams to seed the remaining habitat successfully and the resulting juvenile productivity can be restored to historic levels,, juvenile mortality through the flood control/hydropower system would remain a key limiting factor. To scope this issue, Table 6-9 shows three levels of passage survival that result in flood control impact reductions. These values were used in scenario runs that integrated the other threat reductions. Members of the Planning team were asked to consider a "best case" goal for passage survival through the USACE large tributary dams and reservoirs, resulting from passage actions. Because there was lack of clear input and agreement on this issue, the ODFW chose 75% dam and reservoir survival as a higher end value to use in scenarios. It was noted by some team members that downstream survival improvement could vary greatly from dam to dam, and that fish passage facilities and reservoir operations could potentially be designed to achieve much higher survival rates.[64]

Table 6-9. The range of remaining impact rates after adult access has been restored and different levels of juvenile Chinook passage survival.

	Proportion historic production lost from dam blockage(=current impact rate for lack of spawner access in Table 6-7)	% Above Barrier Proportion IP in reservoirs	% Total production lost due to reservoir	% Remaining recoverable production above dams	Rates of Juvenile passage survival and resulting remaining impact from Flood Control/hydro passage limiting factors[1]		
					.75	.50	.25
N. Santiam	.71	10%	7%	64%	23%	39%	55%
S. Santiam	.85	20%	17%	68%	34%	51%	68%
McKenzie	.25	17%	4%	21%	9%	15%	20%
MF Will	.95	12%	11%	84%	32%	53%	74%

[1] after the % remaining recoverable production above dams is factored in (column 5)

[64] It should be noted that using a rate of 75% survival in the TCM equation shows that improving passage to this level has significant benefits to affected populations, thus justifying the high priority give to passage actions in this Plan.

Subcategory: Spawner Habitat Conditions

In the Scenario Analysis we modeled this threat separate from the spawner access threat described previously, in acknowledgment that pre-spawn mortality would continue to occur above the dams (mostly due to handling). Members of the Planning Team indicated that the adult trap improvements called for in the WP BiOp (NMFS 2008a) will likely reduce prespawn mortality of adults trapped and hauled above the dams by < 10%. Adult fish remaining below the dams will not likely benefit by the trap improvements, and would likely continue to experience high prespawn mortality. It is not clear for some populations what causes the majority of pre-spawn mortality below dams, and this Recovery Plan calls for research to examine potential causes. In the case of the Middle Fork Willamette Chinook population, where the vast majority of natural origin adults would be outplanted above the large flood control facilities, this below-dam mortality will presumably have a minor effect on overall population improvement. But in the North and South Santiam populations, where ~30% of the historical production may have come from, there is a clear need to reduce prespawn mortality below dams to improve population status.

Subcategory: Juvenile Habitat Conditions

See discussion below under Land Management *Subcategory: Freshwater Habitat*

Land Management

Subcategory: Freshwater Habitat

As discussed above, we separated the fresh water habitat LFTs into two subcategories: 1) mortality associated with juvenile habitat conditions due to hydro/flood control (JHM), and 2) mortality associated with other freshwater habitat conditions (non hydro, FWHM). There is underlying uncertainty regarding the extent to which freshwater habitat improvements can increase survival for specific life stages (see McHugh et al. 2004), and whether these increases could contribute to a large enough proportion in total life cycle survival to produce positive growth rates (Budy and Schaller 2007). Ideally one would first identify a mechanistic link between a specific life stage (example: fry survival) with specific habitat attributes, then attempt to derive a numerical fish response (change in survival rate) to modeled improvements in habitat that reduce limiting factors. At the population level there is an assumption that specific habitat improvements will lead to a cumulative watershed condition where salmonid survival is quantitatively enhanced (Bartz et al. 2005). However, these types of analyses require detailed information on existing habitat conditions for specific populations, and life-stage specific survival rates. In addition, UWR juvenile Chinook salmon have a range of early life history behaviors that are linked to flows and temperature, resulting in variable residence and migration time in natal streams and Willamette mainstem habitats. Predicting the population response (increase in adult spawners) from improvements in mainstem habitat is complex, in part because mainstem habitat conditions are not the result of discrete actions but are influenced by the cumulative effects of conditions upstream. While improvements in upstream areas will presumably have a positive effect on mainstem conditions, their magnitude is unknown.

In the absence of specific quantifiable habitat:fish relationships, our initial approach to examine restoration potential was to evaluate available EDT data for Chinook salmon and steelhead. Our goal with EDT data was to help establish upper bounds of the maximum feasible survival improvements. For the Clackamas and McKenzie Chinook, we used EDT data to help estimate improvements in fish survival based in some cases on restoration endpoints (goals) for which the EDT data were modeled. From EDT data we assumed that increases in the adult and smolt equilibrium abundance from current habitat conditions to projected habitat improvements was the net percent survival improvement. We used the EDT average value of the adult and smolt survival improvements to back calculate the mortality reduction these improvements represented. In general we have assumed that an approximate 30-35% decrease in the mortality rate from current conditions in the case of the McKenzie and Clackamas populations is the upper limit of what can feasibly be achieved for Chinook and steelhead. Lacking EDT data for other subbasins, we assumed this mortality decrease was also the maximum feasible improvement for those subbasins.

Subcategory: Estuary Habitat

The Estuary Module assumed that feasible estuarine habitat improvements would result in a maximum increase of 20% in the number of outmigrants leaving the Columbia River Estuary. While the Module authors note the difficulty predicting the exact quantitative benefits of estuary actions, for planning purposes we apply this improvement value for all populations. The current estuary threat estimate of 10% is the same for all UWR populations, and when the Module improvements are applied, we expect the maximum reduction of anthropogenic enhanced mortality to decrease from 10% to 8%.

Other Species

The predation reduction goal used in our recovery scenarios is based mostly on mortality reductions expected from the Caspian Tern Management Plan (USFWS 2005) and the Pikeminnow Reward Program (Beamesderfer et al. 1996). We assume some predation reduction for UWR populations will also occur with pinniped control as outlined in the NMFS final Environmental Assessment of this impact (NMFS 2008d)[65]. In the Willamette River mainstem and subbasins this Recovery Plan calls for liberalizing bag limits on warm water exotic fish, but the reduction in predation from this action is likely to be modest. For UWR Chinook and steelhead, we project, based on the Estuary Module, that the total of the actions identified in the applicable estuary plans equates to an approximate 59-62% reduction in the current mortality due to predation that is human influenced. As with estuary habitat, there is general agreement that these reductions in mortality associated with predation are likely the maximum that can be accomplished to alleviate this impact. In addition, the relatively minor impact that predation represents among all the threats means that decreasing predation mortality further will have relatively little effect on the status of UWR populations.

Harvest Management

As noted in Chapters 4 and 5, there are several fisheries that impact UWR Chinook and steelhead. After review of the primary and secondary LFTs by the Expert Panel, Planning Team, Stakeholder Group, and the general public, fishery harvest rates managed under the approved FMEPs since the listing result in adequate protection of wild populations and will not impede the recovery of populations once the primary and secondary LFTs are addressed. Fishery harvest exploitation rates have been reduced by more than 75% compared to pre-listing exploitation rates. The analyses conducted in the approved FMEPs demonstrate that the new fishing strategies adopted will not impede the recovery of all steelhead and Chinook populations in the Willamette. The fact that the wild populations have not improved in viability status after the substantial fishery harvest reductions have occurred suggests fishery impacts are not the primary or secondary bottlenecks affecting these populations. Other recovery actions in the management of land use, dams, and hatcheries are now needed to improve population viability. Improvements will not be gained from further fishery restrictions. As these fisheries have considerable social and economic value which would be lost for a relatively small reduction in overall mortality, this Plan does not identify

[65] http://www.nwr.noaa.gov/Marine-Mammals/Seals-and-Sea-Lions/upload/Sec-120-Final-EA.pdf

actions to reduce the impact to wild Chinook and steelhead from fisheries, therefore no impact reduction is identified under the scenarios presented here.

Hatchery Management

Subcategory: Juvenile Competition

At this time there is relatively little information regarding the effects of ecological interactions between hatchery and natural-origin juvenile salmon and steelhead. Due to the emerging science on the subject, the potential benefits of reduced juvenile competition in the estuary or in natal subbasins are as yet unknown. Habitat improvements in both of these areas have the potential to lessen the negative effects of competitive interactions to some unknown degree. Modification of hatchery rearing practices that can reduce competition may also contribute to reducing this threat. However, given this uncertainty and the relatively minor impact that juvenile competition is assumed to represent relative to the threats, decreasing competition mortality further may have relatively little effect on the status of UWR populations. Therefore no impact reduction is identified under the scenarios presented here.

Subcategory: Adults

Reducing pHOS to zero is technically feasible for selected species and populations in the short term by reducing or eliminating hatchery production. However, given that hatchery fish support almost all fisheries within the UWR ESU, eliminating hatchery production would reduce or eliminate fisheries in some areas with resulting social and economic impacts. In order to gain management flexibility for considering alternative ways to reduce pHOS, the State of Oregon, U.S. Army Corps of Engineers, and NMFS could review the hatchery mitigation agreements (described in Appendix E) and evaluate them in the context of ESA listings and recent scientific information.. When reintroduction above the dams results in self-sustaining, naturally-produced sub-populations in these locations, the requirement to produce hatchery fish as mitigation for dam construction and operation will be re-assessed. The primary source of pHOS is from the harvest hatchery programs (mitigation programs) in the ESU. Actions that reduce this source of pHOS are coupled with actions that will improve passage, survival, and production of wild fish above flood control/hydropower barriers. Under the assumption that improved sorting facilities below dams (as called for in the WP BiOp, NMFS 2008a) can support an above-barrier guideline of ≤ 5% pHOS above flood control barriers for reintroduction purposes of natural origin fish, pHOS rates below the barriers could remain fairly high and still achieve a *total* subbasin pHOS consistent with VSP criteria. Ultimately, NMFS and ODFW think that the proposed hatchery pHOS at different extinction risk level goals (i.e., 30% for moderate risk, and 10% for low or very low risk, respectively, for within-ESU hatchery fish) are feasible for most populations, and when combined with other threat reductions outlined in the threat reduction scenarios, will contribute to fulfill delisting and broad sense recovery goals. Because most of the populations are proposed to be deliberately managed with split subbasin goals (mitigation production emphasis below mainstem barriers, wild fish management focus above mainstem barriers), average subbasin pHOS goals may eventually be achieved by having low pHOS above barriers, with greater levels in mitigation zones, but NMFS and ODFW should continue to study the adverse effects of high pHOS below the dams on natural productivity of each population. Table 6-10 illustrates how reduced pHOS levels below large barriers (mitigation zones) would contribute to total population pHOS to desired status goals, under a condition of restored access and production of natural origin fish above barriers.

Table 6-10. Projected pHOS levels needed to meet desired status (based on WLC-TRT viability guidelines) for UWR Chinook and winter steelhead populations.

Population	Max total subbasin pHOS to meet desired status goal	Max pHOS below dam to meet desired status[1]
Chinook		
Clackamas	10%	Na
Molalla	Not defined	Na
North Santiam	10%	21%
South Santiam	30%	80%
Calapooia	Not defined	Na
McKenzie	10%	95%[2]
MF Willamette	10%	95%
Steelhead[3]		
Molalla	5%	Na
North Santiam	5%	21%
South Santiam	5%	21%
Calapooia	15%	Na

[1] assumes pHOS above barrier is ≤ 5% and production is equal above and below barrier, therefore proportional to spawning area
[2] below Leaburg, assuming that area below there would be 5% of total production
[3] for steelhead, most hatchery strays are an out-of-DPS stock of summer steelhead, and for viable populations of winter steelhead, pHOS for out-of-DPS fish should be ≤5%.

6.2.2 Threat Reduction Scenarios for Individual Populations

The following tables show threat reduction scenarios for each UWR Chinook and steelhead populations which, if implemented successfully, would lead to a desired status for that population[66]. Included in some of the tables are threat reduction scenarios that would yield 1) a more modest level of recovery, and 2) a more ambitious level of recovery beyond desired status. The scenarios in the tables below are defined as follows:

- Maintain Current Status (into the future): One of the recovery principles outlined by the WLC-TRT was that no population should decline from its current risk status. Since we applied a 20% conservation buffer on the Abundance criterion for future risks, some threats will need to be reduced to some level just to maintain current risk status. This scenario represents the minimum threat reduction necessary to achieve only the 20% increase in abundance to meet unknown future threats and maintain the current risk class. For three of the UWR steelhead populations, the current status is also the Desired Status (following).
- Desired Status (to Delist ESU/DPS): This is the threat reduction scenario that leads to a population-level desired status for that population, as determined within the chosen ESU/DPS-level desired status scenario in Table 6-1, to help meet the ESU/DPS recovery goal of delisting the ESU/DPS. In most cases these scenarios were crafted to improve the extinction risk level of a population to achieve its desired status as indicated in Table 6-1. This scenario represents the threat reduction framework that will guide implementation of actions in this Plan.
- ESU/DPS Viability Buffer: One of the ESU/DPS-level viability principles outlined by the WLC-TRT was that not all population-level recovery efforts will be successful, therefore, where feasible,

[66] Threat reduction scenarios for Broad Sense goals are in Chapter 10, where broad sense recovery criteria are discussed.

recovery goals should include improving some populations beyond the minimum level to meet ESU/DPS viability criteria. Therefore, we have included for two Chinook populations and one steelhead population not targeted for a desired status level to viable (Chinook: Molalla, Calapooia; steelhead: Calapooia) a threat reduction scenario that would improve their extinction risk levels to a low risk level (viable).

Scenario Tables

The threat reduction scenario serve as a comparative exercise in outlining different threat reduction options necessary to achieve a given extinction risk level. The tables are complex and are derived from several chapters. Therefore terms and table organization are provided as follows:

1. Broad Threat Management Categories & Subcategory columns: As summarized in Tables 6-2 and 6-3 above, the broad threats identified in Chapter 5 were reorganized into subcategories to provide better resolution of impacts for those threats. Those ten subcategories are the column headers in row 3 of the following tables, nested within the broader threat categories as column headers in row 2.
2. The population-specific key and secondary limiting factor (LFT) codes from Chapter 5 were associated with the most appropriate threat subcategory, and are binned in rows 5 and 6 under the respective subcategory threat. A few LF codes are associated with more than one threat subcategory. For example, LF code 8a "Physical habitat quality…" is influenced by both Flood Control and Land Management practices. In addition, LF Codes 5a, 5b, 7h, and 10f are essentially due to Columbia basin Hydro operations, but their effects on UWR Chinook and steelhead occur in the estuary as habitat degradation.
3. The impacts (mortality rates of threats) associated with current status (row 8) developed in this chapter are from Table 6-5 and are headed in column 7 by the acronym terms in the TCM equation associated with Table 6-5. As described in the section discussing how tributary threat rates were developed, the cumulative mortality of threat impacts in the Scenario Analysis is multiplicative (i.e., TCM = 1-((1-SAM)x(1-JHM)x(1-SHM)x(1-FWHM)x(1-EHM)x(1-OSM)x(1-HM)x(1-JCM)x(1-HFM))[67]. The 3 sub-column headings in row 7 under Total Reduced Life Cycle Impact (row 6) track reductions in mortality and improvements in adult abundance, resulting from threat reductions in the scenario rows.
4. The VSP Extinction Risk Class indicates current risk status of the VSP parameters (see Chapter 4) under current conditions, and improvements to those risk classes under the different scenarios. A&P= abundance and productivity, DV=diversity, SS=spatial structure).
    a. The A&P (abundance and productivity) VSP parameter value for each scenario was derived from the A/P conservation gaps in Chapter 4, plus a 20% increase to offset future development and climate change uncertainty.
    b. The D (diversity) VSP parameter for each scenario is based on the diversity guidelines described in Chapter 4 for this parameter.
    c. For the SS (spatial structure) VSP parameter there was no quantitative target for a risk level, but it was assumed risk status for SS would be improved if the scenario included increases in A&P that came with improvements in fish access and freshwater habitat.

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[67] For the Scenario Analysis there is not estimate of current mortality impact from lack of downstream passage. It was assumed that lack of spawner access above large flood control/hydropower projects precluded production of naturally produced juveniles, and that total above-barrier mortality was included in the spawner access category. Therefore the Juvenile Passage Mortality term (JPM) was combined with SAM in the TCM equation.

   d. The derivation of the overall extinction risk class from the component parameters is described in Chapter 4, though it is heavily influenced by the A&P component (which tends to also influence D and SS as well).

5. In the scenario rows, each successive scenario employs the threat reductions from the previous row, and adds more threat subcategories (increasing threat integration) and/or more percent decrease in a threat impact rate (increasing threat reduction intensity). Therefore the scenarios are a progressive down-row reduction in threats, reflecting improvements in VSP extinction risk classes.

6. Finally, the text that describes the details of each scenario indicates levels of mortality reduction of a threat from the current estimated impact rates. For the hatchery threat, the term "to VSP pHOS standard" refers to the threshold pHOS values that are aligned with different levels of risk for the Diversity criterion. For Chinook salmon pHOS involves a within-ESU hatchery population, and viable natural populations should maintain a pHOS ≤10%, and populations at moderate risk should maintain a pHOS ≤30%. For steelhead, pHOS is mostly an out-of-DPS hatchery population, and viable natural populations should maintain a pHOS ≤5%.

Several attempts were made to depict the relative importance of each threat category. The figures that follow each population's scenario table provide a visual summary of the relative reductions in mortality impact for each threat category, under current conditions and under desired status. In most cases , estuary and "other species" threats have modest impacts relative to other impacts, and that most reductions in mortality impacts (and contribution to total life cycle survival) will come from a combination of mortality reductions due to threats of flood control/hydropower, freshwater habitat, and hatcheries.

Table 6-11. Threat reduction and VSP scenarios for Clackamas spring Chinook. See the text in Section 6.2.2 for a detailed description of table organization and contents.

Clackamas Spring Chinook																	
	Flood Control / Hydropower (subbasin)				FW Land Use Management	Estuary LFT's	Other Species	Harvest Management	Hatchery Management								
Limiting Factor Importance	Spawner Access	Juvenile Passage	Spawner Habitat Conditions	Juvenile Habitat Conditions	Adult and Juvenile Conditions	Land Use & Flood Control/Hydro	Competition / Predation	Adults	Juv Competition / Predation	Adults							
Key	1a				8a	5ab, 7h, 10f				3a							
Secondary			9k	7i, 8a	8a, 9ahi	8a, 9ahij	6e	11ag	4a								
	Mortality Rates of Threats										**Total Reduced Life Cycle Impact**			**VSP Extinction Risk Class**			
	SAM	**JPM**	**SHM**	**JHM**	**FWHM**	**EHM**	**OSM**	**HM**	**JCM**	**HFM**	**Cumulative Mortality**	**% Mortality Reduction**	**Modeled Abundance**	**A&P**	**DV**	**SS**	**Overall Risk**
Current Status	0.27				0.83	0.10	0.12	0.25		0.33	95%	---	1,369	M	M	L	M
Scenarios																	
Maintain into Future: Moderate Risk *Estuary Module Actions* -max reduction in EHM & OSM threats *Land Management Actions* -small reduction in FWHM ~2%	0.27				0.81	0.08	0.07	0.25		0.33	94%	1.0%	1,641	M	M	L	M
Desired Status: Very Low Risk *Flood Control/Hydro Actions* -small reduction in SAM and JPM *Hatchery Actions* -medium reduction in HFM to VSP pHOS standard	0.24				0.81	0.08	0.07	0.25		0.10	92%	3.6%	2,314	VL	L	L	VL

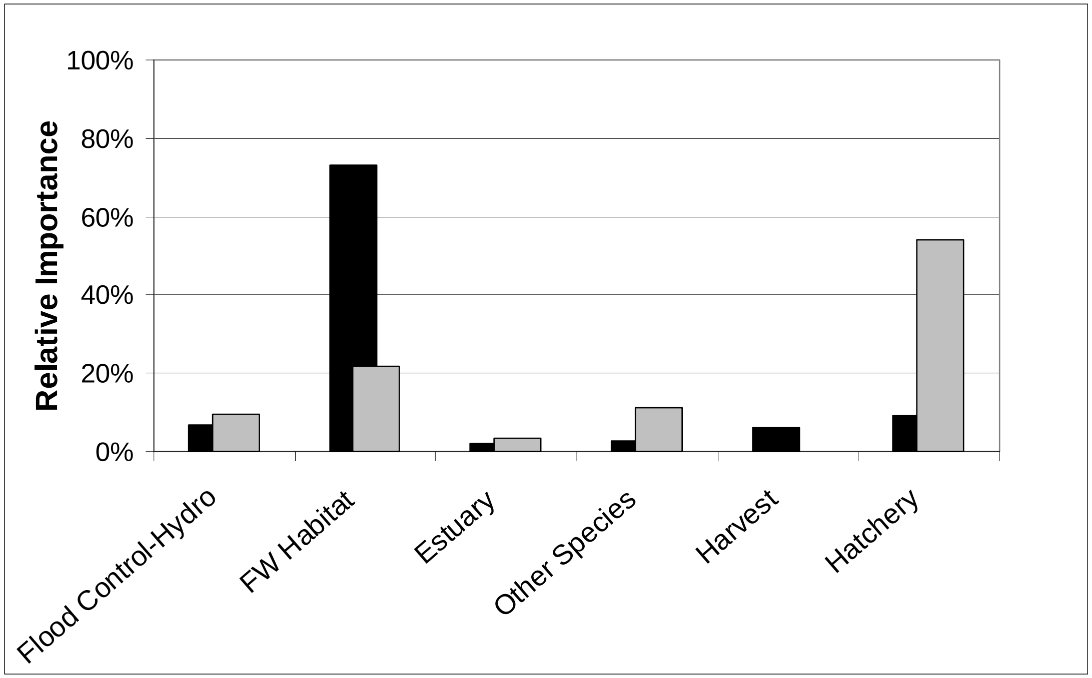

Figure 6-1. For Clackamas spring Chinook, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-11 above depicts a desired status scenario to improve the Clackamas spring Chinook population from a moderate risk of extinction (current status) to a very low risk of extinction. It accomplishes this with: 1) maximum feasible mortality reductions in Estuary and Other Species threats to improve A/P; 2) small/moderate % mortality reductions in FW Habitat and Flood Control / Hydro threats to improve A/P; and 3) moderate reduction in Hatchery threats to improve A/P and to meet a Diversity pHOS threshold for a viable population (≤ 10% pHOS). Under current conditions, FW Habitat mortality has the greatest relative importance to cumulative mortality, and even a small/moderate % reduction in this threat is projected to have a large contribution to reducing cumulative mortality (Figure 6-1[68]). However, as conditions improve towards desired status, there is a rebalancing of relative importance across threat categories.

[68] Relative importance under current conditions was determined by calculating how much the % cumulative mortality reduction changed when a threat category mortality value was held constant, while reducing other threat category mortality values to their desired status targets.

Table 6-12. Threat reduction and VSP scenarios for Molalla spring Chinook. See the text in Section 6.2.2 for a detailed description of table organization and contents.

Molalla Spring Chinook	SAM	JPM	SHM	JHM	FWHM	EHM	OSM	HM	JCM	HFM	Cumulative Mortality	% Mortality Reduction	Modeled Abundance	A&P	DV	SS	Overall Risk
	Flood Control / Hydropower (subbasin)				FW Land Use Management	Estuary LFT's	Other Species	Harvest Management	Hatchery Management		Total Reduced Life Cycle Impact			VSP Extinction Risk Class			
Limiting Factor Importance	Spawner Access	Juvenile Passage	Spawner Habitat Conditions	Juvenile Habitat Conditions	Adult and Juvenile Conditions	Land Use & Flood Control/Hydro	Competition / Predation	Adults	Juv Competition / Predation	Adults							
Key					8ab, 9ach	5ab, 7h, 8a,10f				3a							
Secondary					7a, 9i, 10b	9ahij	6e		4a								
	Mortality Rates of Threats																
Current Status	0.00	0.00	0.00	0.00	1.00	0.10	0.16	0.25	0.05	0.95	100%	---	0	VH	H	H	VH
Scenarios																	
Maintain into Future: VH Risk *Estuary Module Actions* -max reduction in EHM & OSM threats *Land Management Actions* -large reduction in FWHM ~20%	0.00	0.00	0.00	0.00	0.80	0.08	0.08	0.25	0.05	0.95	99%	0.6%	83	VH	H	H	VH
Desired Status: High Risk *Hatchery Actions* -medium reduction in HFM ~40%	0.00	0.00	0.00	0.00	0.80	0.08	0.08	0.25	0.05	0.57	95%	5.1%	699	H	H-M	L	H
ESU Viability Buffer: Low Risk *Hatchery Actions* -large reduction in HFM to VSP pHOS standard	0.00	0.00	0.00	0.00	0.80	0.08	0.08	0.25	0.05	0.10	89%	10.7%	1,471	L	L	L	L

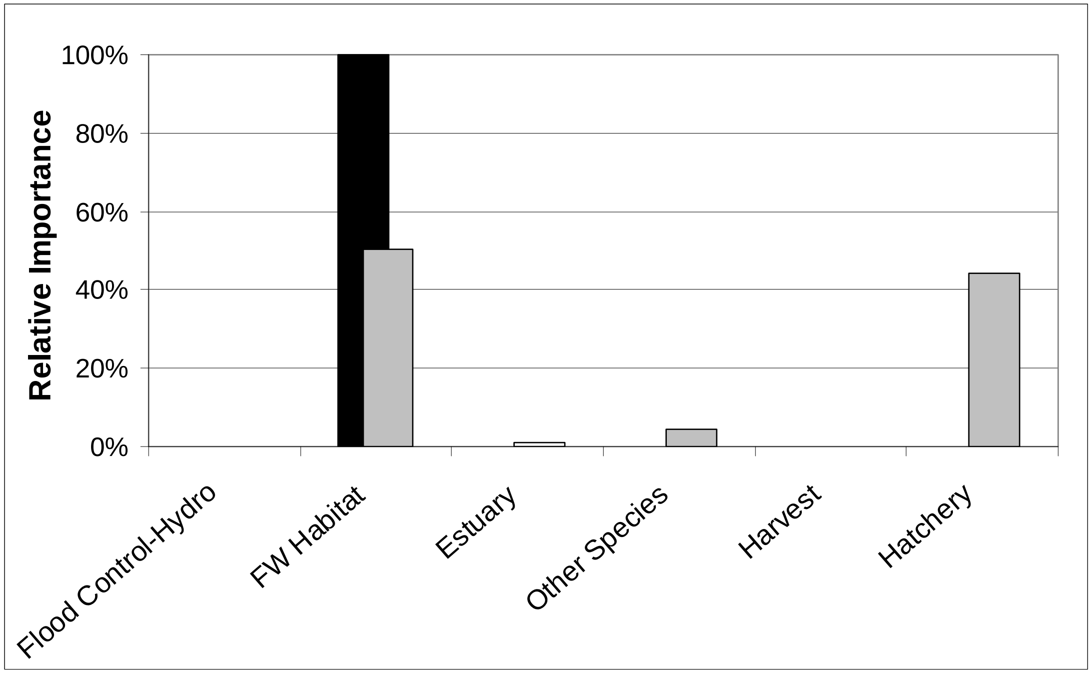

Figure 6-2. For Molalla spring Chinook, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-12 above depicts a desired status scenario to improve the Molalla spring Chinook population from a very high risk of extinction (current status) to a high risk of extinction. It accomplishes this with: 1) maximum feasible mortality reductions in Estuary and Other Species threats to improve A/P; 2) a large reduction in FW Habitat threats to improve A/P and SS; and 3) moderate/large reduction in Hatchery threats to improve A/P and to some extent, Diversity. Under current conditions, FW Habitat mortality has the greatest relative importance to cumulative mortality, and a large % reduction in this mortality source is projected to have a large contribution to cumulative mortality reduction (Figure 6-2). As conditions improve towards desired status, there is a rebalancing of relative importance across threat categories.

Table 6-13. Threat reduction and VSP scenarios for North Santiam spring Chinook. See the text in Section 6.2.2 for a detailed description of table organization and contents.

North Santiam Spring Chinook																	
	Broad Threat Management Categories & Sub-Categories																
	Flood Control / Hydropower (subbasin)				**FW Land Use Management**	**Estuary LFT's**	**Other Species**	**Harvest Management**	**Hatchery Management**								
Limiting Factor Importance	**Spawner Access**	**Juvenile Passage**	**Spawner Habitat Conditions**	**Juvenile Habitat Conditions**	**Adult and Juvenile Conditions**	**Land Use & Flood Control/Hydro**	**Competition / Predation**	**Adults**	**Juv Competition / Predation**	**Adults**							
Key	2b, 2f	1d		9b,10d	8a,9ahi	5ab, 7h, 8a,10f				3a							
Secondary	2k			7bc	8a	9ahij	6ce		4a								
	Mortality Rates of Threats										**Total Reduced Life Cycle Impact**			**VSP Extinction Risk Class**			
	SAM	**JPM**	**SHM**	**JHM**	**FWHM**	**EHM**	**OSM**	**HM**	**JCM**	**HFM**	**Cumulative Mortality**	**% Mortality Reduction**	**Modeled Abundance**	**A&P**	**DV**	**SS**	**Overall Risk**
Current Status	0.71	0.00	0.60	0.97	0.97	0.10	0.17	0.25	0.05	0.90	100%	---	0	VH	H	H	VH
Scenarios																	
Maintain into Future: VH Risk *Estuary Module Actions* -max reduction in EHM & OSM threats *Flood Control/Hydro Actions* -medium reduction in SAM and JPM (improve A/P & SS via passage actions -large reduction in JHM (improve WQ, flows) *Land Management Actions* -large reduction in FWHM ~25% *Hatchery Actions* -small reduction in HFM	0.39	---	0.60	0.29	0.70	0.08	0.08	0.25	0.05	0.88	100%	0.4%	205	VH	H	H	VH

Desired Status: Low Risk *Flood Control/Hydro Actions* -maximum reduction in SAM and JPM (maximize habitat capacity for A/P and SS) -maximum reduction in SHM (resolve pre-spawn mortality impacts) *Land Management* -maximum reduction in FWHM *Hatchery Actions* -large reduction in HFM to VSP pHOS standard	0.23	---	0.12	0.29	0.63	0.08	0.08	0.25	0.05	0.10	90%	9.7%	5,428	L	L	L	L

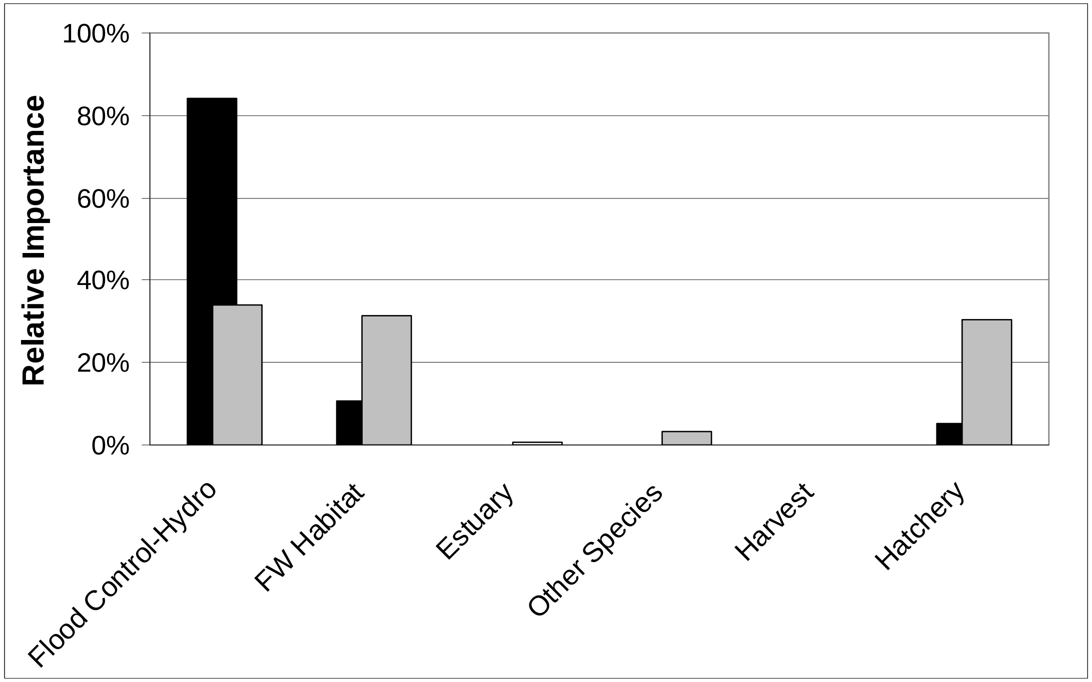

Figure 6-3. For North Santiam spring Chinook, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-13 above depicts a desired status scenario to improve the North Santiam spring Chinook population from a very high risk of extinction (current status) to a low risk of extinction. It accomplishes this with: 1) maximum feasible mortality reductions in Estuary and Other Species threats to improve A/P; 2) maximum mortality reductions in FW Habitat and Flood Control / Hydro threats to improve A/P and SS; and 3) large reduction in Hatchery threats to improve A/P and to meet a Diversity pHOS threshold for a viable population (≤ 10% pHOS). Under current conditions, aggregated Flood Control/Hydro mortality has the greatest relative importance to cumulative mortality, and a large % reduction in this mortality source is projected to have a large contribution to cumulative mortality reduction (Figure 6-3). Note that currently estuary mortality and other species have very little current impact, relative to other life-cycle bottlenecks. As conditions improve towards desired status, there is a rebalancing of relative importance across threat categories.

Table 6-14. Threat reduction and VSP scenarios for South Santiam spring Chinook. See the text in Section 6.2.2 for a detailed description of table organization and contents.

South Santiam Spring Chinook																	
	Flood Control / Hydropower (subbasin)				**FW Land Use Management**	**Estuary LFT's**	**Other Species**	**Harvest Management**	**Hatchery Management**								
Limiting Factor Importance	**Spawner Access**	**Juvenile Passage**	**Spawner Habitat Conditions**	**Juvenile Habitat Conditions**	**Adult and Juvenile Conditions**	**Land Use & Flood Control/Hydro**	**Competition / Predation**	**Adults**	**Juv Competition / Predation**	**Adults**							
Key	2c, 2g	1e		9e,10d	8a,9ahi	5ab, 7h, 8a,10f				3a							
Secondary	2l			7d	8a	9ahij	6ce		4ab								
	Mortality Rates of Threats										**Total Reduced Life Cycle Impact**			**VSP Extinction Risk Class**			
	SAM	**JPM**	**SHM**	**JHM**	**FWHM**	**EHM**	**OSM**	**HM**	**JCM**	**HFM**	**Cumulative Mortality**	**% Mortality Reduction**	**Modeled Abundance**	**A&P**	**DV**	**SS**	**Overall Risk**
Current Status	0.85	0.00	0.30	0.95	0.95	0.10	0.17	0.25	0.05	0.90	100%	---	1	VH	M	M	VH
Scenarios																	
Maintain into Future: VH Risk *Estuary Module Actions* -max reduction in EHM & OSM threats *Flood Control/Hydro Actions* -medium reduction in SAM and JPM (improve A/P & SS via access/passage actions) -large reduction in JHM (improve WQ, flows) *Land Management Actions* -large reduction in FWHM ~20% *Hatchery Actions* -small reduction in HFM	0.51	---	0.30	0.29	0.75	0.08	0.08	0.25	0.05	0.86	99%	0.5%	201	VH	H	H	VH
Desired Status: Moderate Risk *Flood Control/Hydro Actions* -maximum reduction in SAM and JPM (maximize habitat capacity for A/P and SS) -maximum reduction in SHM (resolve pre-spawn mortality impacts) *Land Management* -max. reduction in FWHM *Hatchery Actions* -large reduction in HFM to VSP pHOS standard	0.34	---	0.04	0.19	0.62	0.08	0.08	0.25	0.05	0.30	92%	8.3%	3,116	M	M	L	M

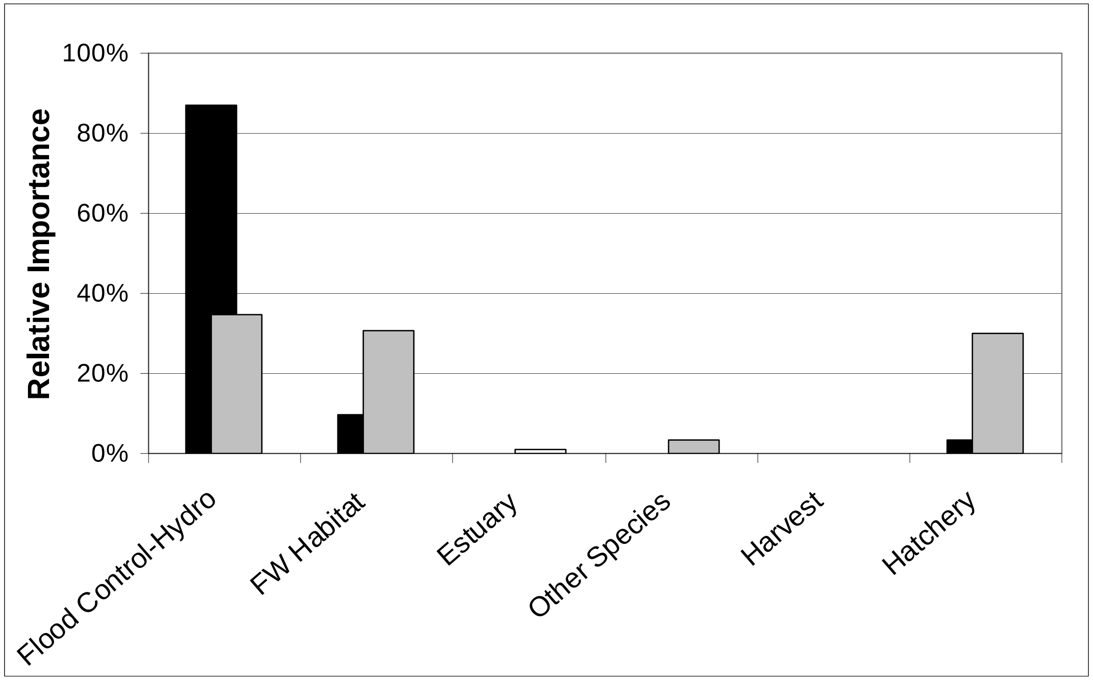

Figure 6-4. For South Santiam spring Chinook, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-14 above depicts a desired status scenario to improve the South Santiam spring Chinook population from a very high risk of extinction (current status) to a moderate risk of extinction. It accomplishes this with: 1) maximum feasible mortality reductions in Estuary and Other Species threats to improve A/P; 2) maximum mortality reductions in FW Habitat and Flood Control / Hydro threats to improve A/P and SS; and 3) large reduction in Hatchery threats to improve A/P and to meet a Diversity pHOS threshold for a population at moderate risk (≤ 30% pHOS). Under current conditions, aggregated Flood Control/Hydro mortality has the greatest influence on current status, and a large % reduction in this mortality source is projected to have a large contribution to cumulative mortality reduction (Figure 6-4). Note that currently estuary mortality and other species have very little current impact, relative to other life-cycle bottlenecks. However, as conditions improve towards desired status, the relative importance of other mortality sources increases..

Table 6-15. Threat reduction and VSP scenarios for Calapooia spring Chinook. See the text in Section 6.2.2 for a detailed description of table organization and contents.

Calapooia Spring Chinook																	
	Flood Control / Hydropower (subbasin)				FW Land Use Management	Estuary LFT's	Other Species	Harvest Management	Hatchery Management								
Limiting Factor Importance	Spawner Access	Juvenile Passage	Spawner Habitat Conditions	Juvenile Habitat Conditions	Adult and Juvenile Conditions	Land Use & Flood Control/Hydro	Competition / Predation	Adults	Juv Competition / Predation	Adults							
Key					2h,9a 9c 9hi 8ab	5ab, 7h, 8a,10f				3a							
Secondary					7a,10b	9ahij	6e		4a								
	Mortality Rates of Threats										**Total Reduced Life Cycle Impact**			**VSP Extinction Risk Class**			
	SAM	**JPM**	**SHM**	**JHM**	**FWHM**	**EHM**	**OSM**	**HM**	**JCM**	**HFM**	**Cumulative Mortality**	**% Mortality Reduction**	**Modeled Abundance**	**A&P**	**DV**	**SS**	**Overall Risk**
Current Status	0.00	0.00	0.00	0.00	1.00	0.10	0.16	0.25	0.05	0.95	100%	---	0	VH	H	VH	VH
Scenarios																	
Maintain into Future: VH Risk *Estuary Module Actions* -max reduction in EHM & OSM threats *Land Management Actions* -large reduction in FWHM ~25%	0.00	0.00	0.00	0.00	0.74	0.08	0.08	0.25	0.05	0.95	99%	0.8%	74	VH	H	H	VH
Desired Status: High risk *Hatchery Actions* -medium reduction in HFM ~40%	0.00	0.00	0.00	0.00	0.74	0.08	0.08	0.25	0.05	0.60	94%	6.3%	598	H	H-M	L	H
ESU Viability Buffer: Low risk *Hatchery Actions* -large reduction in HFM to VSP pHOS standard	0.00	0.00	0.00	0.00	0.74	0.08	0.08	0.25	0.05	0.10	86%	14.2%	1,348	L+	L	L	L+

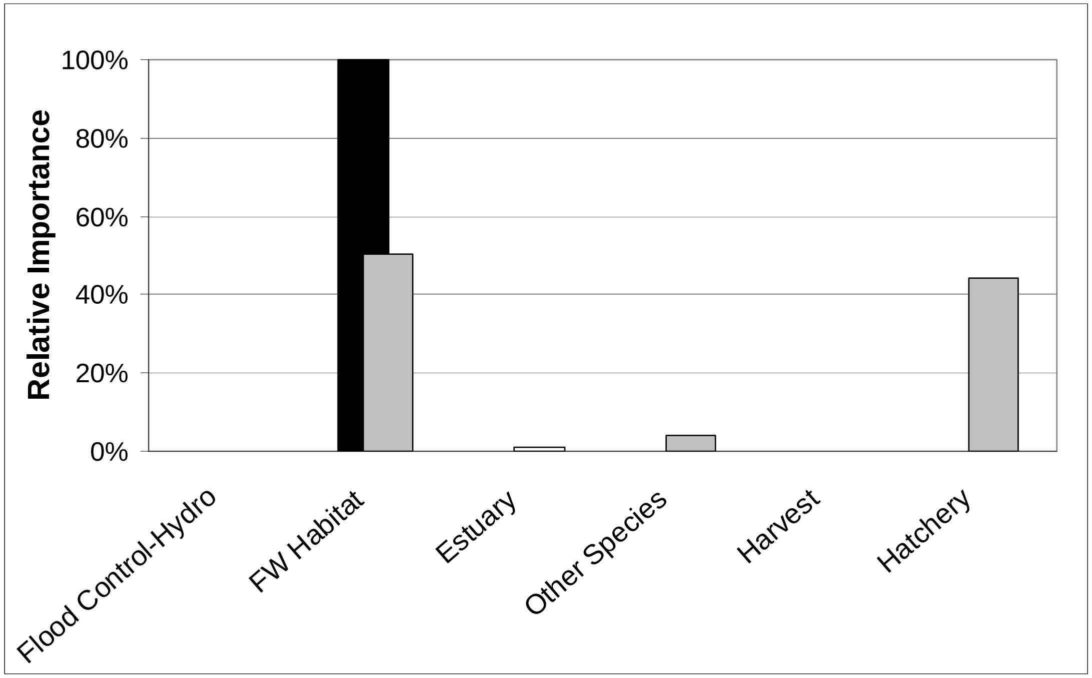

Figure 6-5. For Calapooia spring Chinook, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-15 above depicts a desired status scenario to improve the Calapooia spring Chinook population from a very high risk of extinction (current status) to a high risk of extinction. It accomplishes this with: 1) maximum mortality reductions in Estuary and Other Species threats to improve A/P; 2) large reduction in FW Habitat threats to improve A/P and SS; and 3) moderate/large reduction in Hatchery threats to improve A/P and to some extent, Diversity. Under current conditions, FW Habitat mortality has the greatest relative importance to cumulative mortality, and a large % reduction in this mortality source is projected to have a large contribution to cumulative mortality reduction (Figure 6-5). As conditions improve towards desired status, there is a rebalancing of relative importance across threat categories.

Table 6-16. Threat reduction and VSP scenarios for McKenzie spring Chinook. See the text in Section 6.2.2 for a detailed description of table organization and contents.

McKenzie Spring Chinook																	
	Flood Control / Hydropower (subbasin)				**FW Land Use Management**	**Estuary LFT's**	**Other Species**	**Harvest Management**	**Hatchery Management**								
Limiting Factor Importance	**Spawner Access**	**Juvenile Passage**	**Spawner Habitat Conditions**	**Juvenile Habitat Conditions**	**Adult and Juvenile Conditions**	**Land Use & Flood Control/Hydro**	**Competition / Predation**	**Adults**	**Juv Competition / Predation**	**Adults**							
Key	2d			10d	8a, 9hi	5ab, 7h, 8a,10f				3a							
Secondary		1b		7e, 9g	9a	9ahij	6cde		4a								
	Mortality Rates of Threats										**Total Reduced Life Cycle Impact**			**VSP Extinction Risk Class**			
	SAM	**JPM**	**SHM**	**JHM**	**FWHM**	**EHM**	**OSM**	**HM**	**JCM**	**HFM**	**Cumulative Mortality**	**% Mortality Reduction**	**Modeled Abundance**	**A&P**	**DV**	**SS**	**Overall Risk**
Current Status	0.25	0.00	0.10	0.56	0.56	0.10	0.18	0.25	0.05	0.35	96%	---	4,889	VL	M	M	L
Scenarios																	
Maintain into Future: Low Risk *Estuary Module Actions* -max reduction in EHM & OSM threats *Flood Control/Hydro Actions* -small reduction in SAM and JPM (improve A/P & SS via access/passage actions) -small reduction in JHM (improve WQ, flows) *Land Management Actions* *-small reduction in FWHM* *Hatchery Actions* -small reduction in HFM	0.15	---	0.10	0.51	0.51	0.08	0.09	0.25	0.05	0.30	92%	3.4%	8,414	VL	M	M	L
Desired Status: Very Low Risk *Flood Control/Hydro Actions* -small reduction in SAM and JPM (maximize habitat capacity for A/P and SS) *Land Management Actions* *-small reduction in FWHM* *Hatchery Actions* -modest reduction in HFM to VSP pHOS standard	0.15	---	0.10	0.51	0.51	0.08	0.09	0.25	0.05	0.10	90%	5.7%	10,916	VL+	L	L	VL+

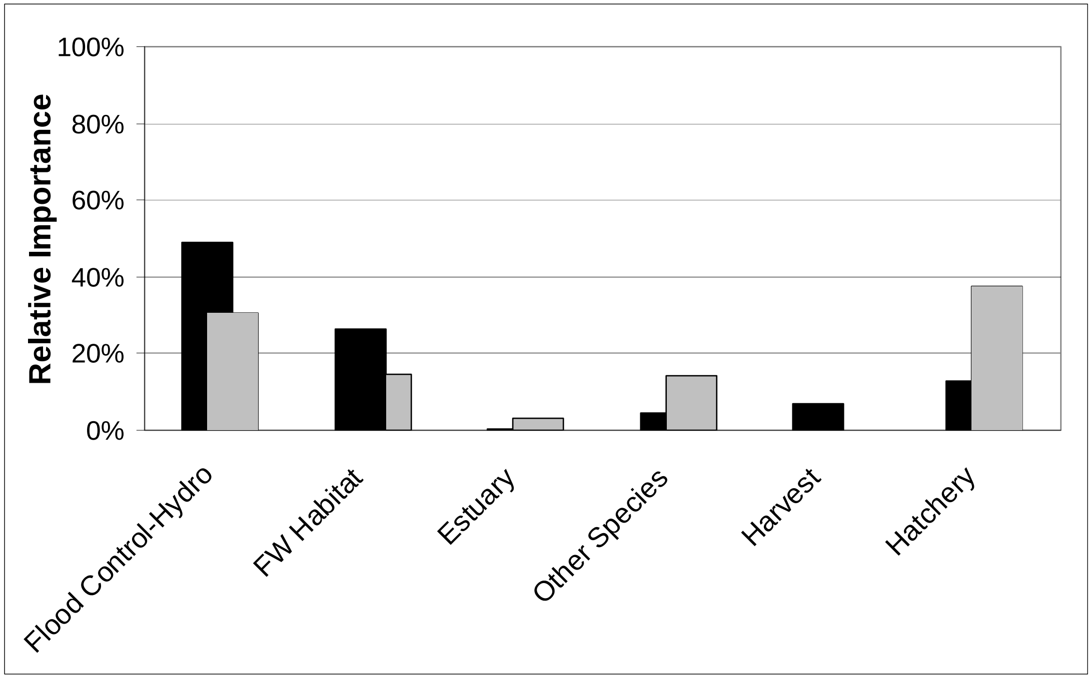

Figure 6-6. For McKenzie spring Chinook, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-16 above depicts a desired status scenario to improve the McKenzie spring Chinook population from a low risk of extinction (current status) to a very low risk of extinction. It accomplishes this with: 1) maximum mortality reductions in Estuary and Other Species threats to improve A/P; 2) moderate reductions in Flood Control / Hydro threats to improve A/P and SS; 3) small reduction in FW habitat threats to improve A/P; and 4) moderate reduction in Hatchery threats to meet a Diversity pHOS threshold for a viable population (≤ 10% pHOS) and to slightly improve A/P. Under current conditions, aggregated Flood Control/Hydro mortality has greatest relative importance to cumulative mortality, followed by FW Habitat, and it is projected that a moderate % reduction in Flood Control/Hydro mortality source and a small to moderate % reduction in FW Habitat mortality will have a large contribution to cumulative mortality reduction (Figure 6-6). As conditions improve towards desired status, there is a rebalancing of relative importance across threat categories.

Table 6-17. Threat reduction and VSP scenarios for Middle Fork Willamette spring Chinook. See the text in Section 6.2.2 for a detailed description of table organization and contents.

Middle Fork Willamette Spring Chinook																	
	Flood Control / Hydropower (subbasin)				**FW Land Use Management**	**Estuary LFT's**	**Other Species**	**Harvest Management**	**Hatchery Management**								
Limiting Factor Importance	**Spawner Access**	**Juvenile Passage**	**Spawner Habitat Conditions**	**Juvenile Habitat Conditions**	**Adult and Juvenile Conditions**	**Land Use & Flood Control/Hydro**	**Competition / Predation**	**Adults**	**Juv Competition / Predation**	**Adults**							
Key	2e	1f	2m	7f, 9f, 10d	8a, 9hi	5ab, 7h, 8a,10f				3a							
Secondary				7g	9a	9ahij	6e		4a								
	Mortality Rates of Threats										**Total Reduced Life Cycle Impact**			**VSP Extinction Risk Class**			
	SAM	**JPM**	**SHM**	**JHM**	**FWHM**	**EHM**	**OSM**	**HM**	**JCM**	**HFM**	**Cumulative Mortality**	**% Mortality Reduction**	**Modeled Abundance**	**A&P**	**DV**	**SS**	**Overall Risk**
Current Status	0.95	0.00	0.80	0.87	0.87	0.10	0.16	0.25	0.05	0.95	100%	---	0	VH	H	H	VH
Scenarios																	
Maintain into Future: VH Risk *Estuary Module Actions* -max reduction in EHM & OSM threats *Flood Control/Hydro Actions* -medium reduction in SAM and JPM (improve A/P & SS via access/passage actions) -medium reduction in SHM -large reduction in JHM (improve WQ, flows) *Land Management Actions* -medium reduction in FWHM ~20% *Hatchery Actions* -small reduction in HFM	0.53	---	0.64	0.42	0.69	0.08	0.08	0.25	0.05	0.81	100%	0.4%	203	VH	H	H	VH
Desired Status: Low Risk *Flood Control/Hydro Actions* -maximum reduction in SAM and JPM (maximize habitat capacity for A/P and SS) -maximum reduction in SHM (resolve pre-spawn mortality impacts)	0.32	---	0.14	0.28	0.56	0.08	0.08	0.25	0.05	0.10	90%	12.8%	5,820	L	L	L	L

-maximum reduction in JHM (improve WQ, flows) *Land Management* -max. reduction in FWHM *Hatchery Actions* -large reduction in HFM to VSP pHOS standard

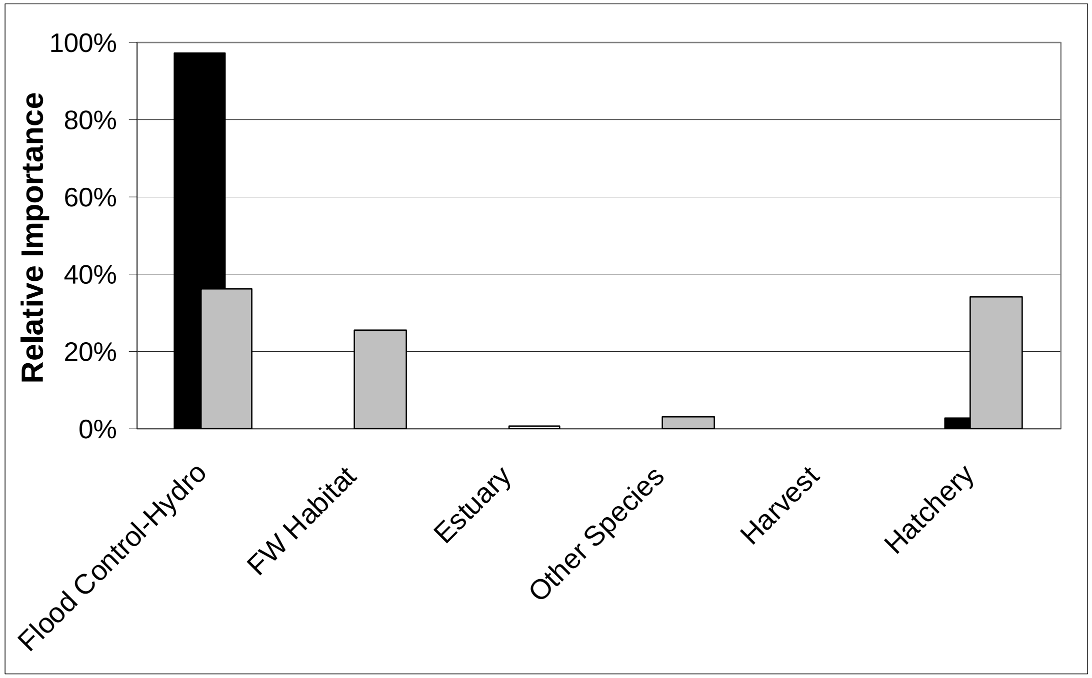

Figure 6-7. For Middle Fork Willamette spring Chinook, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-17 above depicts a desired status scenario to improve the Middle Fork Willamette spring Chinook population from a very high risk of extinction (current status) to a low risk of extinction. It accomplishes this with: 1) maximum mortality reductions in Estuary and Other Species threats to improve A/P; 2) maximum mortality reductions in FW Habitat and Flood Control / Hydro threats to improve A/P and SS; and 3) large reduction in Hatchery threats to improve A/P and to meet a Diversity pHOS threshold for a viable population (≤ 10% pHOS). Under current conditions, aggregated Flood Control/Hydro mortality has greatest relative importance to cumulative mortality, and that a large % reduction in this mortality source is projected to have a large contribution to cumulative mortality reduction (Figure 6-7). As conditions improve towards desired status, there is a rebalancing of relative importance across threat categories.

Table 6-18. Threat reduction and VSP scenarios for Molalla winter steelhead. See the text in Section 6.2.2 for a detailed description of table organization and contents.

Molalla Winter Steelhead																	
	Flood Control / Hydropower (subbasin)				FW Land Use Management	Estuary LFT's	Other Species	Harvest Management	Hatchery Management								
Limiting Factor Importance	Spawner Access	Juvenile Passage	Spawner Habitat Conditions	Juvenile Habitat Conditions	Adult and Juvenile Conditions	Land Use & Flood Control/Hydro	Competition / Predation	Adults	Juv Competition / Predation	Adults							
Key					8a	5ab, 7h, 10f											
Secondary					2a,7a,9a, 9hi,10b	8a,9ahij	6e		4a								
	Mortality Rates of Threats										Total Reduced Life Cycle Impact			VSP Extinction Risk Class			
	SAM	JPM	SHM	JHM	FWHM	EHM	OSM	HM	JCM	HFM	Cumulative Mortality	% Mortality Reduction	Modeled Abundance	A&P	DV	SS	Overall Risk
Current Status	0.00	---	0.00	0.00	0.94	0.10	0.16	0.16	0.05	0.19	97%	---	2,456	VL	M	M	L
Scenarios																	
Maintain into Future: Low Risk *Estuary Module Actions* -max reduction in EHM & OSM threats	0.00	---	0.00	0.00	0.94	0.08	0.08	0.16	0.05	0.19	96%	0.4%	2,744	VL	M	L	L
Desired Status: Very Low Risk *Hatchery Actions* -small reduction in HFM to VSP pHOS standard	0.00	---	0.00	0.00	0.94	0.08	0.08	0.16	0.05	0.05	96%	1.0%	3,226	VL	L	L	VL

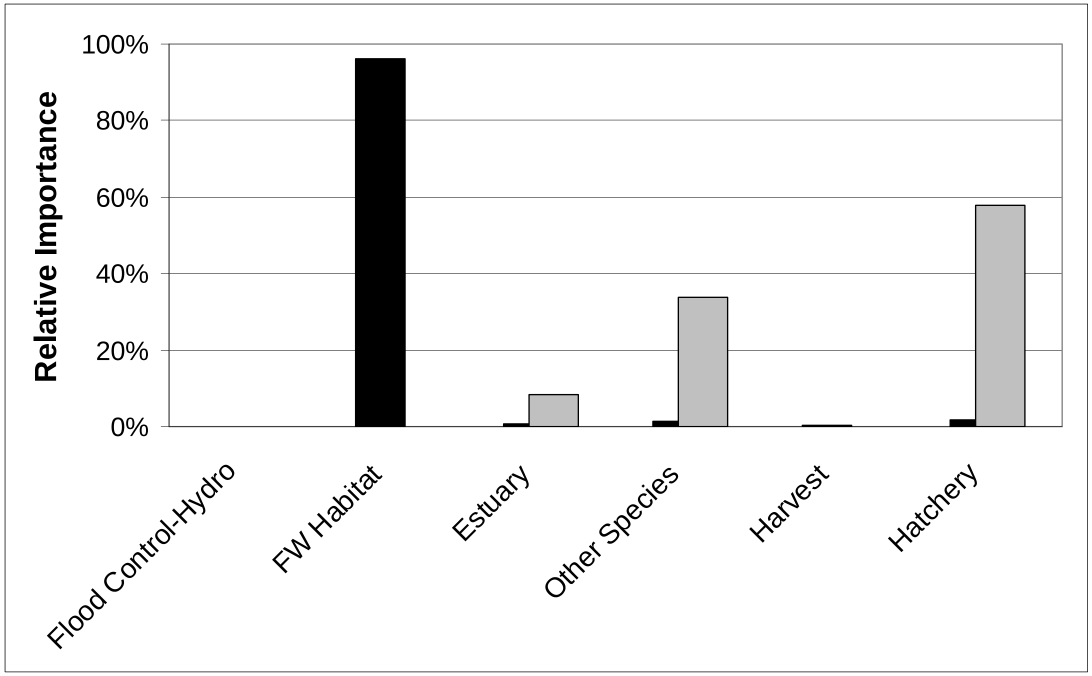

Figure 6-8. For Molalla winter steelhead, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-18 above depicts a desired status scenario to improve the Molalla winter steelhead population from a low risk of extinction (current status) to a very low risk of extinction. It accomplishes this with: 1) maximum mortality reductions in Estuary and Other Species threats to improve A/P; 2) small reduction in Hatchery threats to improve A/P and to meet a Diversity pHOS threshold for a viable population (≤ 5% pHOS of an out-of ESU stock). Although not depicted, SS and A/P will also be improved by large reductions in FW Habitat threats that will be implemented for meeting desired status of Molalla spring Chinook. Under current conditions, FW Habitat mortality has greatest relative importance to cumulative mortality (Figure 6-8), but it is projected that mortality reductions in other categories will likely be sufficient to meet desired status goals. However, steelhead will also benefit from the FW Habitat improvements to meet Molalla spring Chinook goals, moving this population beyond the very low risk threshold. As conditions improve towards desired status, there is a rebalancing of relative importance across threat categories.

Table 6-19. Threat reduction and VSP scenarios for North Santiam winter steelhead. See the text in Section 6.2.2 for a detailed description of table organization and contents.

North Santiam Winter Steelhead																	
	Flood Control / Hydropower (subbasin)				FW Land Use Management	Estuary LFT's	Other Species	Harvest Management	Hatchery Management								
Limiting Factor Importance	Spawner Access	Juvenile Passage	Spawner Habitat Conditions	Juvenile Habitat Conditions	Adult and Juvenile Conditions	Land Use & Flood Control/Hydro	Competition / Predation	Adults	Juv Competition / Predation	Adults							
Key	2b	1d		10acd	8a	5ab, 7h, 8a,10f			4cd	3a							
Secondary	2i*		7c	7b,9d	2a,7a, 9ahi, 10b	9ahij	6e		4a								
	Mortality Rates of Threats										**Total Reduced Life Cycle Impact**			**VSP Extinction Risk Class**			
	SAM	**JPM**	**SHM**	**JHM**	**FWHM**	**EHM**	**OSM**	**HM**	**JCM**	**HFM**	**Cumulative Mortality**	**% Mortality Reduction**	**Modeled Abundance**	**A&P**	**DV**	**SS**	**Overall Risk**
Current Status	0.48	---	0.00	0.57	0.57	0.10	0.17	0.16	0.05	0.14	95%	---	3,668	VL	M	H	L
Scenarios																	
Maintain into Future: Low Risk *Estuary Module Actions* -max reduction in EHM & OSM threats *Hatchery Actions* -medium reduction in HFM to VSP pHOS standard	0.48	---	0.00	0.57	0.57	0.08	0.08	0.16	0.05	0.05	94%	1.3%	4,594	L	L	M	L
Desired Status: Very Low Risk *Flood Control/Hydro Actions* -small reduction in SAM and JPM -small reduction in JHM *Land Management Actions* -medium reduction in FWHM ~20%	0.37	---	0.00	0.48	0.48	0.08	0.08	0.16	0.05	0.05	89%	6.6%	8,362	VL	L	L	VL

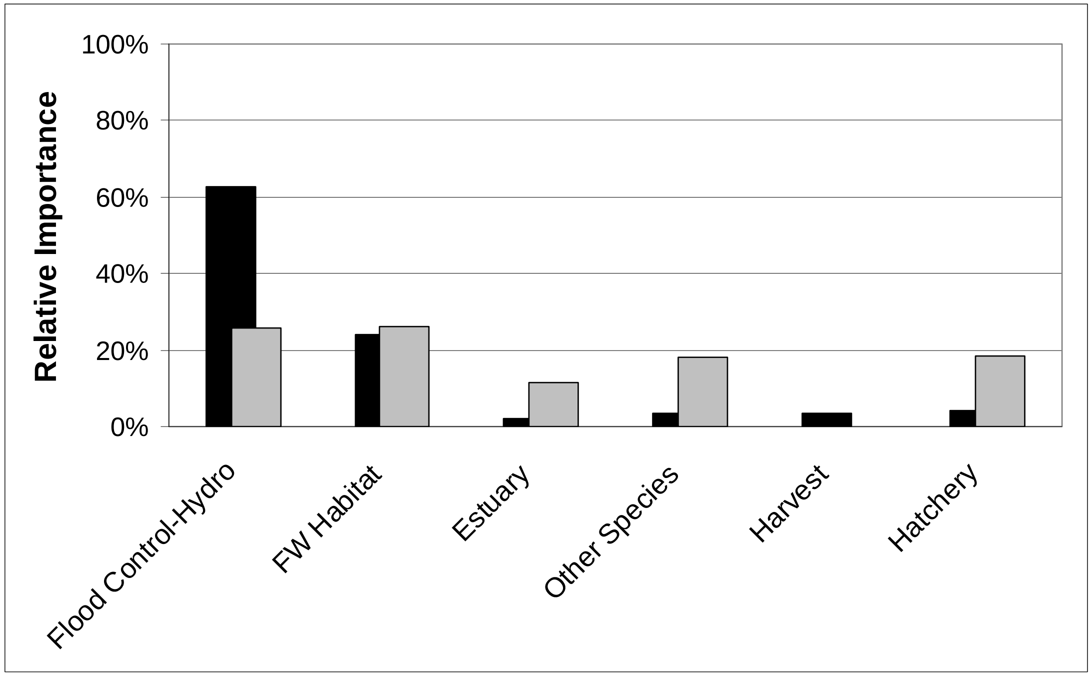

Figure 6-9. For North Santiam winter steelhead, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-19 above depicts a desired status scenario to improve the North Santiam winter steelhead population from a low risk of extinction (current status) to a very low risk of extinction. It accomplishes this with: 1) maximum mortality reductions in Estuary and Other Species threats to improve A/P; 2) mortality reductions in FW Habitat and Flood Control / Hydro threats to improve A/P and SS, which are coupled with large reductions in these threats for actions that will be implemented for meeting desired status of North Santiam spring Chinook; and 3) small reduction in Hatchery threats to improve A/P and to meet a Diversity pHOS threshold for a viable population (≤ 5% pHOS of an out-of ESU stock). Under current conditions, aggregated Flood Control/Hydro mortality has greatest relative importance to cumulative mortality, and it is projected that a small to moderate % reduction in this mortality source will have a large contribution to cumulative mortality reduction (Figure 6-9). As conditions improve towards desired status, there is a rebalancing of relative importance across threat categories.

Table 6-20. Threat reduction and VSP scenarios for South Santiam winter steelhead. See the text in Section 6.2.2 for a detailed description of table organization and contents.

South Santiam Winter Steelhead																	
	Flood Control / Hydropower (subbasin)				FW Land Use Management	Estuary LFT's	Other Species	Harvest Management	Hatchery Management								
Limiting Factor Importance	Spawner Access	Juvenile Passage	Spawner Habitat Conditions	Juvenile Habitat Conditions	Adult and Juvenile Conditions	Land Use & Flood Control/Hydro	Competition / Predation	Adults	Juv Competition / Predation	Adults							
Key	2c	1e		10cde	8a	5ab, 7h, 8a,10f			4cd	3a							
Secondary		2j*		7d,9e	2a,7a, 9ahi, 10b	9ahij	6be		4a								
	Mortality Rates of Threats										**Total Reduced Life Cycle Impact**			**VSP Extinction Risk Class**			
	SAM	**JPM**	**SHM**	**JHM**	**FWHM**	**EHM**	**OSM**	**HM**	**JCM**	**HFM**	**Cumulative Mortality**	**% Mortality Reduction**	**Modeled Abundance**	**A&P**	**DV**	**SS**	**Overall Risk**
Current Status	0.18	---	0.00	0.66	0.66	0.10	0.17	0.16	0.05	0.04	95%	---	2,715	VL	M	M	L
Scenarios																	
Desired Status: Very Low Risk *Estuary Module Actions* -max reduction in EHM & OSM threats *Flood Control/Hydro Actions* -small reduction in SAM and JPM *Land Management Actions* -medium reduction in FWHM	0.14	---	0.00	0.66	0.58	0.08	0.08	0.16	0.05	0.04	92%	2.5%	3,912	VL	L	L	VL

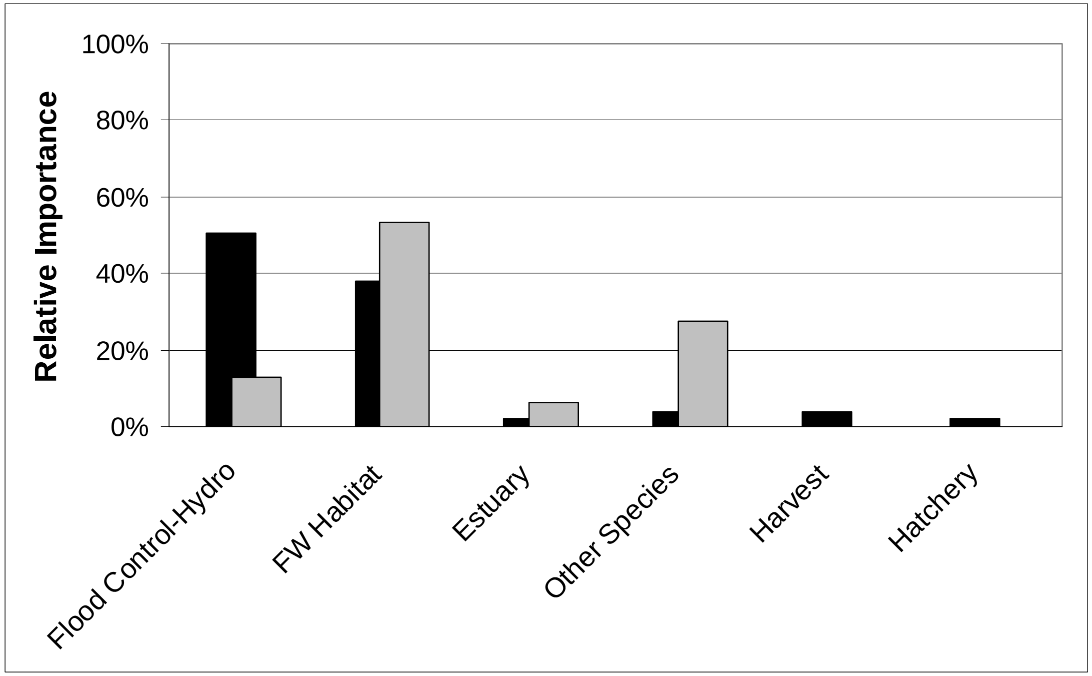

Figure 6-10. For South Santiam winter steelhead, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-20 above depicts a desired status scenario to improve the South Santiam winter steelhead population from a low risk of extinction (current status) to a very low risk of extinction. It accomplishes this with: 1) maximum mortality reductions in Estuary and Other Species threats to improve A/P; 2) small mortality reductions in Flood Control/Hydro threats and moderate mortality reductions in FW Habitat threats to improve A/P and SS, which are coupled with large reductions in these threats for actions that will be implemented for meeting desired status of South Santiam spring Chinook. Under current conditions, aggregated Flood Control/Hydro mortality and FW Habitat mortality have the greatest relative importance to cumulative mortality, and it is projected that a small to moderate % reduction in these mortality sources will have a large contribution to cumulative mortality reduction (Figure 6-10). As conditions improve towards desired status, there is a rebalancing of relative importance across threat categories.

Table 6-21. Threat reduction and VSP scenarios for Calapooia winter steelhead. See the text in Section 6.2.2 for a detailed description of table organization and contents.

Calapooia Winter Steelhead	SAM	JPM	SHM	JHM	FWHM	EHM	OSM	HM	JCM	HFM	Cumulative Mortality	% Mortality Reduction	Modeled Abundance	A&P	DV	SS	Overall Risk
	Flood Control / Hydropower (subbasin)				**FW Land Use Management**	**Estuary LFT's**	**Other Species**	**Harvest Management**	**Hatchery Management**								
Limiting Factor Importance	**Spawner Access**	**Juvenile Passage**	**Spawner Habitat Conditions**	**Juvenile Habitat Conditions**	**Adult and Juvenile Conditions**	**Land Use & Flood Control/Hydro**	**Competition / Predation**	**Adults**	**Juv Competition / Predation**	**Adults**							
Key					8a	5ab, 7h, 10f											
Secondary					2ah,7a, 9ahi, 10b	8a,9ahij	6e		4a								
	Mortality Rates of Threats										**Total Reduced Life Cycle Impact**			**VSP Extinction Risk Class**			
Current Status	0.00	---	0.00	0.00	0.96	0.10	0.16	0.16	0.05	0.00	98%	---	416	M	M	VH	M
Scenarios																	
Desired Status: Maintain at Moderate Risk *Estuary Module Actions* -max reduction in EHM & OSM threats *Land Management Actions* -small reduction in FWHM	0.00	---	0.00	0.00	0.96	0.08	0.08	0.16	0.05	0.00	97%	0.6%	522	M	M	M	M
ESU Viability Buffer: Low Risk *Land Management Actions* -small reduction in FWHM	0.00	---	0.00	0.00	0.94	0.08	0.08	0.16	0.05	0.00	96%	1.9%	751	L	L	L	L

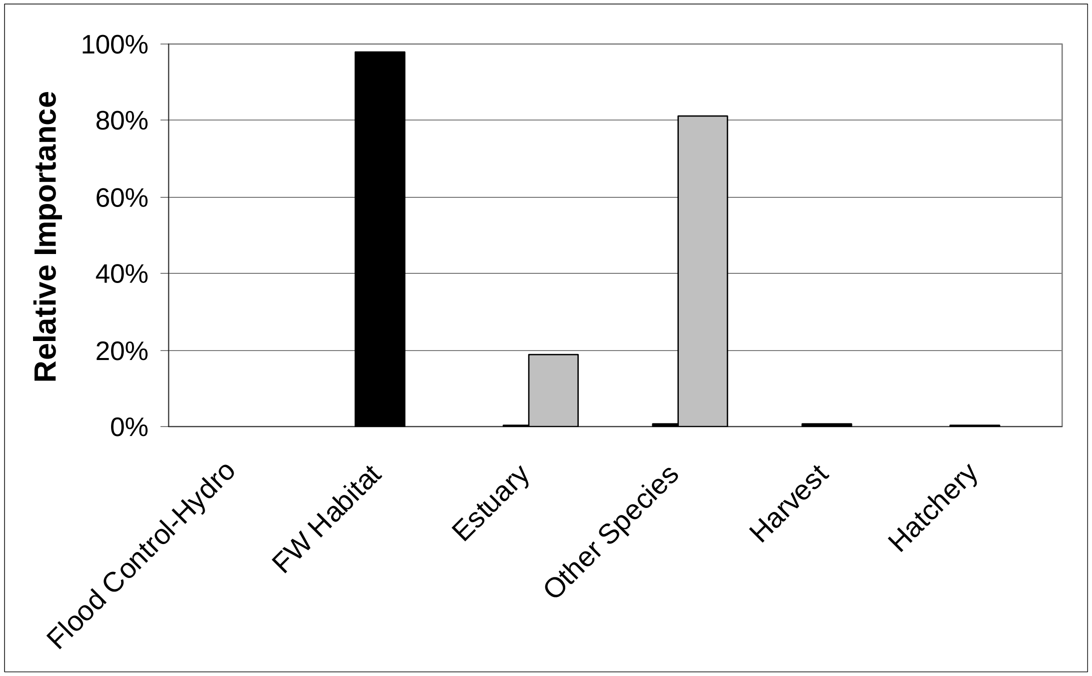

Figure 6-11. For Calapooia winter steelhead, bar chart depicts the percent relative contribution of mortality for each threat category to the cumulative mortality under current baseline conditions (black bars), and the percent relative importance of each threat category to cumulative mortality under the desired status scenario (gray bars). Data are based on associated scenario table.

Table 6-21 above depicts a desired status scenario to maintain the Calapooia winter steelhead population at a moderate risk of extinction. It accomplishes this with: 1) maximum mortality reductions in Estuary and Other Species threats to improve A/P; 2) small reduction in Hatchery threats to improve A/P and to meet a Diversity pHOS threshold for a viable population (≤ 5% pHOS of an out-of ESU stock). Although not depicted, SS and A/P will also be improved by large reductions in FW Habitat threats that will be implemented for meeting desired status of Calapooia spring Chinook. Under current conditions, FW Habitat mortality has the greatest relative importance to cumulative mortality (Figure 6-11), but it is projected that mortality reductions in other categories will likely be sufficient to meet desired status goals.

6.2.3 SLAM

The Species Life-cycle Analysis Modules (SLAM[69]) is a tool designed to model life-cycle dynamics and can be used to evaluate the effect of management actions on population abundance and viability. The SLAM tool was used to check results generated using the CATAS model and address its limitations. SLAM was used to model life-stage specific stochasticity, density dependence, delays in the effects of management changes, and cyclic patterns like inter-decadal ocean oscillations. However, since building each model (i.e. each scenario) is quite time-consuming, models in SLAM were only created for those scenarios that were most likely to be realized. Consequently, we created models in SLAM only for those scenarios that are intended to achieve targeted delisting goals.

SLAM uses repeated random sampling via a Monte Carlo simulation to generate multiple trajectories for a given scenario. Statistics on the population of trajectories, such as the mean or median trajectory with quantiles, the absolute distribution at a given time point, or the percent of trajectories that fall below a threshold value can then be used to describe the scenario. The number of individual animals is tracked through different life stages based on the survival rates from one stage to the next. Further details about development of the life cycle models and parameterization can be found in Appendix D.

In SLAM the probability of extinction is defined as the proportion of trajectories that fall below the Critical Risk Threshold (CRT) for a period of 4 consecutive years. The CRT (or quasi-extinction threshold -QET- in SLAM) is defined as the minimum population size required for a population to be self-sustaining. If a population falls below this threshold for an entire generation it is said to be functionally extinct. Since the offspring of stray hatchery fish contribute to the number of natural spawners in these models, the number of naturally-spawned hatchery origin fish that returned to spawn was added to the CRT. See Appendix D for detailed documentation on the data sources and SLAM model structure used respectively for Chinook and steelhead.

<u>Preliminary Comparison to CATAS</u>

The probability that the population abundance modeled in SLAM, using the threat reductions identified in the Scenario Analysis, would fall below the critical risk threshold (CRT) based on the parameter values for a specific risk scenario was compared to the CATAS model's probability of extinction (see Appendix D for SLAM metadata). In general there was good concordance between the projected extinction risk classes for the two model types. Exceptions were the Molalla and Calapooia spring Chinook model runs, where SLAM predicted a higher risk of extinction than the CATAS model, and in both of these cases the current abundance was below or near the CRT (Table 6-22). If the population abundance is already below the CRT it is easy to see how delays in realizing survival improvements could have a substantial impact on the proportion of trajectories where the population abundance falls below the CRT.
That the two vastly different modeling approaches (CATAS and SLAM) give similar probability of extinction results lends confidence that the threat reductions portrayed in the VSP scenarios summarized in Section 6.2 are projecting improvements in the future status of these populations within a reasonable range. However, it is also clear that when the current population abundance is low relative to the CRT it is important to use a model that can take into account delays in the implementation of recovery.

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[69] The SLAM and time-series generators created by Paul McElhany, Mirek Kos and Anne Mullan are available at http://www.nwfsc.noaa.gov/trt/slam/slam.cfm.

Table 6-22. A comparison of two PVA models. QET = quasi-extinction threshold from SLAM. When the abundance falls below the CRT or QET for 4 consecutive years the population is considered functionally extinct. Models were constructed under both CATAS and SLAM that brought the population to the same equilibrium abundance. The probability of extinction was then calculated for each model. This determined the risk category for the population.

	Current Status A&P Extinction Risk Class		Viability Scenario A&P Extinction Risk Class				
	Abundance	CATAS	CATAS Abundance	CATAS Risk Class	SLAM Abundance	SLAM Risk Class	QET
Chinook							
Clackamas	1,371	M	2,317	VL	3,500	VL	0.001
Molalla	0	VH	696	H	850	VH	0.600
North Santiam	0	VH	5,400	L	5,500	L	0.001
South Santiam	1	VH	3,100	M	4,500	VL	0.000
Calapooia	0	VH	590	H	380	VH	0.470
McKenzie	4,885	VL	8,376	VL	2,800	VL	0.002
MF Willamette	0	VH	5,820	L	2,800	L	0.011
Steelhead							
Molalla	2,443	VL	3,000	VL	1,900	VL	0.000
North Santiam	3,671	VL	8,358	VL	5,000	VL	0.000
South Santiam	2,701	VL	3,913	VL	3,000	VL	0.000
Calapooia	415	M	498	M	375	VL	0.000

SLAM was also used to explore multiple recovery scenarios for the Middle Fork Willamette Chinook population. This was done in part to test some initial assumptions of fish passage improvements through the multiple flood control facilities, and whether restoring production above Hills Creek dam would be needed for a recovery target of low extinction risk. Initial model runs indicated that the most likely projection was to achieve a moderate risk of extinction, under assumptions of passage at all large Middle Fork Willamette River dams. When assumptions of where production was allocated within different areas of the subbasin, different extinction projections were produced, ranging from high risk to low risk. To make SLAM a useful decision tool in this regard, there is a need to develop better capacity and production parameter estimates. It is assumed that RME associated with the WP BiOp (NMFS 2008a) will improve this data gap and that SLAM can then be applied to the decision making process as to how to best implement many Recovery Plan elements.

Chapter 7: Strategies and Actions

To successfully recover UWR Chinook and steelhead populations, strategies must be devised and actions implemented that are effective at: 1) reducing or eliminating the limiting factors and threats identified in Chapter 5 that currently impact viability, and 2) preventing factors that do not currently impact viability from doing so in the future. Because of the diverse life-history of UWR Chinook and steelhead populations and the broad array of limiting factors and threats that affect them, strategies and actions are needed that span their entire life-cycle and address all limiting factor and threat categories. The level to which these strategies and actions must be implemented is guided by the biological risk and threat reduction scenarios described in Chapter 6. This chapter describes the strategies and actions proposed to address the current impacts as well as those needed to prevent or minimize future impacts on UWR Chinook and steelhead populations. This chapter also describes the strategic approach used to develop and prioritize these strategies and actions. While fundamentally intended to produce biological results, strategies and actions included in this Plan also reflect economic, political, social, and cultural considerations. In particular, they are framed to regain the viability of the ESU and DPS as well as make progress toward Broad Sense Recovery Goals. These non-biological considerations are critical to the prospects for developing and implementing an effective and equitable Plan. It is expected that through time, additional actions will be incorporated as part of an adaptive management process. An approach for estimating the costs of implementing these strategies and actions are included in the Implementation chapter (Chapter 9).

7.1 Conceptual Framework

7.1.1 Key Components

The development of a comprehensive suite of actions to recover UWR Chinook and steelhead populations is based on the consideration of the following key components described in this chapter and elsewhere:

- *Threats* – human actions or natural occurrences that cause or contribute to limiting factors.
- *Limiting Factors* – threats can become limiting factors to viable salmonid populations when they interact or accumulate to the extent they degrade the physical, biological, or chemical conditions and associated ecological processes and interactions experienced by the fish.
- *Biological Risk Scenarios* – objectives for improvement in each population from the current status to a desired future status.
- *Threat Reduction Scenarios* – objectives for reducing each threat affecting any population to achieve a desired status.
- *Strategies* – general statements about how threat reduction scenarios will be achieved.
- *Actions* – specific activities that are used to accomplish strategic objectives.
- *Priority Areas* – physical locations (e.g., specific stream reaches) where an action will have the greatest beneficial effect and where the implementation of that action is most feasible.
- *Programs* – regulatory and non-regulatory mechanisms or projects that govern and/or implement actions.

The relationship between these components is shown in Figure 7-1. The development of the strategies and actions needed to recover UWR Chinook and steelhead populations are founded on the assessment of limiting factors and threats (LFTs), described in Chapter 5. The extent to which reductions in LFTs are needed for desired status objectives and how they are balanced across management regimes are projected as scenarios in Chapter 6. Many of the LFTs were specific to some life-stage or geographic area, and the UWR Planning Team helped identify priority actions for specific locations. To provide an ecological context and foundation for identifying actions, a number of overarching strategies were developed, which will be implemented by specific on-the-ground actions. Once strategies and actions were identified, existing programs or potential implementers were identified that will help implementing them.

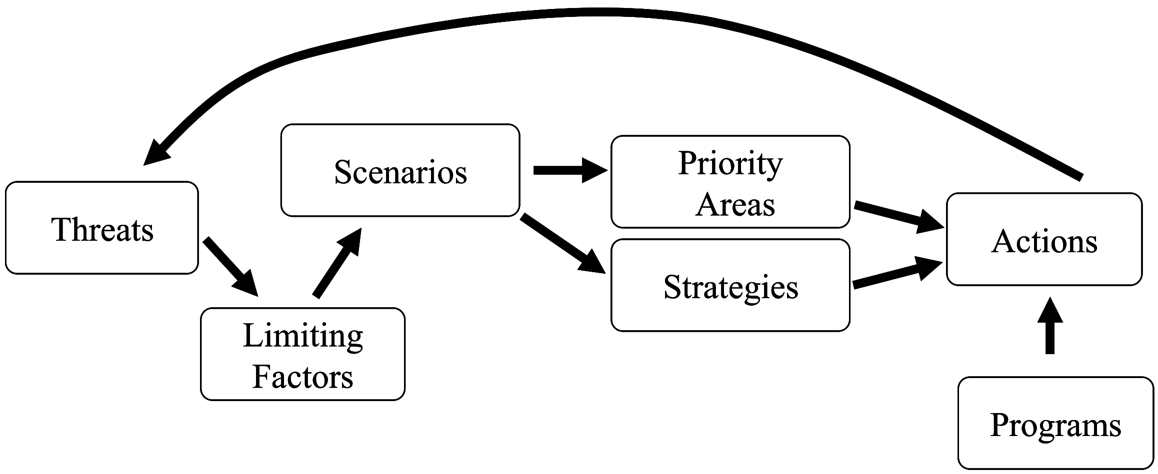

Figure 7-1. Relationship between key components of developing and implementing actions for recovering UWR Chinook and steelhead populations.

7.1.2 General Strategies

The recovery strategies developed for this Plan are based on the conservation biology goals proposed by Trombulak et al. (2004) for achieving biological diversity[70], ecological integrity[71], and ecological health[72]. Achieving these goals in the context of this Recovery Plan requires strategies that incorporate the following general principles (adapted from Groom et al. 2006):

- Act to alleviate the impacts of threats to the viability of UWR Chinook salmon and steelhead populations throughout their entire life cycle
- Set aside or protect the highest quality habitat (including Federal lands above the dams)
- Do not let habitat conditions degrade further and restore ecosystems that have been degraded
- Maintain or restore critical ecological and evolutionary processes
- Develop goals and objectives based on interaction of ecological properties of the system
- Manage fisheries and hatchery programs adaptively so their impacts on wild salmon and steelhead populations are compatible with recovery goals.
- Reduce impacts of predation that are specifically related to anthropogenic alterations to the ecosystem, and prevent the establishment of non-native species, and where necessary eliminate non-native species that have become established.
- Act as quickly as possible to achieve the goals of this Recovery Plan.

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[70] Biological diversity is a measure of the range of variety and variability within and among living organisms and the ecological complexes in which they occur.
[71] Ecological integrity is a measure of the composition, structure, and function of biological systems.
[72] Ecological health is a measure of a biological system's resiliency and ability to maintain itself over time.

Most of these guiding principles are self explanatory. The last principle (act as quickly as possible to achieve the goals of this Recovery Plan) is particularly applicable to subbasin habitat actions and interim flood control/ hydro actions. The need for implementing some subbasin habitat actions in the near term is especially critical given the time it may take for some of these actions to have their full benefit to fish recovery (e.g., shading of riparian vegetation, restoring other riparian and floodplain functions, improving water quality). These actions also need immediate implementation to help buffer against emerging threats that may increase extinction risk for some populations. Interim flood control water quality actions need to be implemented immediately and extensively to help reduce prespawn mortality and early juvenile mortality below WP dams. For four of the Chinook populations and two of the steelhead populations, the interim WP BiOp RPA actions (NMFS 2008a) will play a major role in reduce the current extinction risk, until more permanent BiOP measures can be implemented. The WP BiOp RPAs will play a major role in the success of the general strategies listed above and the more specific strategies listed below. In addition, achieving the Plan objectives will rely on effective alignment of implementing the land management actions with actions occurring under the Flood Control/Hydropower programs.

Based on these general principles, 14 recovery strategies were developed to help organize the development of recovery actions needed for UWR Chinook and steelhead populations. Successful implementation of these strategies will require intensive and coordinated efforts at regional, watershed, and local levels. The relationship between these strategies and the broad threat categories that are contributing to limiting facts affecting viability of UWR Chinook and steelhead populations are shown in Table 7-1. Many of the strategies in Table 7-1 and the on-the-ground actions in Table 7-2 will be implemented in a coordinated fashion, so that significant life-cycle bottlenecks (example: multiple LFTs affecting a critical life stage) are addressed first. For example, many Chinook populations have very high pre-spawning mortality, in some cases due to a combination of known and unknown factors. It will be critical to remove this critical life-cycle bottleneck as soon as possible, so that implementing a full suite of actions for other limiting factors will have the greatest possible biological response and not be thwarted by the presence of a bottleneck that produces high mortality for a life stage. These bottleneck strategies are embedded in the scenarios in Chapter 6 and actions to be implemented immediately are outlined in Chapter 9.

Habitat related strategies in Table 7-1 are more numerous than those for harvest and hatchery management. This does not imply a disproportionate emphasis on habitat management. Rather, there are many more limiting factors and threats in the habitat category than in the harvest and hatchery categories. For example, restoring degraded habitat in a watershed should entail overlapping strategies to address floodplain connectivity and function, riparian condition, passage impairment, inadequate streamflows, lack of habitat complexity, and degraded water quality. On the other hand, reducing the impact of fish harvest to levels that are needed for recovery simply involves a strategy to reduce fishery harvest rates.

Table 7-1. General strategies to recover UWR Chinook and steelhead populations, and their relevance to the broad threats that are impacting those populations.

	Strategy	Broad Threat Categories Addressed				
		Fish Harvest	Hatchery	Flood Control/Hydro	Land Management	Other Species
1	Protect and conserve natural ecological processes that support the viability of wild salmon and steelhead populations and their life history strategies throughout their life cycle.	√	√	√	√	√
2	Restore floodplain connectivity and function and maintain unimpaired floodplain connectivity and function.			√	√	
3	Restore riparian condition and LWD recruitment, and maintain unimpaired conditions			√	√	
4	Restore passage and connectivity to habitats blocked or impaired by artificial barriers, and maintain unimpaired passage and connectivity.		√	√	√	
5	Restore and maintain hydrologic regimes that support the ecological needs of wild salmon and steelhead populations.			√	√	
6	Restore channel structure and complexity, and maintain unimpaired structure and complexity.			√	√	
7	Restore impaired food web dynamics and function, and maintain unimpaired dynamics and function (both impacts of competition for food resources and altered ecosystem function).		√	√	√	√
8	Restore degraded water quality and maintain unimpaired water quality.			√	√	
9	Restore degraded upland processes to minimize unnatural rates of erosion and runoff, and maintain natural upland processes				√	
10	Reduce the impact of non-native plants and animals on wild salmon and steelhead populations and prevent the introduction of new non-native plants and animals		√		√	√
11	Reduce predation on wild salmon and steelhead that has been exacerbated by anthropogenic changes to the ecosystem.		√	√	√	√
12	Manage fisheries so that harvest impacts do not compromise the recovery of wild salmon and steelhead populations	√				
13	Manage hatchery origin fish in ways that support the recovery of wild salmon and steelhead populations.		√			
14	Reduce or eliminate other anthropogenic sources of mortality (e.g., beach stranding of juveniles due to ship wakes in the estuary) and prevent them from becoming a problem in areas where they currently do not occur.	√	√	√	√	√

7.1.3 Development of Actions

The actions summarized below were developed by the Planning Team with assistance from Stakeholder Team members. Most actions are on-the-ground actions that address a key or secondary limiting factor, as described in Chapter 5, and which will contribute to improving VSP attributes and addressing listing factors (as scoped in Chapter 6 scenarios). Other actions are associated with coordination, reporting, and RME needs. For most populations, some level of watershed assessment had been completed that allowed the Planning Team to identify reach- or stream-specific locations for implementation of specific habitat actions. For populations lacking watershed assessments, the Planning Team used its professional judgment to identify locations for implementing specific habitat actions. For most of the Flood Control/Hydro actions, this Plan used the WP BiOp RPAs (NMFS 2008a) as a base set of actions. For estuary actions, this Plan used the NMFS Estuary Module actions as a base set of actions. This Recovery Plan has the highest likelihood of being successful in the shortest amount of time if actions that address the key and secondary limiting factors can be implemented in those areas and for life stages where the greatest benefit will result. This approach will also ensure that the greatest gains in recovery can be made if implementation funds are limited.

Building on Past and Current Efforts

Many steps have already been taken or are currently underway that will improve the status of UWR Chinook and steelhead. In the Willamette River mainstem and population subbasins, State and Federal natural resource managers, local governments, watershed councils, soil and water conservation districts, non-profit organizations, land owners and others continue to improve stream conditions to support viable Chinook and steelhead populations. They are also improving land use practices on uplands and floodplains that are allowing natural ecosystem functions and processes to recover. Efforts underway in the Columbia River estuary will improve estuarine and plume habitats and reduce predation. In the mainstem Columbia River, hydrosystem managers and fish resource managers continue to refine hydropower system operations to address the needs for survival and recovery of Chinook and steelhead from the UWR and other Columbia River ESUs/DPSs. New and innovative actions are being required by the WP BiOp (NMFS 2008a). As described in Chapter 5, extensive harvest management changes in both the Willamette River mainstem and subbasins have already been implemented to reduce the impacts of fisheries.

Much of the existing conservation effort in the region has been guided by a number of regional management plans that have been developed over the last few decades. See Appendix F for a listing of these plans. Many of the actions identified for this Recovery Plan originate in these earlier plans. Successful implementation of this Recovery Plan relies on the combined effort of State and Federal agencies, local governments, watershed councils, soil and water conservation districts, non-profit organizations, local land owners and others committed to the recovery of UWR Chinook and steelhead populations. Most, if not all, of these entities have existing programs that have contributed in the past and in the future will be integral to the implementation of the actions identified in this recovery Plan. Some of these programs are capable of accomplishing their goals with the resources at hand, while others are in need of additional resources in order to fully implement necessary actions. See Appendix G for a listing and description of the key programs that will be involved in implementing many of the actions identified in this recovery Plan.

Enhanced Effort and Innovative Actions

Although past and current efforts continue to play an important role in maintaining the current status and setting the foundation for recovery of UWR salmon and steelhead populations, there is an obvious need for enhanced effort and some innovative approaches. The actions identified for this Plan represent a mixture of continuing actions that are currently working, enhancing the effort for actions that should work if more resources are available for their implementation, and new and innovative actions that are not currently being implemented.

Uncertainty- The Role of Research, Monitoring, and Evaluation

As with developing the biological and threat reduction scenarios, there is uncertainty with how much abundance and productivity will improve given the implementation for some of the strategies and actions. As a result, it is difficult to determine how comprehensive and intense these actions need to be implemented in order to contribute to the desired status for populations. The status and trend and effectiveness monitoring that are outlined in Chapter 8 (RME) will need to be implemented to determine the biological effectiveness of these actions, and integrated in the adaptive management part of this Plan. Uncertainty in survival improvements is not uniform across the suites of actions. For example, actions related to harvest reductions would have more certainty, where an enforceable reduction in harvest will result in a commensurate improvement in spawner abundance, through greater ocean and in-river survival and greater escapement. However, it is also assumed that further reductions in harvest will do little to improve the VSP parameters until key and secondary LFTs and related life-cycle bottlenecks are alleviated. The fish passage actions related to Flood Control/Hydro management also have clear VSP benefits for: 1) adult spawning success (increased productivity, greater spatial structure, less hatchery fish influence) through access to better habitat and less prespawn mortality in wild fish focus areas, and 2) subsequent juvenile survival (productivity). Although VSP improvements are clearly linked to actions that improve tributary and estuary habitat, their implementation is less certain, primarily because they rely heavily on the voluntary efforts of individuals. It may be that individual stream improvement efforts will not be scaled sufficiently to restore enough spatial continuity within a stream to restore riparian and hydrologic function. Coordinated watershed strategies with a multitude of entities will be needed to prioritize and locate actions in stream reaches, and to identify appropriate metrics that can be monitored to reduce uncertainty with action effectiveness.

Linking Actions to Recovery Goals

The population recovery scenarios in Chapter 6 projected survival improvement targets across major threat category to meet A/P VSP targets. We assume that VSP targets and other biological criteria will be met for each UWR Chinook and steelhead population (and thereby achieving a significant ESU recovery goal) by implementing actions in this chapter that reduce key and secondary LFTs. Ideally, it would be desirable to identify the contribution of major suites of actions towards closing the gap between current status and desired status of individual populations. This would allow a more quantitative assessment as to whether the suite of actions in the plan will, when considered in total, achieve the Plan goals. However, our current understanding of the biological response to many of the habitat and “other species” actions precludes such a sufficiency assessment. Instead, this Plan will rely heavily on monitoring the population VSP metrics (described in Chapter 8), in order to provide timely information on both overall progress being made toward achieving VSP targets (population desired status) and the contribution of major actions towards that progress. If monitoring indicates insufficient progress is being made, strategies and major actions will be: 1) recalibrated to increase the level of implementation for some actions, 2) redirected or re-weighted some actions, or 3) integrated into a new set of strategies and actions. As such, this Plan will be modified as part of the adaptive management process outlined in Chapter 9.

Immediate Action

A recurring theme that surfaced during discussions with both the UWR Planning and Stakeholder Teams was the need for immediate implementation of some actions that would “stop the bleeding” and prevent a further decline in the status of UWR Chinook and steelhead populations. Most UWR Chinook populations are currently at a high or very high risk of extinction, and most of these populations are targeted in Chapter 6 (Recovery Scenarios) for lower risk levels. It is critical that some actions that will have immediate effect be implemented now to reduce the probability of extinction. Other actions that will have accruing long term benefits should also be started soon, because these actions will have a larger bearing on progress towards desired status risk level goals. The actions identified in this Plan represent a combination of actions that will have a relatively immediate impact on reducing significant threats to UWR Chinook and steelhead populations (e.g., some hatchery broodstock actions, some interim flood control/hydro actions) as well as actions that will take a longer time before impact reductions are realized (e.g. some habitat actions, some long-term flood control/hydro actions). To meet recovery goals, it is important to implement as soon as possible short-term and long-term restoration actions, as well as protective actions, to stop the decline and begin reducing the risk of extinction on UWR Chinook and steelhead populations. This Plan utilizes a priority setting process based on the strategies (above) and other considerations that are further outlined in Chapter 9, to identify strategies and actions that are the most urgent to implement.

<u>Actions to Address Emerging Threats</u>

In addition to detailed descriptions of current threats and limiting factors, Chapter 5 provided an overview of what UWR Chinook and steelhead populations may confront with projected effects of climate change and human population growth. For this Recovery Plan to succeed, it is important that actions be implemented now that prevent or mitigate for these future impacts. It is anticipated that strategies and actions addressing these emerging threats are not fundamentally different than the actions already in this Plan to address existing LFTs. However, some limiting factors may extend to more life stages or to larger spatial areas, such that existing actions may have to be implemented over a greater area and with more intensity. In addition, some areas may become more important for protection and restoration. For example, UWR stream reaches that drain the Cascade ecoregion may have even greater significance within a recovery strategy if they provide coldwater refugia under climate change scenarios that project warmer summer water temperatures. This would further emphasize the need for fish passage improvements in most subbasins via WP BiOp actions, and possibly the need for protective and restoration measures on publically-owned lands (USFS, BLM) above fish passage barriers and in upper subbasins. Section 9.1.1 in Chapter 9 outlines the strategic guidance to implement actions in the plan, and includes a set of focal issues related to emerging threats, and identifies strategies and actions that address these issues. In the Table 7-2 action matrix, there are codes for actions that have relevance to human population growth and climate change.

7.2 Actions Needed for Recovery

7.2.1 Overarching Approach to Recovery Actions

Most of the actions listed in Table 7-2 are intended to address current and emerging LFTs to the UWR Chinook and steelhead populations. These "LFT" actions are intended to be implemented at levels and in a manner where they reduce significant life-cycle bottlenecks at the population level. Guidance on mortality reduction targets for these bottlenecks and LFTs are outlined in the recovery scenarios (Chapter 6). Effective implementation of some of these on-the-ground actions will require some initial or ongoing: 1) monitoring of current population performance and habitat conditions, 2) assessment of action feasibility, 3) assessment of best approach among potentially competing ways to implement an action, and 4) research on critical uncertainty about a mortality source and effective actions to reduce that mortality source. Many of these "RME" (research, monitoring and evaluation) actions will be further defined through the adaptive management process outlined in Chapter 9. The actions listed in the sections of Table 7-2 are intended to meet the following overarching objectives for each broad threat category.

<u>Flood Control/Hydropower Management</u>

The highest priority actions in this Plan include those to address the direct impacts of flood control/hydropower and dam/reservoir operations are targeted at restoring adult access to and spawning success within historic production areas, reducing adult pre-spawning mortality above and below barriers, reducing juvenile downstream migration mortality through reservoirs and structures, and improving habitat attributes by adjusting flows, water temperature regimes, sediment loads, and large wood recruitment to more natural levels. These actions are intended to increase survival of multiple life stages and create better habitat and food sources in the project subbasins and estuary for juvenile Chinook and steelhead. Most of the actions are identified and will be implemented through the WP BiOp (NMFS 2008a). Integral to the WP BiOp and a benefit to the ESUs are the Reasonable and Prudent Alternatives (RPAs) that delineate how facility maintenance, inspections, and emergency protocols are to be reported and implemented. In some instances RME and workgroups are proposed to better understand the level of change needed and how to make the desired changes to dam/reservoir operations. The WP BiOp also includes several RPAs that represent significant structural and operational changes to the Willamette Project, including downstream passage structures, a temperature control structure, and upgrades to several adult handling facilities. The action table below includes the most significant WP BiOp RPAs relative to how they reduce LFTs. In some cases this Plan has identified, either through provisional modeling or other analyses, where further Willamette Project actions will be needed to assist recovery of the UWR ESUs.

In addition to the subbasin effects of the Willamette Project on UWR ESU LFTs, there are cumulative effect of some Columbia River Hydro impacts that occur downstream of the Willamette basin in the Columbia River estuary. These impacts are being addressed to some extent within the FCRPS BiOp (NMFS 2008e) and the Estuary Module (NMFS 2008b). The table below includes these actions.

<u>Land/Water Management - Subbasin and Willamette River Mainstem Habitat</u>

Subbasin habitat actions are focused on protecting existing functional physical habitat, restoring degraded habitat reaches (adequate pools/glides/riffles, side channels, cover structures, spawning gravels) and improving water quality/quantity. One key component of this is the continued protection of spawning and rearing habitat in public (Federal) lands above the dams in the North Santiam, South Santiam, McKenzie and Middle Fork sub-basins. In addition, there are short-term and long-term strategies and actions that can be located and scaled sufficiently to create complex stream habitat features that can restore hydrologic connectivity with the adjacent riparian area and floodplain. In the short-term, subbasin habitat actions are proposed to help encourage the placement of large wood in streams to create reach complexity, and to protect key stream reaches that contain summer holding pools for Chinook adults. This latter action is augmented by actions that reduce harassment and poaching of adults in summer holding pools. These actions are intended to bridge the gap until long-term habitat actions begin restoring natural habitat forming processes. In the long-term, this Plan proposes creating or improving/maintaining riparian areas to provide a continual source of large wood and other functions (example: shade and filtering functions) that benefit water quality/quantity and complexity. Water quality improvement actions are proposed, many of which are to be implemented through TMDL implementation plans and other supporting programs. Actions are also proposed to identify sources of sediment entering streams and approaches to reduce or eliminate those sources. Actions are also identified to encourage water conservation and coordination of water withdrawals for permitted users. Subbasin habitat actions within smaller tributaries are more focused on steelhead, as Chinook do not often spawn in smaller tributaries. However, Chinook that spawn and rear in larger order streams downstream of steelhead will benefit indirectly from the actions identified and implemented in upstream steelhead habitat, as water quality improvements and habitat forming processes are transmitted downstream. Watershed assessments and Watershed Council action plans will be used to refine the locations for specific habitat actions.

The Willamette River mainstem supports both winter steelhead and spring Chinook at various life stages throughout the entire year. Juvenile Chinook and steelhead also enter the Westside tributaries to rear. The key and secondary limiting factors in the mainstem Willamette and Westside tributaries are related predominately to land use (see Chapter 5 for a full description).

Emerging Threats

There are several actions in Table 7-2 that are indexed for addressing climate change and human population growth. A needed information element (and RME action in this Plan) is to do a formal risk analysis at the population level, specific to climate change projections. This assessment will help prioritize existing actions and identify new strategies and actions.

Land/Water Management - Estuary Habitat

Estuary habitat actions seek to protect and restore habitat complexity (shallow waters, side channels, cover vegetation and structures, riparian areas, wetlands), habitat accessibility (tide gates, other structures) and water quality/quantity. Many of these actions came from the Estuary Module (NMFS 2008b) and apply to the mainstem Columbia River from its mouth to Bonneville Dam and the lower Willamette River below Willamette Falls. The actions identified seek to prevent and reduce invasive species; reduce impacts of development activities; reduce pollutants; and restore and protect off channel, side channel, and riparian habitats. UWR Chinook and steelhead will receive some benefits from these estuary actions, and the most relevant ones from the Estuary Module are included in the table below.

Other Species Management

Increased rates of predation are associated mostly with alterations of stream and estuarine habitats, past management practices to introduce exotic species, and the uncoordinated actions of individuals. Actions related to predation are included in the Table 7-2. Actions to address predation focus on reducing the impacts of birds and fish in the estuary, but RME is included to evaluate the impact above Willamette Falls. As noted in previous chapters, actions addressing predation and competition from hatchery programs are ascribed under hatchery management actions.

Harvest Management

Actions related to harvest seek to keep or reduce harvest to levels that do not inhibit recovery. This Plan relies on the goals and actions identified in the Willamette Chinook and steelhead FMEP's and the Harvest BiOps (NMFS 2008c, NMFS 2008f) to assure harvest risks are managed appropriately (see Chapter 5).

Hatchery Management

Reducing interactions between wild and hatchery fish are the focus of actions related to hatchery management. These interactions are guided by the LFT assessment of hatchery impacts. On-going adult monitoring actions will continue to provide estimates of the level and location of naturally spawning hatchery fish, and an evaluation process will be in place to guide the most effective strategy for reducing hatchery fish on natural spawning grounds. Other actions will examine whether hatchery programs are creating negative ecological effects for wild juveniles via competition or predation. Where negative interactions are found, ODFW proposes to adjust hatchery releases, modify hatchery techniques, and/or remove returning adult hatchery fish.

As passage conditions for adult and juvenile fish begin to improve through actions associated with the WP BiOp, this Plan supports the development of wild fish management areas (similar to the Clackamas subbasin upstream of North Fork Dam) in the upper subbasins of the North and South Santiam's, Mckenzie, and Middle Fork Willamette populations. Currently, hatchery fish are outplanted in these upper subbasins to meet several fish management needs, including supplementing production, and there is support among the fishery co-managers to continue these releases to also meet RME needs associated with the WP BiOp. Eventually, hatchery fish will be used to initiate a more formal re-introduction program, and as wild populations recover to some level, outplanting of hatchery fish will be discontinued. A provisional set of conditions for transitioning from an out-planting program using surplus mitigation hatchery broodstock to a re-introduction program are described in the hatchery management actions in the tables below and in Appendix E. Co-managers are soliciting input from regional experts on the best way to manage the hatchery broodstock now to minimize long-term risk to fish productivity and diversity.

Chinook Salmon Recovery for Extirpated Populations

As noted in Chapter 4 some UWR Chinook populations are considered nearly extinct or extirpated from their natal basins, and there is a need in some cases to deliberately reintroduce fish into those subbasins to start a production cycle. For example, few, if any naturally produced Chinook currently exist in the Molalla and Calapooia basins, and one strategy is to proceed with habitat improvements and allow these subbasins to be re-seeded naturally with Chinook salmon strays from other subbasins. However, in the case of the Molalla population, members of the Planning Team thought this approach would take too long and would not guarantee restoring populations in this subbasin. So, for the Molalla, a provisional proposal has been developed that couples habitat improvements with development of a conservation hatchery program from an identified hatchery stock that would eventually produce a localized broodstock. Details of this strategy are in Appendix E. For the Calapooia Chinook population, this Plan proposes to evaluate whether natural seeding will occur as a result of habitat improvements. If over time it is determined that reintroduction actions are necessary, the RME/Adaptive Management portion of this Plan will outline steps to accomplish reintroduction in the Calapooia.

7.2.2 Summary of Actions

Table 7-2 organizes the recovery actions of this Plan according to how they address the LFTs that were identified for the Chinook salmon and steelhead populations. Therefore the table uses the heading framework from the CH 6 scenarios tables to help indicate where and how an action should be implemented. Chapter 9 provides more detailed information on the actions, including the specifics of the LFTs and life stages being affected, priority locations, and estimated costs and implementation timeframes.

There are several tiers of actions:

Higher-level strategies/actions/processes to decrease general threats across the ESU/DPS, or to administer and support adaptive management and RME

Many of these actions are intended to build the information structure for adaptive management and RME, increase coordination of existing programs, and increase funding for analyses, reporting, and coordination. Many of these actions will also address the uncertainties associated with climate change, and some outline the larger planning and management efforts that will be needed to address the effects that human population growth will have on UWR Chinook and steelhead.

Strategies and actions focused mainly on decreasing LFTs in the estuary

This Plan assumes the estuary actions identified in the Estuary Module and additional estuary actions identified in the OrLCR Plan will be implemented and will benefit the UWR ESU and DPS. Therefore this Plan includes actions from that plan which were determined to reduce LFTs to UWR populations. Those actions are included in Table 7.2.

Strategies and generalized actions focused on decreasing LFTs in freshwater

These actions apply to all UWR populations, and are mostly organized around actions that have relevance to the freshwater ecosystem. Some of these are specific to decreasing LFTs, while others are programmatic within public agencies to protect existing habitat and water resources. Some of these actions represent the continuation of ongoing efforts, while others will require enhancements of existing efforts in order to achieve the recovery goals set out in this Plan.

Strategies and actions focused on decreasing LFTs in the mainstem Willamette River

These actions apply to LFTs identified in the mainstem Willamette River above Willamette Falls. They are a mixture of land protection actions, actions within existing programs for administering uses on urban and rural lands, water quality and flow actions, and on-the-ground actions to restore habitat complexity in the mainstem Willamette River so that it can support rearing and migration of juvenile salmonids. In addition, some of these actions will be applied across all the subbasins, and are not specific to a given subbasin. Since most UWR populations use portions of the mainstem Willamette River for rearing and migration, the habitat actions addressing Willamette River mainstem LFTs will benefit multiple populations. In addition, there are some habitat actions in lower reaches of West-side tributaries that could increase the amount of rearing habitat for multiple populations. However, given these reaches are not within the primary production areas for the designated independent populations, they are given lower priority for habitat improvement relative to improvements needed in the natal subbasins and the mainstem Willamette.

Actions focused on decreasing LFTs within specific subbasins and populations

This section of Table 7.2 shows all the LFTs affecting a population, but only shows the actions that will be focused within the natal subbasin for that population.

Table 7-2. A summary of LFTs for the UWR Chinook salmon ESU and steelhead DPS, and actions to address those LFTs at different levels of organization and spatial scales. Refer to Chapter 5 for legend of LFT codes. Many of the actions have already been identified in supporting plans and are identified in the "Actions" column here as follows: "FCRPS" actions are from the RPA's in the Federal Columbia River Power System BiOp (NMFS 2008e), "CRE" actions are from the Estuary Module (NMFS 2008b), and "WP BiOp RPA" actions are from Willamette Project Biological Opinion (NMFS 2008a). Table subheadings include definitions of other acronyms that are used to categorize actions and are applied to the "Action ID" suffix. An "x" in the LFT matrix indicates that action has a relationship to reducing that LFT, or is related to RME. Within the estuary actions, management domains to address LFTs were indicated as land use management (LUM), flood control/hydropower (FCH), fish harvest management (HVM) and hatchery management (HTM). In the "Future Threats" column, "pg" and "cc" refer to actions and strategies that have relevance to population growth and climate change respectively.

		Flood Control / Hydropower (subbasin)				FW Land Use Management	Estuary LFT's	Other Species	Harvest Management	Hatchery Management			
Action ID	**Action**	**Spawner Access**	**Juvenile Passage**	**Spawner Habitat Conditions**	**Juvenile Habitat Conditions**	**Adult and Juvenile Conditions**	**Land Use & Flood Control/Hydro**	**Competition / Predation**	**Adults**	**Juv Competition / Predation**	**Adults**	**Emerging Threats**	**RME**
ESU: Higher-level Strategies/Actions/Processes to decrease General Threats across ESU/DPS, or Administer & Support Adaptive Management/RME ADM: Adaptive Management / Implementation / RME / Information and Education / Plan Support and Administration PHQ: Actions that decrease Physical Habitat Quality Limiting Factors WQH: Actions that decrease Water Quality / Water Quantity / Hydrograph Limiting Factors CPP: Actions that decrease Competition, Predation, and Population Trait Limiting Factors													
1 - ESU-ADM	Develop three-year Implementation Schedules across and within populations for priority actions at a site-specific scale based on existing reach-specific habitat assessments, identified regulatory requirements, other threat reduction needs, research and monitoring needs, and adaptive management.	x				x	x		x		x	cc, pg	x
2 - ESU-ADM	NMFS support coordination of organizations and funders who help provide and implement incentive programs for landowners.	x				x			x		x	cc, pg	x
3 - ESU-ADM	Complete annual reporting for this plan and coordinate adaptive management actions as necessary and indicated by monitoring and reporting results.	x				x	x		x		x	cc, pg	x
4 - ESU-ADM	Regularly update inventories and maps of instream habitat					x	x						x

	conditions, water quality, wetlands, and riparian conditions (including restoration projects) to more accurately capture current habitat conditions.												
5 - ESU-ADM	Identify whether there are dependent and independent winter steelhead populations in West-side tributaries, and if appropriate, determine status goals for them.												x
6 - ESU-ADM	Assess adequacy of local regulatory programs to address listing threat factors within the federal ESA framework (e.g., 5-year status reviews, delisting decision, other).	x			x	x			x		x		x
7 - ESU-ADM	Implement credible, science-based programs, policies and rules that contribute collectively to protect fish and water resources.	x				x	x	x	x		x	cc, pg	x
8 - ESU-ADM	Provide adequate funding and staffing for existing programs to achieve their mandates.	x				x			x		x	cc, pg	x
9 - ESU-ADM	Enhance efforts to enforce existing land use regulations, laws, and ordinances.					x	x						
10 - ESU-ADM	Form a UWR-specific hatchery genetic technical group (HGTG; comprised of RIST and other experts) to conduct scientific review of current UWR hatchery programs and develop recommendations for achieving a conservation (reintroduction) hatchery program or suite of strategies that promotes and maintains a locally adapted population in the short term (until other LFT conditions are improved), and how to maintain VSP attributes and recovery goals while managing within a split basin management framework where there are hatchery mitigation goals in lower subbasins.										x		x
11 - ESU-ADM	(similar to FCRPS RPA 7) To address forecasting and climate change/variability, hold annual forecast performance reviews and report on effectiveness of experimental or developing/emerging technologies.	x				x	x		x		x	cc	x
12 - ESU-ADM	Conduct detailed climate change risk analysis for all populations and use this to help prioritize existing actions, or develop new ones. Incorporate these into the Implementation Schedule.	x				x	x	x	x		x	cc	x
13 - ESU-ADM	Adequately fund and implement RME needed to answer critical uncertainties related to the assumptions under which the recovery plan was developed.	x				x		x	x		x	cc, pg	x
14 - ESU-ADM	Participate in the development of emerging ecosystem markets and ensure they are shaped to be consistent with recovery goals and actions.					x	x					cc, pg	x
15 - ESU-ADM	Fund development and maintenance of web-based data management and reporting, including tracking needs and accomplishments by entity through a map-based depiction of prioritized actions and locations.	x				x	x		x		x	cc, pg	x
16 - ESU-ADM	ODFW and NMFS provide expanded staffing support as needed to develop and coordinate Recovery Plan Implementation schedules and actions with associated processes and programs (example: WP BiOP RME and other WP BiOP WATER teams).	x				x			x		x	cc, pg	x

17 - ESU-ADM	State of Oregon agencies clearly describe the large wood goals in subbasins and potential ways to achieve these goals.	x				x							
18 - ESU-ADM	Provide liability protection for landowners that participate in restoration projects.					x	x					cc, pg	x
19 - ESU-ADM	Explore land use strategies and regulations to reduce ownership fragmentation, including, but not limited to, acknowledging the importance of family owned forests and supporting actions that help sustain working family owned forests.					x	x					cc, pg	x
20 - ESU-ADM	Promote and provide technical support for volunteer efforts of private landowners and user groups to increase the amount of large wood in stream channels (e.g. site-specific riparian management plans, placement of large wood, reducing removal).					x	x						x
21 - ESU-ADM	Provide technical and financial assistance to landowners with property damage due to beavers, and provide incentives to landowners that want to manage their land to achieve the habitat benefits provided by beaver dams.					x							x
22 - ESU-ADM	Expand monitoring of populations to track status and trends of VSP metrics and improve understanding of the composition of natural spawners (what type/pHOS? how many? where from? timing?), other life history information, and habitat.	x				x			x		x	cc	x
23 - ESU-ADM	Determine funding sources and strategies to implement monitoring needed to track progress towards achieving recovery goals.	x				x	x		x		x	cc	x
24 - ESU-ADM	Provide education on the goals of recovery plans, what is needed to achieve these goals, and how citizens can contribute.					x							
25 - ESU-ADM	Continue to fund outreach efforts that have known success in educating and engaging landowners.					x							
26 - ESU-ADM	Fund OSU Extension Service to provide Riparian Function Workshops for all Oregon Plan participants to improve success rate of volunteer projects.					x						cc, pg	
27 - ESU-ADM	Provide education and outreach to contractors, developers, and resource owners.					x	x					cc, pg	
28 - ESU-ADM	Implement and expand upon I&E to use demonstration sites where landowners can view the results of various types of restoration efforts. Focus on demonstration sites where the landowner was active in the restoration activity.					x	x					cc, pg	
29 - ESU-ADM	Mark all hatchery fish to support harvest management goals and hatchery managements goals.								x		x		x
30 - ESU-ADM	Support tagging efforts and different tagging types and technologies from each hatchery release to meet RME and management goals.								x		x		x
31 - ESU-PHQ	Develop proactive framework to minimize future development impacts in key reaches and floodplains.	x				8a	x					cc, pg	x
32 - ESU-PHQ	Where habitat restoration targets exist and progress toward					8a						cc,	x

	them is tracked, but where targets are not being met in the first five years of implementation.											pg	
33 - ESU-PHQ	DSL will work within existing mandates to facilitate implementing habitat actions in this Plan.					8a	x					pg	
34 - ESU-PHQ	(similar to CRE-15) Reduce the introduction and spread of invasive plants by implementing education and monitoring projects that increase public awareness of exotic plant species and proper stewardship techniques.					8a		x					
35 - ESU-PHQ	Provide enhanced incentives for habitat restoration work.					8a	x						
36 - ESU-PHQ	Conduct sediment source analysis and then implement actions to reduce sediment from identified sources.	x				x	x						
37 - ESU-PHQ	Improve coordination and streamlining of habitat restoration efforts for a) impaired instream habitat complexity, b) floodplain processes and access to off-channel habitat by increasing lateral movement with improvements in revetments, dikes and floodwalls, and c) riparian conditions	x				x	x						
38 - ESU-WQH	(similar to CRE-20 but expanded to include FW areas) Reduce non-point sourcing and loading of nutrients and pesticides from land use activities in subbasin streams, the Willamette River mainstem, and estuary. Implement pesticide and fertilizer BMP's to reduce loading.					9h	9h					cc,pg	
39 - ESU-WQH	Support RME that evaluates cumulative and interactive effects of contaminants on different salmonid life stages.					9i	9i						x
40 - ESU-WQH	(CRE-23) Implement stormwater BMP's in cities, towns, and rural areas.					9i	9i						x
41 - ESU-WQH	Provide more technical resources and incentives to small (non-metropolitan) communities so they have the infrastructure to better manage runoff from impervious surfaces.					9i	9i					cc,pg	
42 - ESU-WQH	(similar to CRE-21) Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.					9i	9i						
43 - ESU-WQH	Develop, update, implement stormwater management plans for urban areas and roads.					9i	9i						
44 - ESU-WQH	Develop recommendations for land management scenarios that address hydrograph changes due to climate change, impervious surfaces, and other factors that result in altered water runoff.					x	x					cc,pg	x
45 - ESU-WQH	Develop options for water banking and implement.	x				x	x					cc,pg	

46 - ESU-CPP	Continue the release of hatchery fish as smolts to reduce competition and predation with wild fish in tributaries and estuaries.							x			x		
47 - ESU-CPP	Investigate the feasibility of coordinated release timing among hatcheries, to reduce the numbers of out-migrating hatchery fish in-river at any one time.							x			x		
48 - ESU-CPP	Eliminate/reduce/shift hatchery programs to decrease mainstem and estuary competition and predation and reduce straying of hatchery fish onto natural spawning grounds							x	x		x		
49 - ESU-CPP	Require hatchery programs/releases that are new, or increased more than 10% from 2009 levels to complete or modify an HGMP and receive ODFW Fish Division approval.							x			x		
EST: Strategies and Actions focused mainly on decreasing LFT's in the Estuary													
ALL: All populations													
50 - EST-ALL	(see Estuary Module actions that improve habitat and flows)						5a FCM x LUM						
51 - EST-ALL	(see Estuary Module actions that improve flows)						5b FCM x LUM						
52 - EST-ALL	Work with various stakeholders to restore and develop complex habitat for rearing juveniles in the lower Willamette River.						8a LUM					cc,pg	x
53 - EST-ALL	Protect remaining shallow water habitat in estuary, especially high quality habitat in the lower estuary.						8a LUM x FCH					cc	
54 - EST-ALL	Coordinate with the Portland Harbor Natural Resource Damage Assessment and Restoration process to implement restoration in the Lower Willamette River that will aid salmon and steelhead recovery.						8a LUM						
55 - EST-ALL	Identify and acquire conservation flexibility in key salmonid habitats in the estuary.						8a LUM					cc,pg	x
56 - EST-ALL	Expand upon current efforts to remove invasive plant species where they inhibit natural or deliberate re-establishment of native riparian plant species.						8a LUM						
57 - EST-ALL	Acquire conservation management flexibility for priority sites in the PDX Metro area.						8a LUM						
58 - EST-ALL	As feasible, re-establish connection between Columbia Slough and Columbia River to improve flushing and water quality.						8a LUM						
59 - EST-ALL	(CRE-10) Breach or lower dikes and levees to establish or improve access to off-channel habitats.						8a LUM x FCH						

60 - EST-ALL	(similar to CRE-11) Reduce the square footage of over-water structures in the estuary and lower mainstem Willamette River. Where possible, modify remaining overwater structures to provide beneficial habitat.						8a LUM						x
61 - EST-ALL	(CRE-6) Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.						8a LUM x FCH						x
62 - EST-ALL	(CRE-12) Reduce the effects of vessel wake stranding in the estuary.						8a LUM						x
63 - EST-ALL	(CRE-7) Reduce entrainment and habitat effects resulting from main and side-channel dredge activities and ship ballast intake in the estuary.						8a LUM						x
64 - EST-ALL	(CRE-8) Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.						8a LUM						x
65 - EST-ALL	(CRE-5) Study and mitigate the effects of entrapment of fine sediment in Columbia basin reservoirs, to improve nourishment of the littoral cell.						7h FCH						x
66 - EST-ALL	(CRE-3) Establish minimum instream flows for the lower Columbia River mainstem that would help prevent further degradation of the ecosystem.						10f FCH						
67 - EST-ALL	(CRE-4) Adjust the timing, magnitude and frequency of 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, plume, and littoral cell.						10f FCH						x
68 - EST-ALL	(FCRPS RPA's 10-13) Columbia River Treaty and non-Treaty storage management, agreements, and coordination.						10f FCH						
69 - EST-ALL	(FCRPS RPA 14) Manage flow during dry years to maintain and improve habitat conditions for ESA-listed species.						10f FCH						
70 - EST-ALL	(OrLCR Plan) Draft storage reservoirs to meet lower Columbia summer flow and velocity equivalent objectives on a seasonal and weekly basis.						10f FCH						
71 - EST-ALL	(OrLCR Plan) Operate reservoirs at rule curves and seek additional flow augmentation volumes from Snake River and Canadian reservoirs to better meet spring and summer flow and velocity objectives.						10f FCH						
72 - EST-ALL	(FCRPS RPA 4) Operate the FCRPS storage projects for flow management to aid anadromous fish.						10f FCH						
73 - EST-ALL	(FCRPS RPA 5) Operate the FCRPS run-of-river mainstem lower Columbia River and Snake River projects to minimize water travel time through the lower Columbia River to aid in juvenile fish passage.						10f FCH						
74 - EST-ALL	(FCRPS RPA 6) In-season water management via water management plans and by the Regional Forum.						10f FCH					cc,pg	
75 - EST-ALL	(CRE-22) Monitor the estuary for contaminants and restore or mitigate contaminated sites.						9i LUM						

76 - EST-ALL	Incorporate and coordinate Recovery Plan actions in lower Willamette River with habitat mitigation actions to be funded with the Port of Portland Superfund Clean-Up.						9j FCM x LUM						x
77 - EST-ALL	(CRE-2) Operate Columbia basin hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.						x LUM						
78 - EST-ALL	(FCRPS RPA's 8-9) Manage the FCRPS for operations and fish emergencies.						x LUM x FCH x HVM x HTM	6b				cc	x
79 - EST-ALL	(CRE-19) Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.											cc,pg	
80 - EST-ALL	To decrease juvenile salmonid competition in the estuary and straying by adults, investigate other hatchery release strategies, reductions, or program shifts to lower river terminal areas for commercial and/or sport harvest, including those from out-of-ESU and especially if there are surplus hatchery fish which are not harvested.							x	x	4a			x
81 - EST-ALL	(similar to CRE-18) Reduce competition with non-native fish in the estuary.							4				cc	
82 - EST-ALL	(similar to CRE-13) Manage pikeminnow and non-native piscivorous fishes to reduce predation on juvenile salmonids.						x LUM x FCH x HVM x HTM	6b				cc	x
83 - EST-ALL	(CRE-16) Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.						x LUM x FCH x HTM	6e			x		
84 - EST-ALL	(CRE-17) Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.						x LUM x FCH x HTM	6e			x		x
85 - EST-CM	Shift mainstem commercial spring Chinook harvest to terminal areas during low return years (de facto "sliding scale").								11a		x		
86 - EST-CM	Monitor harvest levels in all fishery areas for all species (direct and indirect mortality).								11a		x		x

FW: Strategies and Generalized Actions focused on decreasing LFT's in Freshwater; OC: Ocean

ALL: All populations													
87 - FW-ALL	Improve the maintenance of fish screens and fish passage structures.	x	x		x	x					x		
88 - FW-ALL	(similar to CRE-1 but for FW areas above Willamette Falls) Protect and restore riparian areas on private lands throughout the rearing zones for Chinook and steelhead that are not covered by of riparian actions in TMDL implementation plans.					8a						cc, pg	
89 - FW-ALL	(similar to CRE-9 but for FW areas above Willamette Falls) Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high quality habitat.					8a						cc, pg	
90 - FW-ALL	Where population-level habitat monitoring indicates statistically-significant temporal degradation of key habitat features, encourage new/revised regulatory measures for key habitat feature(s) that eliminate further degradation, protect existing high quality areas, and allow long-term/"passive" restoration in other areas.			x	x	8a						cc,pg	x
91 - FW-ALL	Restore substrate recruitment to the mainstem Willamette River from tributary areas using a combination of peak flows and substrate supplementation.			x	x	8a							
92 - FW-ALL	Maintain and restore the best available spawning, rearing, and migration habitats, and acquire reaches or management flexibility where ecological processes (function) and salmonid historical habitat are impaired or lost.			x	x	8a							
93 - FW-ALL	Remediate adverse effects of rural roads and trails on aquatic physical habitat quality and water quality. Develop funding methods for retiring USFS/USBLM roads and private roads.					8a							
94 - FW-ALL	When reviewing new permits or activities, apply road and bridge fluvial performance standards that allow free passage of fish, sediment, and flows.					8a							
95 - FW-ALL	Work with landowners on alternatives to installing riprap along the banks of rivers and streams.			x		8a							
96 - FW-ALL	Protect and conserve rare and unique functioning habitats that may exert different selective pressures on segments of the population, thereby increasing genetic and life history diversity.					8a		x				cc	

97 - FW-ALL	Support WS Councils to conduct watershed education and outreach activities for landowners and in schools.					8a							
98 - FW-ALL	Develop methodology to assess and identify, and then protect, stream reaches and population strongholds which will be resilient/resistant to climate change impacts.					x						cc,pg	
99 - FW-ALL	ID and restore priority non-functioning wetlands.					8a						cc,pg	
100 - FW-ALL	Restore natural riparian communities and their function.					8a						cc,pg	
101 - FW-ALL	Support local governments to meet future water allocation and treatment needs, and stormwater management to minimize human population growth impacts on listed Chinook and steelhead.					10b						cc,pg	
102 - FW-ALL	(In coordination with supporting actions for LFT 9a) Increase protection and implementation of appropriate instream flows for UWR salmonids by a) removing barriers to coordinating with relevant management agencies on water withdrawals, b) encouraging BMP's to conserve water and reduce pollution loads, and c) not issuing anymore water rights within subbasins.	x				10b						cc,pg	
103 - FW-ALL	Work with ODEQ TMDL program (DMA Implementation Plans) to improve temperature and other water quality standards, to prioritize implementation on high priority CHS and STW areas. Also incorporate other reporting to ID other priority reaches for LFT's 9h and 9i (toxins and nutrients)	x				9a, 9c 9h, 9i							x
104 - FW-ALL	Implement RME of headwater springs to investigate the concern that they may be drying up due to land management practices.					9a						cc	x
105 - FW-ALL	Inventory and protect seeps, springs, and other coldwater sources.					9a						cc	x
106 - FW-ALL	Limit future in-river and groundwater withdrawals so that they do not impede achievement of recovery goals.					x						cc,pg	
107 - OC-ALL	Implement the new Pacific Salmon Treaty (reduce ocean fisheries on Chinook).								x		x		
108 - OC-ALL	Support mark-selective ocean fisheries when a new PST is negotiated in 10 years.								x		x		

MST: Strategies and Actions focused on decreasing LFT's in the Mainstem Willamette River
MST/SUB: Flow actions focused in subbasins to decrease LFT's in the Mainstem Willamette River for multiple populations
ALL: All populations
AMO: Actions for populations upstream of the Molalla River (NS, SSA, CA, MK, MF)

109 - MST-ALL	Maintain safe passage of juvenile and adult Chinook and steelhead at Willamette Falls.	2n											
110 - MST-ALL	Look for opportunities to remove unnecessary revetments or increasing setbacks in the Mainstem Willamette and in subbasins. Minimize new ones in the future.				X	8a						pg	
111 - MST-ALL	Release flows from WP dams and other storage dams to meet flow targets in mainstem Willamette River for rearing and migration.			10c		x							
112 - MST-AMO	Restore structure and function to strategic natural riparian reaches in the mainstem Willamette River				8a							cc,pg	
113 - MST-AMO	Increase overall channel complexity, floodplain connectivity, and flood storage to the mainstem Willamette River to increase and improve salmonid rearing and migration habitat.				x	8a						pg	
114 - MST-AMO	Protect existing highest quality salmonid rearing and migration habitats through conservation measures, acquisition, and/or regulation.					8a						cc,pg	
115 - MST-AMO	Consistently apply BMP's and existing regulations to protect and conserve natural ecological processes, with a focus on those that affect UWR CHS and STW and the LFT's identified in this Recovery Plan.					8a							
116 - MST-AMO	Protect and restore aquatic habitat function at confluence areas of Willamette River tributaries.				x	8a							
117 - MST-AMO	Use road and bridge fluvial performance standards that allow free passage of fish, sediment, and flows in the Mainstem Willamette River and subbasins.					8a							
118 - MST-ALL	Implement and evaluate the effectiveness of the "Agricultural Water Quality Management Area Rules" (SB 1010 plans) for the mainstem Willamette River and subbasins.					9h							
119 - MST-AMO	(see other actions involving TMDL's) Support implementation plans associated with TMDL compliance and focus salmonid habitat restoration efforts in those reaches where other LFT's are being improved and productivity can be restored					9h							

120 - MST/SUB-AMO	Evaluate the potential for releasing habitat-forming flows from WP Project storage dams to complement habitat restoration activities in the mainstem Willamette River.				10d	x							
121 - SUB -ALL	ODFW District staff lead the coordination and updating of ODFW's Fish Passage Program database to document status of remaining high priority barriers or passage problem areas.	x	x			2a							x
122 - SUB -ALL	Pursue development of a cooperative agreement or habitat conservation plan with land owners to further protect fish habitat in the future.					8a							
123 - SUB -ALL	Protect and restore headwater rivers and streams (salmon and non-salmon bearing) to protect the sources of cool, clean water and normative hydrologic conditions.					8a						cc	
124 - SUB -ALL	Evaluate allocation policies and legal and illegal water withdrawals, and look for opportunities to keep more water instream.				x	9a						cc,pg	
125 - SUB -ALL	Support the funding and implementation of Water Quality Management Plans (TMDL Implementation Plans) of Designated Management Agencies (DMA's) to meet their objective of restoring riparian vegetation as part of a larger strategy to restore and protect streams.					9a							x
Clackamas Spring Chinook													
Importance of LFT at Life Stage and Geographic Area	**Key**		1a			8a	5ab, 7h, 10f				3a	---	---
	Secondary			9k	7i, 8a	8a, 9ahi	8a, 9ahij	6e	11ag	4a		---	---
Status and Mortality Rate Assumption for Scenarios	Current Status: *Moderate*	0.27				0.83	0.10	0.12	0.25		0.33	---	---
	Desired Status: *Very Low*	0.24	0.00	0.00	0.00	0.81	0.08	0.07	0.25	0.00	0.10	---	---
126 - SUB -CM	Provide / improve fish passage in Clackamas subbasin tributaries.		1a										
127 - SUB -CM	Implement all measures in the Clackamas River Hydroelectric Project (FERC Project No. 2195) Fish Passage and Protection Plan, including measures for downstream fish passage (3% or less mortality at River Mill and North Fork dams), Oak Grove Mitigation and improvements to North Fork fish ladder/trap.		1a										
128 - SUB -CM	Breach, lower, remove, or relocate dikes and levees to establish or improve access to off-channel habitats; vegetate dikes and levees.					8a							
129 - SUB -CM	Review land use plans in context of salmon recovery needs (i.e., forest lands of higher value to salmon recovery than					8a							

	urbanized lands).												
130 - SUB -CM	Finish Clackamas Fish Habitat Analysis.					8a							
131 - SUB -CM	Protect remaining high-quality off-channel habitat from degradation.					8a							
132 - SUB -CM	Restore or create off-channel habitat and/or access to off-channel habitat: side channels.					8a							
133 - SUB -CM	Restore or create off-channel habitat and/or access to off-channel habitat: alcoves, wetlands, and floodplains. - Restoration includes revegetation.					8a							
134 - SUB -CM	Improve or regrade/revegetate streambanks.					8a							
135 - SUB -CM	Protect intact and functioning riparian areas through riparian easements and acquisition					8a							
136 - SUB -CM	Restore (plant and/or fence) and protect (conservation easements, acquisition) riparian areas that are degraded.					8a							
137 - SUB -CM	Annually place 8,000 yd3 of spawning sized gravel below River Mill Dam as per FERC settlement agreement.			x	7i	x							
138 - SUB -CM	Utilize the Clackamas Hydroelectric Project Mitigation and Enhancement Fund to provide for habitat mitigation and enhancements in the Clackamas Basin.			8a	8a	x							
139 - SUB -CM	Restore instream habitat complexity, including large wood placement (mitigate for loss of spring Chinook habitat complexity due to Clackamas hydropower dams).			8a	8a	x							
140 - SUB -CM	Restore instream habitat complexity, including large wood placement.					8a							
141 - SUB -CM	Daylight stream.					8a							
142 - SUB -CM	Create confluence habitat with cool water, restore channel and reconnect upper creek.					8a							
143 - SUB -CM	Reconnect tributary to Willamette River and create high quality habitat at tributary junction.					8a							
144 - SUB -CM	(similar to LFT 7f [MF] and 7e [MK]) Within authority of current FERC license, increase retention and sourcing of gravels and other materials below PGE facilities with a combination of habitat improvements, targeted flows, and augmentation.			x	7i	x							
145 - SUB -CM	Establish minimum ecosystem-based instream flows.					9a							
146 - SUB -CM	Reduce impact that roads have on impaired hydrograph.					8a							
147 - SUB -CM	Implement all water quality and hydrograph measures in the Clackamas River Hydroelectric Project (FERC Project No. 2195) Fish Passage and Protection Plan.			9k	9k	x							
148 - SUB -CM	Maintain existing wild fish sanctuary.	x	x	x					x		3a		
149 - SUB -CM	Operationally open the hatchery trap for a longer period.	x							x		3a		
150 - SUB -CM	(Purchase a freezer trailer to aid the logistical disposition to carcass placement, tribes, and food banks if program is maintained).					x					x		

Molalla Spring Chinook and Steelhead													
CHS: Importance of LFT at Life Stage and Geographic Area	**Key**					8ab, 9ach	5ab, 7h, 8a,10f				3a	---	---
	Secondary					7a, 9i, 10b	9ahij	6e		4a		---	---
CHS: Status and Mortality Rate Assumption for Scenarios	Current Status: *Very High*	0.00	0.00	0.00	0.00	1.00	0.10	0.16	0.25	0.05	0.95	---	---
	Desired Status: *High*	0.00	0.00	0.00	0.00	0.80	0.08	0.08	0.25	0.05	0.57	---	---
STW: Importance of LFT at Life Stage and Geographic Area	**Key**					8a	5ab, 7h, 10f				3a	---	---
	Secondary					2a,7a,9a, 9hi,10b	8a,9ahij	6e		4a		---	---
STW: Status and Mortality Rate Assumption for Scenarios	Current Status: *Low*	0.00	---	0.00	0.00	0.94	0.10	0.16	0.16	0.05	0.19	---	---
	Desired Status: Very Low	0.00	---	0.00	0.00	0.94	0.08	0.08	0.16	0.05	0.05	---	---
151 - SUB -MO	Improve known high priority STW passage impediments in the Molalla subbasin	x	x			2a							x
152 - SUB -MO	Identify priority reaches in Molalla subbasin where habitat restoration projects can be implemented and monitored.					8a, 9a							x
153 - SUB -MO	Reconnect floodplains to channels.					8a							
154 - SUB -MO	Reduce harassment of adult spring Chinook while they are holding during the summer.					8b							
155 - SUB -MO	Improve summer water quality of headwater areas for oversummering Chinook by implementing sufficient riparian buffers .					9c						cc	
156 - SUB -MO	Reform the existing harvest augmentation hatchery CHS program (non-local stock) into separate augmentation and conservation programs. (See Molalla Reintroduction proposal, Appendix E)					x			x		3a		x
North Santiam Spring Chinook and Steelhead													
CHS: Importance of LFT at Life Stage and Geographic Area	**Key**	2b, 2f	1d		9b,10d	8a, 9ahi	5ab, 7h, 8a,10f				3a	---	---
	Secondary	2k			7bc	8a	9ahij	6e		4a, 6c		---	---
CHS: Status and Mortality	Current Status: *Very High*	0.71	0.00	0.60	0.97	0.97	0.10	0.17	0.25	0.05	0.00	---	---

Rate Assumption for Scenarios	*Desired Status: Low*	0.23	---	0.12	0.29	0.63	0.08	0.08	0.25	0.05	0.00	---	---
STW: Importance of LFT at Life Stage and Geographic Area	**Key**	2b	1d		10acd	8a	5ab, 7h, 8a,10f			4cd	3a	---	---
	Secondary		2i*	7c	7b, 9d	2a, 7a, 9ahi, 10b	9ahij	6e		4a		---	---
STW: Status and Mortality Rate Assumption for Scenarios	Current Status: *Low*	0.48	---	0.00	0.57	0.57	0.10	0.17	0.16	0.05	0.14	---	---
	Desired Status: *Very Low*	0.37	---	0.00	0.48	0.48	0.08	0.08	0.16	0.05	0.05	---	---
157 - SUB -NS	Implement WP-RPA's 4.12.3 and 4.13 to provide safe and effective downstream passage through Detroit reservoir and Detroit and Big Cliff dams for juveniles and kelts.		1d										x
158 - SUB -NS	Work with and assist landowners with grants, funding, and design to screen the known water diversions.		x			2a							
159 - SUB -NS	As needed, evaluate effectiveness of success of upstream passage of adults at the Salem Ditch / Mill Creek headgate structure.	x				2a							x
160 - SUB -NS	Evaluate juvenile fish passage efficiency at the Mill Creek millrace diversion dam and modify the existing fishway if necessary.		x			2a							x
161 - SUB -NS	(see relation to LFT 2k) Reduce pre-spawn mortality by reducing injury and stress related to fish handling at and above USACE facilities.	2b		x					x		x		x
162 - SUB -NS	Until downstream passage facilities are completed and have demonstrated safe and timely passage, supplement natural production in the subbasin by implementing the interim trap-and-haul measures described in the 2008 WP BiOp to outplant adult fish into historical habitat above the Big Cliff/Detroit flood control/hydropower complex.	2b		x					x		x		x
163 - SUB -NS	Reduce fish loss and migration delays of juvenile and adult fish at Santiam Water Control District irrigation canal/hydro projects.	x	x			2f							
164 - SUB -NS	(related to LFT 9a coordination action) Ensure adequate streamflows exist for upstream migration of salmon during summer low flow periods at Geren/Stayton Island, and evaluate if there are other stream flow-related passage barriers in the subbas in summer.	x				2f							x
165 - SUB -NS	Improve fishway function and efficiency at Lower Bennett dams for both juvenile and adult fish.	x	x			2f					x		x

166 - SUB -NS	(see related LFT 1d actions for NS juveniles)		2i*								x		x
167 - SUB -NS	(see LFT 2b for handling actions) Resolve uncertainty of any remaining pre-spawn mortality not associated with injury and stress associated with Minto Collection facility.	2k		2k		x			x		x		x
168 - SUB -NS	(see actions associated with LFT 7c) Restore substrate recruitment and reduce streambed coarsening below dam projects.			x	7b	x							
169 - SUB -NS	(same as for LFT 7f [MF] and 7e [MK]) Increase retention and sourcing of gravels and other materials below USACE facilities with a combination of habitat improvements, targeted flows, and augmentation.			x	7c	x							
170 - SUB -NS	Identify priority reaches in North Santiam subbasin where habitat restoration projects can be implemented and monitored.					8a							x
171 - SUB -NS	In priority moderate-gradient stream reaches in the NS subbasin, increase habitat complexity to provide juvenile fish refugia during high flows, and to augment other channel forming processes and habitat/water quality actions in this Plan.					8a							
172 - SUB -NS	Restore natural function of the North Santiam River near Stayton Ponds	x				8a							
173 - SUB -NS	(WP BiOp Water Quality RPA's) Release flows from Detroit/Big Cliff dams to meet flow targets in the North Santiam River that protect spawning, incubation, rearing and migration of salmonids.				10a	x							x
174 - SUB -NS	Modify dam operations for multiple diversions at Geren/Stayton Island, e.g. Upper and Lower Bennett, SWCD pill dam.		x			10b							
175 - SUB -NS	(WP RPA 5.2) Construct, operate, and evaluate a temperature control structure at Detroit Dam to release water that more closely resembles normative water temperatures, reduces TDG exceedences, and meets TMDL temperature targets downstream of NS dams and operating dams to maximize benefits to Chinook and steelhead				9b	x							x
176 - SUB -NS	(see WP RPA 5.2 to address LFT 9b; temperature control facility action)				9d	x							x

177 - SUB -NS	Manage current CHS Harvest Mitigation Hatchery Program (HMP) facilities and broodstock to meet mitigation goals, but do so in a manner that the genetic and demographic impacts of program do not pose unacceptable risk to extant NOR fish populations or compromise long term productivity of a reintroduction stock that would preclude success of conservation reintroduction/supplementation program above Detroit Dam.	x		x					x		3a		x
178 - SUB - SAN	For Steelhead, conduct RME to identify most effective means to reduce inter-basin pHOS, so that over the long term average total basin pHOS < 5% (for the out-of-ESU stock).	x						x	x		3a		x
179 - SUB - SAN	Ensure hatchery summer steelhead smolts migrate quickly to the ocean by evaluating a suite of acclimation and release strategies.							x	x	4c			x
180 - SUB - SAN	Convene a BiOp WATER working group to further examine the competition risk of STS on NOR STW fry and winter parr.							x		4c			x
181 - SUB - SAN	Allow retention of fin-clipped trout in areas open to fishing to reduce residual STS smolts.								x	4d			
182 - SUB - SAN	Reduce natural spawning of non-native summer steelhead.							x	x	6c			x
South Santiam Spring Chinook and Steelhead													
CHS: Importance of LFT at Life Stage and Geographic Area	**Key**	2c, 2g	1e		9e,10d	8a, 9ahi	5ab, 7h, 8a,10f				3a	---	---
	Secondary	2l			7d	8a	9ahij	6e		4ab, 6c		---	---
CHS: Status and Mortality Rate Assumption for Scenarios	Current Status: *Very High*	0.85	0.00	0.30	0.95	0.95	0.10	0.17	0.25	0.05	0.90	---	---
	Desired Status: Moderate	0.34	---	0.04	0.19	0.62	0.08	0.08	0.25	0.05	0.30	---	---
STW: Importance of LFT at Life Stage and Geographic Area	**Key**	2c	1e		10cde	8a	5ab, 7h, 8a,10f			4cd	3a	---	---
	Secondary		2j*		7d, 9e	2a, 7a, 9ahi, 10b	9ahij	6be		4a		---	---
STW: Status and Mortality Rate Assumption for Scenarios	Current Status: *Low*	0.18	---	0.00	0.66	0.66	0.10	0.17	0.16	0.05	0.04	---	---
	Desired Status: Very *Low*	0.07	---	0.00	0.43	0.43	0.08	0.08	0.16	0.05	0.04	---	---
183 - SUB - SSA	Improve downstream passage through Foster reservoir and dam for juveniles and kelts.		1e								x		

184 - SUB - SSA	Evaluate further whether safe and effective downstream passage through Green Peter reservoir and dam is a viable alternative and highly beneficial in supporting improvements in VSP criteria for desired status risk level (CHS-Moderate, STW-Very Low).		1e										
185 - SUB - SSA	Provide technical and funding assistance to the SSA Watershed Council in restoring consistent fish passage into Ames Creek.	x	x			2a							
186 - SUB - SSA	Evaluate whether juvenile fish can pass the breached Jordan Dam on Thomas Creek.	x	x			2a							
187 - SUB - SSA	As needed, finalize evaluation of velocity testing and adjustment of baffles at the Lebanon diversion, to assure screen is still working within intent of NMFS design criteria.	x	x			2a							
188 - SUB - SSA	Determine whether the diversion screen on Lacomb Creek meets current juvenile fish standards.	x	x			2a							
189 - SUB - SSA	(see relation to LFT 2l) Reduce pre-spawn mortality by reducing injury and stress related to fish handling at and above USACE facilities.	2c				x			x		x		x
190 - SUB - SSA	Within the WP BiOp COP process, evaluate further whether access to and production above Green Peter Dam is a viable alternative and highly beneficial in supporting improvements in VSP criteria for desired status risk level (CHS-Moderate, STW-Very Low).	2c									x		x
191 - SUB - SSA	Until downstream passage facilities are completed and have demonstrated safe and timely passage, supplement natural production in the subbasin by implementing the interim trap-and-haul measures described in the 2008 WP BiOp to outplant adult fish into historical habitat above Foster Dam.	2c							x		x		x
192 - SUB - SSA	Clarify if passage criteria are being met, or if further RME is needed for the new fishways at Lebanon Dam.	2g				x							x
193 - SUB - SSA	(see related LFT 1e actions for SSA juveniles)		2j*								x		
194 - SUB - SSA	(see LFT 2c for handling actions) Resolve uncertainty of any remaining pre-spawn mortality not associated with injury and stress associated with Foster Dam Collection facility.	x		2l		x			x		x		x
195 - SUB - SSA	(WP RPA 2.7) Implement environmental pulse flows and combine with WP RPA actions below to restore substrate recruitment and reduce streambed coarsening below dam projects.				7d	x							x
196 - SUB - SSA	Identify priority reaches in South Santiam subbasin where habitat restoration projects can be implemented and monitored.				x	8a							
197 - SUB - SSA	In priority moderate-gradient stream reaches in the South Santiam subbasin, increase habitat complexity to provide juvenile fish refugia during high flows, and to augment other				x	8a							

	channel forming processes and habitat/water quality actions in this Plan.												
198 - SUB - SSA	Work with landowner adjacent to Waterloo Park to reestablish a long abandoned side channel for rearing and spawning.					8a							
199 - SUB - SSA	(WP BiOp WQ RPA's) Release flows from Foster/Green Peter dams to meet flow targets in the South Santiam River that protect spawning, incubation, rearing and migration of salmonids.	x		x	10e								
200 - SUB - SSB	(no specific actions for LFT 7a; see relevant riparian actions under LFT code 8a)					7a							x
201 - SUB - SSA	(WP RPA's 5.1, 5.1.2, and potentially 5.1.3) Evaluate feasibility and effectiveness of interim operational temperature control at Foster and Green Peter dams.			x	9e	x							x
202 - SUB - SSA	Manage current CHS Harvest Mitigation Hatchery Program (HMP) facilities and broodstock to meet mitigation goals, but do so in a manner that the genetic and demographic impacts of program do not pose unacceptable risk to extant NOR fish populations or compromise long term productivity of a reintroduction stock that would preclude success of conservation reintroduction/supplementation program above Foster Dam.	x							x		3a		x
Calapooia Spring Chinook and Steelhead													
CHS: Importance of LFT at Life Stage and Geographic Area	**Key**					2h, 9ac, 9hi, 8ab	5ab, 7h, 8a,10f				3a	---	---
	Secondary					7a,10b	9ahij	6e		4a		---	---
CHS: Status and Mortality Rate Assumption for Scenarios	Current Status: *Very High*	0.00	0.00	0.00	0.00	1.00	0.10	0.16	0.25	0.05	0.95	---	---
	Desired Status: *High*	0.00	0.00	0.00	0.00	0.74	0.08	0.08	0.25	0.05	0.60	---	---
STW: Importance of LFT at Life Stage and Geographic Area	**Key**					8a	5ab, 7h, 10f						---
	Secondary					2ah, 7a, 9ahi, 10b	8a,9ahij	6e		4a	---	---	---
STW: Status and Mortality Rate Assumption for Scenarios	Current Status: *Moderate*	0.00	---	0.00	0.00	0.96	0.10	0.16	0.16	0.05	0.00	---	---
	Desired Status: *Moderate*	0.00	---	0.00	0.00	0.96	0.08	0.08	0.16	0.05	0.00	---	---
203 - SUB -CA	Continue to work with agencies and private parties for a solution on the passage of adult CHS over Sodom and Shear dams that are associated with the Thompson's Mill State Park site.	x				2h							

204 - SUB -CA	In priority moderate-gradient stream reaches in the Calapooia subbasin, increase habitat complexity to provide juvenile fish refugia during high flows, and to augment other channel forming processes and habitat/water quality actions in this Plan.					8a							
205 - SUB -CA	Identify for protection and restoration, reaches in upper Calapooia River where deep pools can be maintained or created, for target summer water temperature < 70°F.					8a							
206 - SUB -CA	Eliminate parking areas along main line roads, and decrease harassment near those pools where investments in spring Chinook holding pools have been made to minimize disturbance to the fish.					8a							
207 - SUB -CA	Identify priority reaches in Calapooia subbasin where habitat restoration projects can be implemented and monitored.					8a							
208 - SUB -CA	Work in a priority up or downstream direction, eliminating even small breaks in shading to increase and expand cool water zones and fish bearing habitat.					8a							
209 - SUB -CA	Use fencing, weed control, and planting of native conifers at appropriate sites.					8a							
210 - SUB -CA	Improve summer water quality of headwater areas for oversummering Chinook by implementing sufficient riparian buffers.					9c						cc	
211 - SUB -CA	Modify hatchery CHS program practices in other subbasins of the ESU to minimize pHOS in the Calapooia subbasin.					x		x	x		3a		
McKenzie Spring Chinook													
Importance of LFT at Life Stage and Geographic Area	**Key**	2d			10d	8a, 9hi	5ab, 7h, 8a, 10f				3a	---	---
	Secondary		1b		7e, 9g	9a	9ahij	6e		4a, 6cd		---	---
Status and Mortality Rate Assumption for Scenarios	Current Status: *Low*	0.25	0.00	0.10	0.56	0.56	0.10	0.18	0.25	0.05	0.35	---	---
	Desired Status: *Very Low*	0.15	---	0.10	0.53	0.53	0.08	0.09	0.25	0.05	0.10	---	---
212 - SUB -MK	Restore adult access of natural origin fish to historic habitat blocked by large dams.	2d									x		x
213 - SUB -MK	(see related Leaburg action for LFT 3a to improve facility sorting) Provide safe and effective upstream passage of adult salmon migration at the Leaburg Dam left and right bank fish ladders.	2d							x		x		x
214 - SUB -MK	Provide safe and effective upstream passage of adult salmon at Walterville tailrace.	2d											x
215 - SUB -MK	Provide safe and effective downstream passage through Cougar reservoir and dam.		1b								x		x
216 - SUB -MK	Continue to operate and maintain the Walterville fish screen to provide safe and effective fish passage.		1b										
217 - SUB -MK	Provide safe and effective downstream passage through Trail Bridge reservoir and dam.		1b										x

218 - SUB -MK	Ensure new fish screen functions appropriately for Chinook salmon at the Leaburg Diversion		1b										x
219 - SUB -MK	(same as for LFT 7c [NS] and 7f [MF]) Increase retention and sourcing of gravels and other materials below USACE facilities with a combination of habitat improvements, targeted flows, and augmentation.				7e	x							
220 - SUB -MK	Continue to support implementation of Goal 1 restoration actions described in "The McKenzie Watershed Conservation Strategy" (2002), stated as to protect and restore key fish and wildlife habitats.					8a							x
221 - SUB -MK	Identify priority sites in the lower McKenzie River subbasin where habitat protection is needed and restoration is desirable, design restoration projects, implement work, and monitor.					8a							x
222 - SUB -MK	Protect and enhance the McKenzie/Willamette Confluence Area and lower river.					8a						pg	x
223 - SUB -MK	Continue to implement the McKenzie WS Council's "Action Plan for Recreation and Human Habitat".					8a						pg	
224 - SUB -MK	Implement the "Lane County Riparian Development Ordinance."					8a						pg	
225 - SUB -MK	Coordinate projects of the McKenzie River Trust to implement priority habitat restoration projects.					8a							
226 - SUB -MK	Coordinate projects with the "Friends of the Mohawk" to implement priority habitat restoration projects.					8a							
227 - SUB -MK	Operate Trail Bridge Dam to minimize adverse effects of ramping on fish stranding, redd desiccation, and loss of habitat in the McKenzie River downstream of Trail Bridge.				10d								x
228 - SUB -MK	Operate McKenzie subbasin WP flood control/hydropower projects to mimic natural temperature regime, while at the same time complementing the downstream passage benefits of spilling, and minimizing exceedence of TDG (total dissolve gas) below projects, and managing ramping rates to minimize stranding of early Chinook life stages.				9g								x
229 - SUB -MK	Until the Cougar downstream passage facility is completed and has demonstrated safe and timely passage, continue to supplement natural production in the subbasin by implementing the interim trap-and- haul measures described in the 2008 BiOp to outplant adult fish into historical habitat above the USACE Cougar flood control/hydropower complex.	x							x		3a		x
230 - SUB -MK	Manage current CHS Harvest Mitigation Hatchery Program (HMP) facilities and broodstock to meet mitigation goals, but do so in a manner that the genetic and demographic impacts of program do not pose unacceptable risks to the remaining wild fish population or impede long term recovery goals of the McKenzie CHS population.	x							x		3a		x

231 - SUB -MK	Reduce number of hatchery STS released.							x	x	6c			
232 - SUB -MK	Evaluate the potential for reduction of predation on juvenile Chinook by reducing or discontinuing releases of hatchery trout in the McKenzie River upstream of Leaburg Dam.							x	x	6d			
233 - SUB -MK	Release hatchery trout in areas and during periods when Chinook are not as susceptible to predation.							x	x	6d			
234 - SUB -MK	Evaluate predation by hatchery trout and conduct a net benefit analysis on the effects of hatchery trout releases on bull trout population size in Trail Bridge Reservoir.									6d			x
Middle Fork Willamette Spring Chinook													
Importance of LFT at Life Stage and Geographic Area	**Key**	2e	1f	2m	7f, 9f, 10d	8a, 9hi	5ab, 7h, 8a, 10f				3a	---	---
	Secondary				7g	9a	9ahij	6e		4a		---	---
Status and Mortality Rate Assumption for Scenarios	Current Status: *Very High*	0.95	0.00	0.80	0.87	0.87	0.10	0.16	0.25	0.05	0.95	---	---
	Desired Status: *Low*	0.32	---	0.14	0.09	0.56	0.08	0.08	0.25	0.05	0.10	---	---
235 - SUB -MF	Within the 2008 BiOp COP process and BRT activities, evaluate further whether eventual reintroduction and production above Hills Creek Dam is a viable alternative to other remedies for improving VSP criteria to meet desired status risk level (Chinook-Low).	2e									x		x
236 - SUB -MF	Provide safe and effective downstream passage through the Dexter/Lookout Point flood Control/hydropower complex to benefit all size classes of juvenile migrants produced above Lookout Pt. Dam.		1f								x		x
237 - SUB -MF	Provide safe and effective downstream passage through Fall Creek reservoir and dam.		1f								x		x
238 - SUB -MF	Provide safe and effective downstream passage through Hills Creek reservoir and dam.		1f								x		x
239 - SUB -MF	(see relation to LFT 2m) Reduce pre-spawn mortality by reducing injury and stress related to fish handling at and above USACE facilities.	2e				x			x		x		x
240 - SUB -MF	Until downstream passage facilities are completed and have demonstrated safe and timely passage, supplement natural production in the subbasin by implementing the interim trap-and-haul measures described in the 2008 WP BiOp to outplant adult fish into historical habitat above Fall Creek, Dexter/Lookout Pt, and Hills Creek Dams	2e							x		x		x
241 - SUB -MF	(see LFT 2e for handling actions) Resolve uncertainty of	x		2m		x					x		x

	any remaining pre-spawn mortality not associated with injury and stress associated with Middle Fork Willamette Collection facilities.												
242 - SUB -MF	(same as for LFT 7c [NS] and 7e [MK]) Increase retention and sourcing of gravels and other materials below USACE facilities with a combination of habitat improvements, targeted flows, and augmentation.			x	7f	x							
243 - SUB -MF	(see actions associated with LFT 7f) Restore substrate recruitment and reduce streambed coarsening below dam projects.			7g		x							
244 - SUB -MF	If it does not exist, develop proactive framework to minimize future urbanization impacts in Lower Middle Fork Willamette Basin					8a						pg	
245 - SUB -MF	Evaluate the restoration opportunities identified in the Lower MF Willamette Watershed Assessment (2002) for riparian and aquatic habitat, with emphasis on CHS.					8a							x
246 - SUB -MF	Implement the "high priority actions" that benefit CHS identified under each of the six Goals in MF Willamette Watershed Council's Action Plan.					8a							
247 - SUB -MF	Identify priority sites in the Lower Middle Fork Willamette subbasin where habitat protection is needed and restoration is desirable, design restoration projects, implement work, and monitor.				x	8a							x
248 - SUB -MF	Operate WP flows in MF subbasin to mimic the natural temperature regime in the fall				9f								x
249 - SUB -MF	Manage current CHS Harvest Mitigation Hatchery Program (HMP) facilities and broodstock to meet mitigation goals, but do so in a manner that the genetic and demographic impacts of program do not pose unacceptable risk to extant NOR fish populations or compromise long term productivity of a reintroduction stock that would preclude success of conservation reintroduction/supplementation program above MF Willamette dams.	x							x		3a		x

Chapter 8: Research, Monitoring, and Evaluation to Measure Progress Towards Recovery

Research, monitoring, and evaluation (RME) are needed to assess the status of listed species and their habitat, track progress toward achieving recovery goals, and provide information needed to refine recovery strategies and actions through the process of adaptive management. This chapter outlines the RME needs of this Recovery Plan as they pertain to biological VSP criteria (i.e., abundance, productivity, diversity, and spatial structure) and listing criteria (i.e., habitat degradation, fish harvest, hatcheries, disease and predation, inadequate regulatory mechanisms, or other natural or manmade factors) affecting the continued existence of UWR Chinook salmon and winter steelhead populations.

Because RME needs related to the Columbia River estuary are pertinent to all recovery domains in the Columbia River basin, RME plans for the estuary are being developed elsewhere. Within the Willamette River subbasins, a large RME effort is now underway by Federal action agencies in support of the WP BiOp (NMFS 2008a). Many of the elements in the WP BiOp RME plan have clear linkages with the overall RME needs of this Recovery Plan, and Chapter 9 describes some of the RME and implementation relationships between the WP BiOp and Recovery Plan. Chapter 9 (Implementation) of this Plan describes how the proposed RME will be incorporated into an adaptive management Plan.

Much of the following RME guidance for the UWR Chinook and steelhead Recovery Plan comes from *"Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance"*[73] (NMFS 2007a). Based on this guidance, RME in this Plan is specifically designed to:

- Provide information to key questions that need to be addressed in de-listing decisions.
- Track progress toward achieving recovery goals.
- Provide managers and others implementing actions the Plan with information needed to adjust management actions (i.e., what does and doesn't work and why).
- Address questions of metrics and indicators, including frequency, distribution, and intensity of monitoring.
- Evaluate the adequacy of existing monitoring programs to meet the needs of this recovery Plan, identify needed adjustments in those programs, and outline additional monitoring not currently provided by existing programs.

8.1 Key Questions, Analytical Guidelines, Measurable Criteria, and RME Needs

In order to identify the RME needed to support this Recovery Plan it is necessary to consider: 1) the key questions that must be answered for de-listing decisions, 2) the analytical framework that will be used to answer these questions, and 3) the specific measurable criteria (or benchmarks) against which progress towards achieving recovery goals will be measured.

The NMFS listing status decision framework described in Chapter 3 provides the foundation for the information that is needed to inform de-listing decisions. Key questions can be divided into those pertaining to ESU/DPS viability (i.e., biological criteria) or the status of statutory listing factors (i.e., threats criteria). Questions on ESU/DPS viability are based on the four VSP parameters, and questions on

[73] http://www.nwr.noaa.gov/Salmon-Recovery-Planning/ESA-Recovery-Plans/upload/Adaptive_Mngmnt.pdf

the status of statutory listing factors are based on information of threats related to habitat condition, hydropower, fish harvest, disease and predation, regulatory programs, hatcheries, and natural events.

Guidance on the analytical framework for biological recovery criteria were provided by the Willamette/Lower Columbia Technical Review Team (McElhany et al. 2006[74]). If and when such guidance becomes available, the RME outlined in this Plan related to the threats criteria may need to be updated.

Measurable criteria related to biological recovery are based on the specific goals for each UWR Chinook salmon and winter steelhead population (see Chapter 6). Measurable criteria for the listing criteria are primarily based on the goals of specific actions described in Chapter 7 (Strategies and Actions) that are designed to address the listing factors. For assessing biological criteria, the benchmarks outlined in this chapter are intended to serve as interim measures of progress towards achieving recovery goals. The suite of RME identified as necessary to evaluate these measurable criteria will also ultimately provide the foundation for more comprehensive viability analyses such as those described in McElhany et al. (2007[75]) that follow the viability criteria framework established by the Willamette/Lower Columbia Technical Recovery Team (McElhany et al. 2006).

8.2 RME Categories

An RME Plan needs to provide information to answer three fundamentally different questions:

1. What is the condition or status of X over time?
2. What is the effect of Y on the condition or status of X?
3. What are the uncertain relationships or conditions that are critical to making good decisions?

The programs that generate data to address these three classes of questions are fundamentally different. While they can be related, integrated or interconnected, they cannot be substituted one for the other. As described by NMFS (2007a), there are six general types of monitoring that are relevant to Recovery Plan implementation and assessment.

Status monitoring is used to characterize existing conditions, establish a baseline for future comparisons, and capture temporal and spatial variability in the parameters of interest. *Trend monitoring* involves measurements taken at regular time or space intervals to assess the long-term trend in a particular parameter. Status and trend monitoring is equally pertinent to both the biological and listing factor criteria.

The general monitoring approach in this Plan to obtain information on status and trend of fish abundance, distribution, and habitat conditions will be to follow a GRTS[76] survey design structure, similar to what is currently implemented for Oregon Coastal Coho and for additional species in the ORLCR Recovery Plan. Individual components of this approach are outlined in this chapter, but an overview of this integrated monitoring approach is in Firman and Jacobs (undated[77]). Where possible, sampling of downstream migrating juveniles and/or returning adults will supplement the GRTS-based sampling to provide more precise estimates of survival and productivity.

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[74] http://www.nwfsc.noaa.gov/trt/wlc_docs/Revised_WLC_Viability_Criteria_Draft_Apr_2006.pdf
[75] http://www.nwfsc.noaa.gov/trt/trt_documents/part_1_sep07.pdf
[76] Generalized Random Tessellation Stratified – see Stevens and Olsen, A.R. (2004).
[77] http://oregonstate.edu/dept/ODFW/spawn/pdf%20files/reports/emappaper.pdf

Implementation monitoring determines whether actions were carried out as planned. For example, if a restoration action is initiated to fence 20 miles of stream with the objective of reducing stream temperature and fine sediment input from run-off and bank erosion, implementation monitoring would consist of confirming the presence of the fence.

Compliance monitoring determines whether specified criteria are being met as a direct result of an implemented action. With the fencing example, the compliance monitoring indicator would be an assessment of the project's basic intent – preventing livestock from entering the riparian corridor – and thus an appropriate metric would be the presence or absence of livestock in the fenced-off area. Because implementation and compliance monitoring deal mainly with evaluating whether or not actions are being implemented, they are generally more applicable to monitoring related to the listing factors.

Effectiveness monitoring evaluates whether the management actions achieved their direct effect or objective. Success may be measured against "reference areas," "baseline conditions," or "desired future conditions." In the fencing example, effectiveness monitoring indicators would assessment the project's effect on improving riparian habitat, given that the project was properly implemented and in compliance with expected impact. Because effectiveness monitoring deals mainly with determining the effectiveness of actions designed to ameliorate the impacts of listing factors, it is generally not pertinent to monitoring related to the biological criteria.

Critical Uncertainty Research verifies the basic assumptions behind effectiveness monitoring and models, prioritization of limiting factors and threats, or any other topic for which assumptions have been made, which if untrue, would significantly alter the actions identified for implementation by the recovery Plan. Because critical uncertainties are associated both with biological criteria and listing factors, critical uncertainty research is needed in both contexts[78].

8.3 Biological Recovery

As described earlier, biological recovery is assessed in terms of four VSP parameters: 1) abundance; 2) productivity; 3) spatial structure; and 4) diversity. The following describes the decisions, key questions, analytical guidelines, measurable criteria, and specific RME needed by this Recovery Plan in order to assess the status of biological recovery of UWR Chinook and steelhead populations.

8.3.1 Decisions and Key Questions[79]

<u>Decisions</u>

1. The aggregate status and change in status over time of the populations and habitats within the ESU/DPS attains a level of risk, natural sustainability, or probability of persistence sufficient to consider the ESU/DPS viable.
2. The status and change in status of the population's viability parameters, in the aggregate, demonstrate a level of risk, or probability of persistence, sufficient to consider that the population has achieved the viability targets established for its classification (i.e., the level of risk considered acceptable for this population).

<u>Key Questions</u>

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[78] In most cases the detailed approach and proposals for critical uncertainty will be prioritized, developed, and implemented as part of implementation, specifically during development of the three-year Implementation Schedules (see Chapter 9).
[79] Decisions and key questions come from a 2007 NMFS document entitled "*Adaptive Management for ESA-Listed Salmon and Steelhead Recovery: Decision Framework and Monitoring Guidance*".

Does the ESU have a high probability or a clear trending toward a high probability of persistence? Specifically do:

1. At least two populations in the ESU/DPS have at least a 95% probability or are clearly trending toward a high probability of persistence (i.e., low extinction risk)?
2. Other populations in the ESU/DPS have persistence probabilities consistent with or are clearly trending toward a high probability of ESU/DPS persistence (i.e., the average of all ESU/DPS population scores is 2.25 or higher, based on the TRT's scoring system)?

The population-specific extinction risk levels needed to achieve both ESU/DPS delisting and broad sense recovery are described fully in Chapters 6 and 10. As outlined in Chapter 4 (Current Status) the ability to evaluate these risk levels relies on collecting and analyzing information related to the four VSP parameters (abundance, productivity, spatial structure, and diversity). What follows is an outline of the analytical guidelines for each of these VSP parameters, along with the specific measurable criteria required as part of an ESA recovery Plan and under Oregon's Native Fish Conservation Policy.[80]

8.3.2 Analytical Guidelines, Measurable Criteria, and RME for Abundance and Productivity[81]

Analytical Guidelines – Abundance and Productivity

1. In general, viable populations should demonstrate a combination of population growth rate, productivity, and abundance that produces an acceptable probability of population persistence. Various approaches for evaluating population productivity and abundance combinations may be acceptable, but must meet reasonable standards of statistical rigor.
2. A population with a non-negative growth rate and an average abundance approximately equivalent to estimated historical average abundance should be considered to be in the highest persistence category. The estimate of historical abundance should be credible, the estimate of current abundance should be averaged over several generations, and the growth rate should be estimated with an adequate level of statistical confidence. This criterion takes precedence over criterion 1.

Measurable Criteria – Abundance and Productivity

Abundance and Productivity Metric

Annual estimates of the abundance of naturally-produced spawners in each UWR Chinook and steelhead population.

Abundance and Productivity Evaluation Thresholds (de-listing)

Pass – The observed spawner abundance is ≥ the abundance modeled for de-listing (shown in the threat reduction and VSP scenario tables for each population in Chapter 6) at least six times in any 12-year[82] period *and* the average observed spawner abundance is ≥ the average modeled abundance for delisting over that same time period.
Fail – The observed spawner abundance is ≥ the abundance modeled for de-listing less than six times in any 12-year period *or* the average observed spawner abundance is < the average modeled abundance for de-listing over that same time period.

Abundance and Productivity Evaluation Thresholds (broad sense recovery)

[80] http://www.dfw.state.or.us/fish/nfcp/rogue_river/docs/nfcp.pdf
[81] Analytical guidelines are from Willamette/Lower Columbia Technical Review Team (WLCTRT 2006).
[82] 12 years was selected because it represents roughly three to four brood cycles for Chinook salmon and steelhead and should thus provide a reasonable snapshot in time of the trend in status of a population.

Pass – The observed spawner abundance is ≥ the abundance modeled for broad sense recovery at least six times in any 12-year[9] period *and* the average observed spawner abundance is ≥ the average modeled abundance for broad sense recovery over that same time period.
Fail – The observed spawner abundance is ≥ the abundance modeled for broad sense recovery less than six times in any 12-year period *or* the average observed spawner abundance is < the average modeled abundance for broad sense recovery over that same time period.

Analytical Procedures for Abundance and Productivity

As described in Chapter 4 (Population Conservation Gaps) we developed stock-recruitment curves for each UWR Chinook and steelhead population as a way of determining the abundance and productivity needed to achieve de-listing and broad sense recovery. Because the abundance and productivity derived from these recruitment curves represent the long term (i.e., 100 year) average, there is a need to develop annual benchmarks of abundance and productivity that will allow more timely assessments of progress towards recovery goals. Thus, in addition to the stock recruitment curves generated for each population, we need annual estimates of spawner abundance, harvest of wild fish, age at return, and an index of climate impact. Because natural fluctuations in climate conditions play such a significant role in the annual abundance of salmon and steelhead spawners, it is necessary to scale the average abundance targets to an annual index of climate.
The following generic example illustrates how this information will be used to derive annual benchmarks for abundance and productivity against which progress towards recovery can be assessed.

Step 1- Obtain recruitment parameters for population[83]

Alpha	Beta	Gamma	Clm Indx	Indx Lag
1.986	9343	1.999	CRF	-2

Step 2 – Determine the age composition of the returning fish

Return Year	Parental Brood Years					
	age 2	age 3	age 4	age 5	age 6	age 7
2002	2000	1999	1998	1997	1996	1995

Step 3 – Obtain total number of spawners (hatchery + wild) for each brood year

Spawner Abundance by Parent Year					
2000	1999	1998	1997	1996	1995
843	363	858	895	361	1876

Step 4- Obtain climatic index for each brood year

1998	1997	1996	1995	1994	1993
0.524	0.587	0.462	0.164	0.200	-0.159

Step 5 – Calculate recruits for each brood year using the following equation based on recruitment curve

1) $$Ln(R_t) = Ln(\alpha) + Ln(S_t) - Ln(1 + (\alpha/\beta * S_t)) + (\gamma * C_{t+lag})$$

where S_t is the total number of fish that spawned (including both hatchery and wild fish) in year t, R_t is the number of naturally produced recruits that were produced by the fish that spawned in year t, C is the climatic index with a lag period equal to t+lag, where lag may assume any value in the search range form -3 to +3, and α, β, γ are parameters for the recruitment equation.

[83] CRF stands for Columbia River Flow

Estimated pre-harv Recruits w/o recovery actions, pre-harv					
2000	1999	1998	1997	1996	1995
4051	2166	3630	2070	993	1939

(note numbers above are calculated as the exp(Ln(Rt)) estiamted from Eq 1)

Step 6 – Calculate recruits after fishery (i.e. spawners) using the fishery impact rates used to determine the "modeled current" abundance described in chapter 6 (0.10 in this case).

Estimated pre-harv Recruits w/o recovery actions, pre-harv					
2000	1999	1998	1997	1996	1995
4051	2166	3630	2070	993	1939

(note numbers above are calculated as the exp(Ln(Rt)) estiamted from Eq 1)

Step 7 – Multiply each brood year recruits by recovery scalar[84] (described in chapter 4) to obtain the number of spawners needed to meet recovery goals given climate conditions for each brood year.

Estimated post-harv Recruits WITH recovery actions					
2000	1999	1998	1997	1996	1995
7074	3782	6338	3615	1734	3385

Step 8 – Use the age composition for this population to determine how many of each age fish returned using the brood year recruits estimated in Step 7.

Age at Spawning (Proportion of Total)						
2	3	4	5	6	7	
0.000	0.005	0.510	0.398	0.083	0.004	2002 Forecast
age 2 (00BY)	age 3 (99BY)	age 4 (98BY)	age 5 (97BY)	age 6 (96BY)	age 7 (95BY	TOTAL
0	20	3232	1439	143	14	4848

Step 9 – Take the forecast total for 2002 return and expand it by 20% as described in Chapter 6 to provide a buffer for the impacts of climate change.

4848 x 1.20 = 5818

Step 10 – The number derived in Step 9 is the forecast return of adult fish for 2002 if recovery goals have been met. These annual forecasts can be plotted along with the actual number of spawners observed to track progress towards recovery (see Figure 1 for a hypothetical example). In this example the population does not pass the abundance and productivity measurable criteria since observed spawner abundance equals or exceeds the forecasted abundance needed to achieve recovery goals only four out of the 12 years.

[84] The recovery scalar is the amount that the current survival rate needs to be improved to get the probability of CRT to the threshold for the risk category targeted for this population – in this instance the recovery scalar for this example population to achieve a low risk of extinction = 1.94

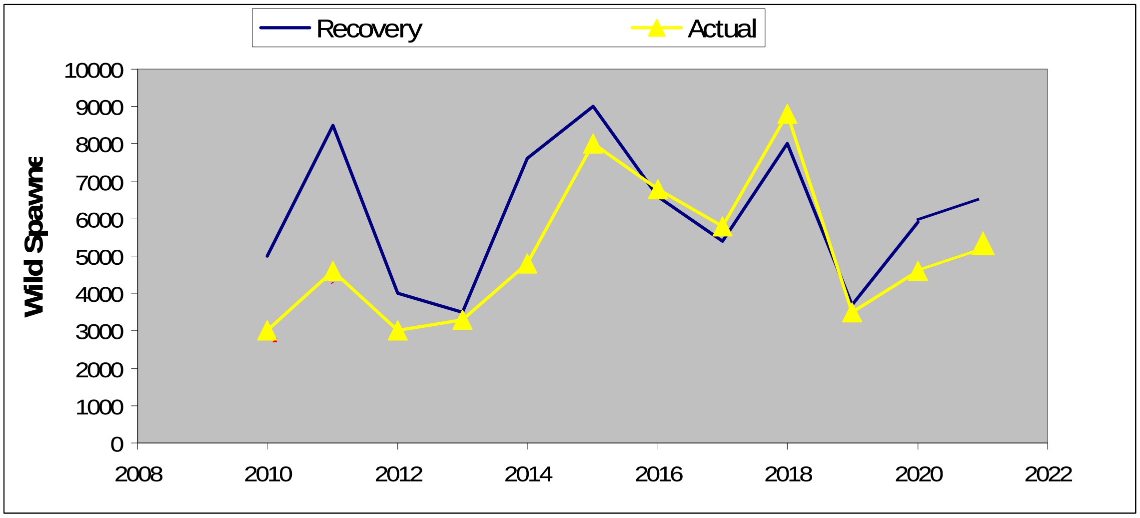

Figure 8-1. Hypothetical example comparing observed spawner abundance with recovery goals scaled to climate conditions.

RME Needed to Assess Abundance and Productivity

Status and Trend Monitoring

1. Annual estimates of the spawner abundance of natural and hatchery origin fish in each UWR Chinook and steelhead population.

   Relevance: Needed to calculate annual spawner and recruit estimates.

   Approach: Census surveys in subbasins where feasible. Where census-based surveys are not feasible, monitoring will include spatially balanced, random surveys based on the Generalized Randomized-Tessellation Stratified (GRTS) technique (Stevens and Olsen, 2004). Field protocols for winter steelhead will follow those outlined in ODFW (2007b[85]), and protocols for spring Chinook will follow those outlined in Schroeder et al. (2007[86]). The objective will be to provide annual estimates of spawner abundance with a 95% confidence interval of ±30%. Examination for hatchery fin clips of carcasses recovered during spawning surveys will delineate the proportion of hatchery fish. These samples will be supplemented where necessary and feasible with scale and/or otolith analyses, and capture of live fish when carcasses cannot be recovered (e.g., steelhead redd surveys). Spawner abundance monitoring will also rely on the future infrastructure and coordinated monitoring at the upgraded fish collection facilities at WP Project dams and other fish handling facilities.

2. Annual estimates of mortality due to harvest for each UWR Chinook and steelhead population.

   Relevance: A needed component of estimating total recruits for abundance and productivity analyses.

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[85] http://oregonstate.edu/dept/ODFW/spawn/pdf%20files/reports/07StwManual.pdf
[86] https://nrimp.dfw.state.or.us/CRL/Reports/AnnPro/annual%2006-07_final_web%20v3.pdf

Approach: TBD[87]. The procedures adopted for the FMEP's for Chinook and steelhead will be the foundation for these estimates.

Critical Uncertainty Research

1. Better information on extent of potential spawning and rearing distribution of each UWR Chinook and steelhead population.

   Relevance: Accurate expansion of survey data to population estimates requires accurate information on population range.

   Approach: Map-based approach using existing IP layers and correcting as needed with expert opinion and field verification.

2. Development of efficient survey designs for assessing patchily-distributed populations based on understanding factors that influence annual variation in distribution (e.g., fish abundance and streamflow).

   Relevance: Traditional GRTS-based surveys can be misleading or costly to implement when populations exhibit patchy distributions. Understanding of factors that influence distribution will aid the design of more precise and efficient surveys.

   Approach: TBD

3. Cost effective survey designs and methods for assessing fish populations in streams where conditions (stream size, turbidity, cover) reduce the efficacy of traditional visual survey methods.

   Relevance: Many areas in the upper Willamette River subbasins are not amenable to traditional visual spawning survey protocols.

   Approach: TBD

4. Annual estimates of the marine and freshwater survival rates of natural origin spring Chinook and winter steelhead for selected areas in the upper Willamette River subbasins.

   Relevance: Needed to provide supplemental information on environmental factors influencing observed abundance and productivity.

   Approach: At least two intensively monitored watersheds (i.e., trapping of adults in and juveniles out) the ESU/DPS.

8.3.3 Analytical Guidelines, Measurable Criteria, and RME for Spatial Structure

Analytical Guidelines

1. The spatial structure of a population must support the population at the desired productivity, abundance, and diversity levels through short-term environmental perturbations, longer-term environmental oscillations, and natural patterns of disturbance regimes. The metrics and measurable criteria for evaluating the adequacy of a population's spatial structure should specifically address:
   a. Quantity: Spatial structure should be large enough to support growth and abundance, and diversity criteria.

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[87] Early in the implementation phase of this Recovery Plan, workgroups will be convened to develop the approach for this and all other TBD RME elements.

b. Quality: Habitat underlying spatial structure should be within specified habitat quality limits for life-history activities (spawning, rearing, migration, or a combination) taking place within the patches.
c. Connectivity: Spatial structure should have permanent or appropriate seasonal connectivity to allow adequate migration between spawning, rearing, and migration patches.
d. Dynamics: The spatial structure should not deteriorate in its ability to support the population. The processes creating spatial structure are dynamic, so structure will be created and destroyed, but the rate of loss should not exceed the rate of creation over time.
e. Catastrophic Risk: The spatial structure should be geographically distributed in such a way as to minimize the probability of a significant portion of the structure being lost due to a single catastrophic event, either anthropogenic or natural.

Measurable Criteria – Spatial Structure

Spatial Structure Metric – Percent Occupied Habitat

The occupancy of spawning adults or juveniles at spatially balanced, random survey sites.

Percent Occupied Habitat Evaluation Thresholds

Pass – The percentage of sites not occupied by spawning adults or rearing juvenile spring Chinook or winter steelhead is ≤ the thresholds shown Table 8-1 at least six times during a twelve year period *and* the overall average percentage of sites not occupied during that same time period is ≤ than the thresholds shown Tables 8-1.

Fail – The percentage of sites not occupied by spawning adults or rearing juvenile spring Chinook or winter steelhead is > the thresholds shown Table 8-1 at least six times during a twelve year period *or* the overall average percentage of sites not occupied during that same time period is > the thresholds shown Tables 8-1.

Table 8-1. Occupancy thresholds for UWR Chinook and steelhead populations.

Population	Watershed Size	Delisting Risk Goal	Occupancy Threshold	
			Delisting	Broad Sense (Very Low Risk)
Spring Chinook				
Clackamas	medium	VL	10%	10%
Molalla	small	H	50%	5%
North Santiam	medium	L	20%	10%
South Santiam	medium	M	20%	10%
Calapooia	small	H	50%	5%
McKenzie	large	VL	15%	15%
Middle Fork Willamette	medium	L	20%	10%
Winter Steelhead				
Molalla	large	VL	15%	15%
North Santiam	large	VL	15%	15%
South Santiam	large	VL	15%	15%
Calapooia	small	M	25%	5%

Spatial Structure Metric – Geographic Distribution

Comparison of the spatial pattern of potential spawning distribution to that observed using SVB[88] spatial statistics.

Geographic Distribution Evaluation Thresholds (Adults and Juveniles)

> *Pass* – The observed distribution the SVB statistic of sites occupied by four or more adult spawning fish or one juvenile is not significantly different from a random distribution at least six times in any 12-year period.
>
> *Fail* – The observed distribution the SVB statistic of sites occupied by four or more adult spawning fish or one juvenile is not significantly different from a random distribution less than six times in any 12-year period.

Analytical Procedure for Spatial Structure

The manner in which juveniles and adults (spawners) are distributed within the freshwater portion of a population's home range is an important consideration in assessing the conservation status of a population (McElhany et al. 2000, Bisson et al. 1997). Healthy populations will experience periods when the distribution of spawners becomes spatially compressed (e.g., during poor marine survival periods) and periods when the spatial distribution of spawners expands (e.g., during good marine survival). It is important to keep in mind that distribution is also governed by some factors that are unrelated to population size, like weather patterns. During years with little rain and low stream flows, fish may not be able to access much of the habitat and distribution may be constricted even if the population size is large. The challenge is to select a criterion that will identify when a restriction in spawner distribution is greater than expected for a healthy population under given environmental conditions.

Because adult and juvenile salmon and steelhead often rely on different aspects of habitat during their stay in freshwater, it is important that the distribution of both adult and juveniles are monitored. ODFW and NMFS have established two measurable criteria for spatial structure. Both rely on spatially balanced, random surveys of the presence/absence of adult spawners and rearing juveniles that are conducted throughout their historic range. Adult spawner surveys will also provide information needed on abundance and productivity as described earlier. Surveys for spatial structure will not need to be conducted above barriers that do not allow the passage of wild fish; however, the survey design process will include such sites to enable a statistically rigorous analysis of occupancy across a species historic distribution[89].

The first measurable criterion is based on WLC-TRT guidance on the relationship between population persistence and the overall percentage of accessible habitat. Analysis of survey data for this criterion is relatively straight forward and simply involves calculating the percentage of sites that where spawners are absent.

The second criterion is designed to obtain information on the geographic distribution of spawning. For this criterion we will use the SVB statistic (Stevens 2006) to determine if the spatial distribution of occupied sites is comparable to the spatial distribution of sites where spawning may potentially occur. To calculate the SVB statistic, a polygon will be drawn around each point that encompasses the area closer to that point than to any other. If the polygons are similar in size and shape, then the distribution is more regular. If the polygons differ in size and shape then the distribution is more clustered. One criterion that is sensitive to both variation in area and shape is the variation of the distance from a point to the boundary

[88] SVB stands for Sides, Vertices, and Boundaries
[89] Random survey sites above known barriers will be automatically assigned to the "absent" category.

of its polygon. If we define a Side as a division between two polygons, a Boundary as a segment of the domain boundary, and a Vertex as the intersection between two Sides or a Side and a Boundary, then the SVB can be approximated by the mean square deviation (MSD) of the distance from a sample point to Sides, Vertices, and Boundaries, relative to a nominal value (such as the MSD for a hexagon with area = [domain area / number of samples]).

To test that occupancy occurs at random over the population's range, a pattern of random presence/absence can by simulated by assigning each of the survey points either 0 (indicating absence) or 1 (indicating presence). By repeating the process multiple times, each time calculating the SVB statistic, a distribution of the SVB statistic can be constructed. The distribution will be specific to that particular population, because it will depend on the geometry of the stream network occupied by a population. The distribution will also depend on the occupancy rate.

Various hypotheses can be tested by choosing an occupancy rate, and then assigning absence following some hypothesized relationship. For example, to test the hypothesis of a shrinking domain, higher probability of absence could be assigned to stream sites near the domain boundary, or to stream segments deemed to have less suitable habitat. Standard randomization test procedures can then be used to establish significance level of the test. It is then possible to test various hypotheses about the actual distribution by comparing the observed value to the random distribution. A population would pass this criterion as long as the observed SVB statistic distribution did not significantly differ from the random distribution.

RME Needed to Assess Spatial Structure

Status and Trend Monitoring

1. Annual estimates of the distribution and density of natural origin spawning adult and rearing juvenile spring Chinook and winter steelhead for each UWR population.

   Relevance: Used in combination with habitat information to assess existing spatial structure relative to desired status.

   Approach: Spatially balanced, random surveys based on the Generalized Randomized-Tessellation Stratified (GRTS) technique (Stevens and Olsen, 2004). Snorkel and electrofishing surveys for juveniles following protocols described in Rodgers (2000[90]) and Rodgers (2001[91]). Field protocols for spawning winter steelhead will follow those outlined in ODFW (2007b[92]). Field protocols for spawning spring Chinook will follow those outlined in Schroeder et al. (2007[93]). The objective will be to detect a change in spatial distribution of ± 15% with an 80% certainty.

2. Five-year assessment of habitat conditions throughout the accessible distribution of each UWR spring Chinook and winter steelhead population.

   Relevance: Used in combination with fish distribution information to assess existing spatial structure relative to desired status. Need to know whether or not changes in observed fish distribution are due to changes in habitat conditions.

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[90] http://nrimp.dfw.state.or.us/crl/Reports/WORP/WORPAN99.pdf
[91] https://nrimp.dfw.state.or.us/crl/Reports/WORP/WORPAN00.pdf
[92] http://oregonstate.edu/dept/ODFW/spawn/pdf%20files/reports/07StwManual.pdf
[93] https://nrimp.dfw.state.or.us/CRL/Reports/AnnPro/annual%2006-07_final_web%20v3.pdf

Approach: Spatially balanced, random surveys based on the Generalized Randomized-Tessellation Stratified (GRTS) technique (Stevens and Olsen, 2004). Field sampling protocols will be based on ODFW Aquatic Inventory protocols[94].

3. Annual monitoring of streamflow and temperature.

   Relevance: Distribution can be significantly influenced by streamflow and temperature (e.g., less habitat being assessable during drought years).

   Approach: TBD

Critical Uncertainty Research

1. Refinement of knowledge of the extent of historical spawning and rearing distribution of each UWR Chinook and steelhead population.

   Relevance: Needed for comparisons of desired or potential distribution to actual distribution.

   Approach: TBD

2. Refinement of knowledge of the accuracy of field protocols to detect occupancy.

   Relevance: Presence of individuals in samples is proof of occupancy, but absence can not be proven. The problem is that frequency of "false" absences depends on the abundance and distribution of individuals, the sampling method and intensity, and the grain of sampling. This can be particularly problematic for species that are rare or patchily distributed or as species and populations decline in abundance and distribution leading to errors in estimates that vary with habitat and environmental conditions and species abundance.

   Approach: TBD

3. Refinement of knowledge of relationship factors that influence annual variation in distribution (e.g., fish abundance, streamflow, water temperature).

   Relevance: Needed to refine spatial distribution measurable criteria.

   Approach: TBD

4. Refinement of knowledge of the relationship between spatial structure and viability.

   Relevance: While it is acknowledged that spatial structure has the potential to play a major role in population viability, there is little quantitative information on how the extent of this relationship.

   Approach: TBD

8.3.4 Analytical Guidelines, Measurable Criteria, and RME for Diversity

Analytical Guidelines

1. Sufficient life-history diversity must exist to sustain a population through short-term environmental perturbations and to provide for long-term evolutionary processes. The metrics and measurable criteria for evaluating the diversity of a population should be evaluated over multiple generations and should include:

[94] http://oregonstate.edu/dept/ODFW/freshwater/inventory/pdffiles/hmethd08.pdf

a. substantial proportion of the diversity of a life-history trait(s) that existed historically,
b. gene flow and genetic diversity should be similar to historical (natural) levels and origins,
c. successful utilization of habitats throughout the range,
d. resilience and adaptation to environmental fluctuations.

Measurable Criteria – Diversity

Diversity Metric #1: Effective Population Size

Effective population size relates to a minimum population level that must be maintained to minimize the genetic risks associated with small population size such as: inbreeding depression, the loss of diversity through genetic drift, and the accumulation of maladaptive mutations. Since the population abundance goals described in Chapter 6 are designed to equal or exceed abundance needed to satisfy effective population size requirements, passing the abundance and productivity thresholds described in Chapter 6 will mean that effective population size requirements are met.

Diversity Metric #2: Interbreeding with hatchery fish

See measurable criteria for hatchery related threats in section 8.4.5.

Diversity Metric #3: Anthropogenic mortality

See measurable criteria for fish harvest related threats in section 8.4.2.

Diversity Metric #4: Life-history traits

Approach TBD – see discussion below on analysis procedures for diversity metrics.

Diversity Metric #5: Habitat diversity

TBD – see discussion below on analysis procedures for diversity metrics.

Analytical Procedures for Diversity Metrics

Within-population diversity is the result of phenotypic differences among individuals. These differences provide the flexibility of the population as a whole to respond successfully to short-term environmental variations. They also are the basis by which populations are able to adapt and evolve as conditions within their home range go through changes that are more permanent. Therefore, maintaining sufficient within-population diversity is an issue of both short-term and long-term survival.

Within-population diversity is affected by a variety of forces including: evolutionary legacy, immigration from other populations, mutation, selection, and random loss of genetic variation due to small population size. However, population size (abundance) is most commonly recognized as a concern for species that are vulnerable to extinction. The genetic consequences of small population size and numerous approaches to defining minimum population abundance thresholds have been investigated widely (Soulé 1980; Lande 1995; Franklin and Frankham 1998; Rieman and Allendorf 2001). In nearly all cases, this becomes an exercise of identifying a rate at which genetic variation can be lost without causing a risk to a population's short or long-term persistence. The diversity criterion incorporates this concept.

While there is general consensus that life-history diversity is important to the long term resilience of salmon and steelhead populations, there is little consensus or guidance available on specifically how information on life-history diversity should be analyzed in order to assess whether or not salmon and steelhead populations have the range of life-history characteristics necessary for long term resilience in the face of a changing climate. As a result, it is difficult to establish specific pass/fail thresholds for this metric. Despite this, we believe that monitoring of key life history traits (see RME needs below) are important to establish a baseline and trend for diversity evaluations. This combined with more research into what key life-history traits should be maintained in the face of future climate change and reconstruction of the historical life-history diversity of UWR spring Chinook and winter steelhead populations should help to better define future analytical approaches.

Given that there is considerable uncertainty about how and what to monitor, a monitoring approach involving stratifying the status and trend abundance sampling (described earlier) by distinct environments that are presumably the template for the expression of diversity might provide information on the relationship between diversity metrics and environmental/habitat conditions.

RME Needed to Assess Diversity

Status and Trend Monitoring Needs

1. Periodic monitoring of key life history characteristics of each UWR spring Chinook and winter steelhead population. For example:
    a. Timing of return to fresh water
        - Run time (e.g., fall vs. spring)
        - Variation within a specific run time
    b. Age at maturation
    c. Spawn timing
    d. Outmigration timing
        - Distribution to downstream or upstream rearing habitat
        - Specific nursery habitat utilization
    e. Smoltification timing
        - Entrance to marine environment
        - Duration of residence in intertidal or Columbia River plume areas
    f. Developmental rate
    g. Egg size
    h. Fecundity
    i. Freshwater distribution
    j. Ocean distribution
    k. Size at maturation
    l. Timing of ascension to the natal stream

    Relevance: Information of key life history characteristics is important to understanding the long-term resilience and adaptability of UWR spring Chinook and winter steelhead populations.

    Approach: TBD

2. Annual monitoring of the spatial distribution, abundance, and origin of adult spring Chinook and winter steelhead spawning in the wild in each UWR population area.

    Relevance: If fish spawn and rear in a variety of freshwater habitats in a subbasin, the population, as a whole, will be buffered against year-to-year environmental variations. Hatchery strays can impact the diversity of wild populations.

    Approach: See RME needs for abundance and productivity.

3. Regular hatchery monitoring.

Relevance: Hatcheries affect diversity largely through the process of domestication and introgression. Additionally, hatchery propagation may produce non-genetic effects on the expression of life history traits via non-natural rearing regimes.

Approach: TBD

4. Periodic genetic marker monitoring.

   Relevance: Monitoring of genetic changes within and among populations can reveal changes in the genetic characteristics of a population or ESU/DPS.

   Approach: TBD

5. Periodic assessment of habitat diversity, occupancy, and anthropogenic changes to habitat and the environment.

   Relevance: Assessing the effects of artificial selection must include the degree to which a population's life history diversity has been modified relative to its historical locally-adapted state.

   Approach: See RME needs for spatial structure.

Critical Uncertainty Research

1. Research into which life-history traits or other diversity parameters are the most meaningful measures of diversity, particularly in the context of future climate change impacts.

   Relevance: Development of meaningful measures of diversity is difficult largely because of the lack of understanding of the expression of individual life history traits (the genetic and environmental effects) and the degree of correlation between those traits.

   Approach: TBD

2. Reconstruction of the historical life-history diversity of UWR spring Chinook and winter steelhead populations

   Relevance: Needed in order to provide a template for life history diversity benchmarks.

   Approach: TBD

8.3.5 Summary of Strategic Approach to Monitoring VSP Parameters

The strategy for monitoring the seven UWR Chinook and four steelhead populations involves following basic components:

1. Conduct research to document the precision and bias associated with various fish monitoring protocols (e.g.. spawning surveys, snorkel surveys, smolt trapping) across the range of conditions that exist within the UWR subbasins.
2. Where field protocols for spawning surveys are deemed to provide acceptable precision and bias, and access is possible for most of the potential areas in the sample frame, implement either GRTS-based or census-based spawning surveys to provide population level information on abundance (spawners), productivity (recruits/spawner), diversity (occurrence of hatchery strays on spawning grounds, run timing, size, age, genetics), and distribution. Goal is to provide annual spawner abundance estimates at the population scale with a precision of ± 30% or better. NOTE that these surveys are preferable to fixed station counting since they have the potential to provide

information on distribution which is not available with fixed station counts. They are, however, only preferable if they can produce estimates with acceptable precision and bias.

3. Where field protocols are not amenable, use information from existing or new adult trapping facilities to provide abundance, productivity, and diversity for sub-watershed areas. (In these instances we will not be able to assess distribution criteria.) Conduct research to assess the representativeness of these index areas and evaluate magnitude of pre-spawning mortality.
4. Cross check precision and bias of GRTS-based or census-based spawning surveys by comparing the results of survey implemented above adult traps to counts made at the traps. Conduct these evaluations over the range of conditions that exist within the UWR areas.
5. Evaluate the potential for using sonar (e.g., DIDSON) to monitor abundance. Implement where feasible and cost effective in situations where surveys cannot be conducted or adult trapping facilities do not exist.
6. Develop programs to monitor fishery related mortality[95] that include reliable information on bias and precision.
7. Conduct hatchery monitoring to provide information on number of fish released, marked[96], returned to hatchery, and wild fish collected for brood stock.
8. Where field protocols for juvenile surveys provide acceptable precision and bias, and access is possible for most of the potential areas in the sample frame, implement GRTS-based surveys to provide information on an index of abundance (fish/m^2), productivity (juveniles per mile/spawners per mile), and distribution. Goal is to provide annual estimates of juvenile density at the population scale with a precision of $\pm$ 30% or greater.
9. In at least two populations trap adults in and juveniles out to provide estimates of marine and freshwater productivity (i.e., Life Cycle Monitoring sites, use Detroit facility and Cougar? Facility-or modify Leaburg to include a juvenile monitoring facility??). Goal is to provide annual estimates of adults in and juveniles out of selected watersheds with a precision of $\pm$ 30% or better.
10. Evaluate how well Life Cycle monitoring sites represent conditions outside of the index areas and investigate the potential for implementing additional trap sites that could be operated periodically on a rotating basis to "calibrate" index sites to broader areas.

Priorities

Monitoring of harvest or hatcheries basically is considered the cost doing business. Therefore, decisions to continue existing harvest or hatchery monitoring or to implement new monitoring will be primarily linked to decisions regarding the existence of these harvest or hatchery programs. If harvest or hatchery programs exist, the monitoring described in items F and G (above) become high priority. Without this information we not only will have a difficult time assessing any of the VSP parameters in any wild populations exposed to fishery or hatchery impacts, but will also not meet the management needs of harvest and hatchery programs.

For the other monitoring components (spawners, juveniles, life/cycle), when funds are limited there are three primary ways to reduce monitoring effort (and thus expenditures). In priority order these are:

1. Reduce effort throughout the sample frame[97] (may decrease precision).

[95] Needed for productivity estimates.
[96] Needed to estimate pHOS.
[97] The sample universe or spatial extent over which the target indicator may be distributed.

2. Reduce effort in parts of the sample frame (may increase bias).
3. Eliminate one or more of the components describe above (may result in inability to provide any information on certain monitoring objectives).

Oregon's strategic approach *to fluctuations in monitoring support* is to design monitoring programs that are scalable and provide information on the variance structure of monitored indicators. This information will enable calibration of information gathered during periods of reduced effort to information gathered during periods of enhanced (or non-reduced) effort. Oregon's first priority is to use this approach to reduce effort throughout the sample frame while still keeping (at least for the short term) acceptable precision.

In instances when either calibration information has not been developed, does not show that acceptable precision and bias goals can be achieved with reduced effort, or where budget shortfalls require deeper reductions, Oregon's next priority is to reduce effort in parts of the sample frame. For UWR Chinook and steelhead populations, Oregon will follow priorities set for delisting goals in Chapter 6 of this Plan. Under the delisting scenario in the Plan the Molalla and Calapooia Chinook salmon populations are currently at very high risk of extinction, and are not targeted for recovery to viable status, and thus will be the first areas where species specific monitoring of adult escapement or juvenile abundance will be either temporarily suspended or postponed if necessary to respond to budget shortfalls.

Finally, if the two steps described above still do not yield enough fiscal reductions to meet budget shortfalls, Oregon's final step will be to eliminate entire monitoring components in the following order:

1. GRTS-based juvenile surveys
2. Life cycle monitoring
3. GRTS-based spawner surveys

By following this strategic approach, Oregon believes that with adequate funding it can provide scientifically rigorous information on the four VSP parameters that is crucial for future decisions on the status and trend of UWR spring Chinook and winter steelhead. This strategic approach also provides a rational way to establish priorities for providing quality information given available monitoring resources, and provides managers and policy makers with a better framework for making decisions regarding the funding of monitoring programs.

8.3.6 Summary of Current Monitoring for VSP Parameters

A variety of monitoring programs are currently in place that can provide some of the information needed to assess VSP parameters in the future for UWR Chinook and steelhead populations. These data and programs will need to be evaluated in the context of the approaches needed to address the VSP metrics.

8.4 Listing Factors

In addition to RME needed to address the biological criteria, to be approved by NMFS, a recovery plan must also include RME that addresses the five ESA section 4(a)(1) listing factors:

A. The present or threatened destruction, modification, or curtailment of the species' habitat or range
B. Over-utilization for commercial, recreational, scientific or educational purposes
C. Disease or predation
D. The adequacy of existing regulatory mechanisms
E. Other natural or manmade factors affecting its continued existence

In contrast to the measurable criteria developed for biological recovery (which have a direct connection to assessments of population viability), the measurable criteria described below for the listing factors are primarily related to directly tracking the success of actions designed to reduce the impact of current threats or serve as an early warning for emerging threats.

The following describes the decisions, key questions, measurable criteria, and RME needed by this Plan to assess the status of the five listing factors.

8.4.1 Decisions, Key Questions, Metrics and RME for Listing Factor A: The Present or Threatened Destruction, Modification, or Curtailment of a Species' Habitat or Range.

Decisions

1. Habitat related threats have been ameliorated such that they do not limit attainment of the desired status of the population. The desired status of each population is defined by viability criteria identified in the Recovery Plan.
2. Flood Control/Hydropower related threats have been ameliorated such that they do not limit attainment of the desired status of the populations relative to population-specific viability criteria identified in the Recovery Plan.

Key Habitat Related Threat Question

Are there significant effects of habitat degradation on the observed abundance, productivity, spatial structure, and diversity of the natural-origin fish in this population?

Measuring Habitat Related Threats

Habitat Related Metrics

Five year assessments of:

- Floodplain Connectivity and Function
- Channel Structure and Complexity
- Riparian Condition and LWD Recruitment
- Stream Substrate
- Water Quality and Stream Flow
- Fish Passage
- Pre-spawn mortality

Evaluation Thresholds for Habitat Related Metrics – All Species

Pass – Positive trend in the status of the habitat degradation metrics
Fail – Negative trend or no improvement in the status of the habitat degradation metrics

Analytical Procedures for Habitat Related Metrics

Although we may achieve passing grades for the biological population criteria, the ESU/DPS can still be deemed at risk of extinction if habitat conditions are deteriorating. Even if conditions are not declining but simply remaining the same, it is clear that that significant improvement to habitat conditions is needed to achieve recovery goals. A "status quo" in habitat conditions would also serve as an indication that recovery goals are not being met.

By establishing baseline conditions for the habitat metrics listed above, and periodically reassessing these conditions, we will be able to evaluate whether or not habitat conditions are improving, staying the same, or declining. In tributary streams we can also compare habitat conditions to those at relatively undisturbed "reference" sites to gauge how far current habitat conditions are from "pristine" conditions. Ultimately we would like to establish goals for each habitat metric that would enable us to assign a target number of stream miles in each population area that should have habitat conditions similar to reference conditions. However, our current lack of quantitative information that specifically links habitat conditions to the biological criteria (i.e., abundance, productivity, diversity, and spatial structure) makes it difficult to develop quantitative habitat status benchmarks. Instead, until more research is conducted to establish a more sound quantitative linkage between habitat conditions and the biological criteria, we have opted to establish measurable criteria evaluation thresholds that are based on the trend in habitat conditions.

An example of the types of analyses that will be conducted on the collected instream habitat data may be found in ODFW (2005b[98]). Comparison of monitored habitat conditions to undisturbed "reference" sites to gauge departure from pristine conditions has been a common goal in monitoring across the region, but it is often complicated by relatively high variability in individual parameters and limited power to detect meaningful trends. Because of this, it is critical that habitat information be regularly reviewed to assess ability of monitoring program to detect biologically meaningful changes in habitat conditions.

RME Needed to Assess Habitat Related Threats

Status and Trend Monitoring

1. Five year estimates of the spatial pattern and status of indicators of floodplain connectivity and function, channel structure and complexity, riparian condition and LWD recruitment, stream substrate, and fish passage within each UWR population area.

   Relevance: Used to establish baseline habitat conditions and habitat trend in subbasin streams reaches.

   Approach: Spatially balanced, random surveys based on the Generalized Randomized-Tessellation Stratified (GRTS) technique (Stevens and Olsen 2004). Field sampling protocols will be based on ODFW Aquatic Inventory protocols[99]. Objective will be to characterize habitat conditions at ± 15% with 80% certainty.
2. Five year estimates of the spatial pattern and status of indicators of floodplain connectivity and function, channel structure and complexity, riparian condition and LWD recruitment in the mainstem Willamette River and estuary

   Relevance: Used to establish baseline habitat conditions and habitat trend in the estuary and mainstem Willamette reaches.

   Approach: Spatially balanced, random surveys based on the Generalized Randomized-Tessellation Stratified (GRTS) technique (Stevens and Olsen 2004). Field sampling protocols will be based on ODFW Aquatic Inventory protocols, but specific methods for these larger reaches will need to be established.

3. Annual assessments of status and spatial pattern of water quality for each UWR population area, the mainstem Willamette, and in the estuary. This includes monitoring of stormwater and cropland runoff for status/trends of concentrations of malathion, diazinon, and chlorpyrifos, and identify their sources.

   Relevance: Used to establish baseline water quality conditions and water quality trend in tributary streams and the estuary

[98] http://nrimp.dfw.state.or.us/OregonPlan/default.aspx?p=152&path=ftp/reports/Final%20Reports/Agency%20Reports/ODFW&title=&link= (select ODFWHabitatFinalReport.pdf)
[99] http://oregonstate.edu/dept/ODFW/freshwater/inventory/pdffiles/hmethd08.pdf

Approach: Spatially balanced, random water quality sampling based on the Generalized Randomized-Tessellation Stratified (GRTS) technique (Stevens and Olsen 2004). Survey design will be integrated with habitat and fish monitoring survey design. Field sampling protocols will be based on ODEQ protocols. An example of the types of analyses that will be conducted on the collected water quality data may be found in ODEQ (2005[100]), and monitoring associated with implementing TMDL's.

4. Annual assessments of status and spatial pattern of streamflow for each UWR population area and for streamflows entering the mainstem Willamette River and estuary

   Relevance: Used to establish baseline streamflow conditions and trend in streamflows in subbasin streams and entering the mainstem Willamette River and estuary.

   Approach: TBD

Implementation and Compliance Monitoring

1. Annual assessments of compliance with existing habitat protection rules and regulations (those in place at the time of the assessments).

   Relevance: Needed to assess compliance with rules and regulations designed to protect habitat conditions

   Approach: Depending on the extent of the regulatory issue, agencies responsible for managing and/or enforcing habitat protection rules and regulations will either conduct annual censuses or statistically rigorous field surveys to assess compliance

2. Annual assessments of the implementation of habitat management best management practices

   Relevance: Application of recognized best management practices is a critical component of volunteer efforts to protect and restore habitat. Regular assessments of the extent to which best management practices are being implemented is a critical component of adaptively managing volunteer habitat programs (e.g. lack of implementation may mean that more technical assistance or other incentives are needed).

   Approach: TBD

3. Annual assessments of implementation of recovery actions designed to protect and restore habitat conditions

   Relevance: Needed to assess degree of implementation of recovery plan actions designed to protect and restore habitat conditions

   Approach: Depending on the scope of the action implementation, agencies responsible for managing or implementing the actions will either conduct annual censes or statistically rigorous field surveys to assess implementation.

Effectiveness Monitoring

1. In coordination with the Pacific Northwest Monitoring Partnership (PNAMP), establish a series of Intensively Monitored Watersheds which can be used to assess the effect of habitat restoration

[100]http://nrimp.dfw.state.or.us/OregonPlan/default.aspx?p=152&path=ftp/reports/Final%20Reports/Agency%20Reports/ODEQ&title=&link=

and protection measures and best management practices. Studies will be designed that have the ability to detect a 30-50% change in fish response.

Relevance: Needed to assess the effectiveness of habitat restoration and protection

Approach: TBD

2. Site specific monitoring of the effectiveness of habitat protection and best management practices

   Relevance: Needed to assess the effectiveness of habitat protection and best management practices

   Approach: TBD

3. Annual before and after habitat evaluations of sites where habitat restoration actions of been implemented

   Relevance: Needed to assess the effectiveness of reach specific habitat restoration efforts

   Approach: ODFW Aquatic Inventory survey protocols

Critical Uncertainty Research

1. Improved understanding of impact that habitat related limiting factors and threats have relative to other potential limiting factors and threats over the entire life-cycle of UWR spring Chinook and steelhead populations

   Relevance: Needed to better inform decisions on where to prioritize funds for recovery actions

   Approach: TBD

Key Flood Control/Hydropower Related Threat Question

There are multiple questions related to the Flood Control/Hydro threat, many of which are posed in the WP BiOp, and in subsequent WATER working groups. Those processes will be the forum for developing questions, metrics and associated RME to address Listing Factor A for hydro effects related to the observed abundance, productivity, spatial distribution, and diversity of the natural-origin fish in this population?

Flood Control/Hydropower Related Metrics

Among the annual assessments to be conducted are:

a. Fish passage (adults and juveniles)
b. Pre-spawn mortality
c. Above and below dam habitat conditions, including flow and WQ conditions

Evaluation Thresholds for Flood Control/Hydropower Related Metrics

Adult Fish passage

Pass – sufficient number of natural origin adults are allowed above barriers to seed available habitat

Fail – insufficient number of natural origin adults are allowed above barriers to seed available habitat

Juvenile Fish passage

Pass –at each dam/reservoir complex, juvenile survival through reservoir and dam is consistently within standards NMFS applies to similar complexes in other BiOps or FERC agreements
Fail – at each dam/reservoir complex, juvenile survival through reservoir and dam is consistently below standards NMFS applies to similar complexes in other BiOps or FERC agreements

Prespawn mortality (for mature female fish on or near spawning grounds)

Pass – viable populations: % mortality $\leq$ 10%[101]; non-viable populations: $\leq$ 30%
Fail – viable populations: % mortality > 10%; non-viable populations: > 30%

Physical habitat conditions (including flow)

Pass – TBD
Fail – TBD

Water quality conditions

Pass – meet TMDL load allocations for each subbasin
Fail – exceed TMDL load allocations for each subbasin

Analytical Procedures for Hydropower Related Metrics

TBD via the RME subgroups of the WATER technical teams, formed under the WP BiOp.

RME Needed to Assess Flood Control/Hydropower Related Threats

To be determined within the Comprehensive RME Plan developed for the WP BiOP and related WATER subgroups.

8.4.2 Decisions, Key Questions, Metrics, and RME for Listing Factor B: Over-utilization for commercial, recreational, scientific or educational purposes

Decision

Harvest related threats have been ameliorated such that they do not, and will not, limit attainment of the desired status of populations relative to population-specific viability criteria stated in the recovery Plan.

Key Harvest Related Threat Questions

1. Are there significant effects of fish harvest on the observed abundance, productivity, spatial structure, and diversity of the natural-origin fish in this population?
2. Does the status of the *other* listing factors modify the absolute risk posed by the current and potential future status of *this* listing factor?

Measuring Harvest Related Threats

Harvest Related Metrics

Annual estimates of the number of wild Chinook salmon and steelhead harvested from each UWR population.

Evaluation Thresholds for Harvest Related Metrics for UWR populations of spring Chinook and winter steelhead (FMEP's guidelines)

[101] Based on McKenzie estimates for a population already at a low risk of extinction

Pass – Chinook: Total freshwater mortality ≤ 15%; steelhead: Total freshwater mortality ≤ 20%;
Fail – Chinook: Total freshwater mortality >15%; steelhead: Total freshwater mortality > 20%;

Analytical Procedures for Harvest Related Threats

Apply FMEP procedures

RME Needed to Assess Harvest Related Threats

Status and Trend Monitoring

1. Annual estimates of mortality due to incidental mortality from recreational fishery for each UWR spring Chinook and winter steelhead population, and the aggregated commercial harvest impact rate of Chinook in the lower Columbia River gillnet fishery

   Relevance: Used to directly assess compliance with harvest measurable criteria.

   Approach: Implement through Willamette Chinook and steelhead FMEPs

Implementation and Compliance Monitoring

1. See item #1 under status and trend monitoring

Effectiveness Monitoring

1. Conduct studies to assess effectiveness of harvest management actions needed to achieve harvest impact goals.

   Rationale: Critical information for the adaptive management process.

   Approach: Implement through Willamette Chinook and steelhead FMEPs

Critical Uncertainty Research

1. Review existing information on mortality associated with catch and release and determine if information is adequate to assess mortality impact in potential mark-selective fisheries and if not, implement studies to assess impact that would occur in mark-selective fisheries.

   Rationale: Accurate fishery/gear specific release mortality rates are needed to estimate impacts to released stocks.

   Approach: TBD

2. Improved, population-specific understanding of impact that mortality and phenotypic selection related to fish harvest has relative to other potential limiting factors and threats over the entire life-cycle of UWR spring Chinook and winter steelhead populations.

   Relevance: Needed to better inform decisions on harvest management and where to prioritize funds for recovery actions. Maintaining existing diversity and improving diversity where impaired is critical for populations to be resilient in the face of climate change. See recent work on harvest impacts on diversity

   Approach: TBD

3. Initiate snapshot genetic sampling programs in the various fisheries designed to capture the genetic structure of the TRT populations within the specific fishery in preparation for a future

coast-wide annual coordinated genetic stock identification approach and recalibration of the FRAM model

Relevance: The Fishery Regulation Assessment Model (FRAM) is currently used by the Pacific Fishery Management Council (PFMC) to annually estimate impacts of proposed ocean and terminal fisheries on Chinook and coho salmon stocks (PFMC 2008). FRAM is a single-season modeling tool with separate processing code for Chinook and coho salmon. The Chinook version models populations from central California north to southern British Columbia, Canada. The FRAM has been used in recent years, not only to model harvest fisheries, but to determine compliance with ESA restrictions on allowable take. Currently, 3,833 stock groups are represented in the Chinook FRAM. Each of these groups have both marked and unmarked components to permit assessment of mark-selective fishery regulations. For most wild stocks and hatchery stocks without marking or tagging programs, the cohort size of the marked component is zero; therefore, the current version of FRAM has a virtual total of 76 stock groups for Chinook. The model assumes that CWT fish accurately represent the modeled stock. In nearly all cases wild stocks are aggregated with hatchery stock and both are represented by the hatchery stock. As the coast moves toward stock identification that goes beyond CWTs, the FRAM model will continue to need to be modified.

Approach: TBD

4. Research on freshwater entry migration timing.

   Relevance: One key uncertainty that could potentially reduce the commercial gillnet impact on wild UWR spring Chinook is a better understanding of when and how adult UWR fish migrate through the lower Columbia River mainstem and estuary. If they were temporally and spatially segregated from other stocks, there may be options to adjust gillnet seasons to avoid wild UWR fish. There is some timing information that can be inferred from hatchery stocks based on CWTs, but almost none on wild fish. The Willamette Falls fish counts provide some temporal resolution for wild fish for entry into the Willamette basin, but does not fill the gap for time of freshwater entry. A program of intensive radio tracking that tagged fish in the estuary, then tracked them all the way to their natal subbasins would allow managers to set fisheries to avoid or reduce impacts to sensitive stocks. PIT tagging could be used as well, but would not provide as much spatial and temporal resolution. In the lower Columbia River, these will always be mixed stock fisheries. Implementation of this kind of research could provide information that may allow for complete avoidance of listed stocks, rather than simply "reduced impacts" from mark-selective fisheries.

   Approach: TBD

8.4.3 Decisions, Key Questions, Metrics, and RME for Listing Factor C: Disease and Predation

<u>Decision</u>

Disease and predation related threats have been ameliorated such that they do not, and are not likely to limit attainment of the desired status of populations relative to viability criteria stated in the recovery Plan

<u>Key Disease and Predation Related Threat Questions</u>

1. Are there significant effects of disease on the observed abundance, productivity, spatial structure, and diversity of the natural-origin fish in this population?

2. Are there significant effects of predation by marine mammals, avian predators, or piscine predators on the observed abundance, productivity, spatial structure, and diversity of the natural-origin fish in this population?
3. Does the status of the *other* listing factors modify the absolute risk posed by the current and potential future status of *this* listing factor?

Measuring Disease and Predation Related Threats

Disease Related Metrics

None identified[102].

Predation Related Metrics

Annual assessments of the predation impact on UWR spring Chinook and winter steelhead by Caspian terns, double-crested cormorants, northern pikeminnow, and marine mammals in the estuary.

Evaluation Thresholds for Caspian Tern and Double-crested Cormorant Predation Metric

Pass – TBD
Fail – TBD

Analytical Procedures for Disease and Predation Related Threats

TBD

RME Needed to Assess Disease and Predation Related Threats

Status and Trend Monitoring

1. Monitoring of predation associated with anthropogenic alterations in the Columbia River Estuary and at Willamette Falls.

   Relevance: Needed to assess status and trend in predation rates.

   Approach: TBD

2. Sampling of natural populations in and near the hatcheries to determine the occurrence of pathogens that may cause disease in the natural population.

   Relevance: Needed to assess the extent to which pathogens and the diseases they cause exist in wild populations due to hatchery operations

   Approach: TBD

3. Watershed scale sampling for the occurrence of invasive aquatic species known to affect salmon and steelhead

   Relevance: Needed to assess the magnitude of impact of invasive aquatic species such as Chinese mitten crabs, non-native zooplankton (*Pseudodiaptomus inopinus*) on wild salmon and steelhead

   Approach: TBD

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[102] Although no specific benchmarks have been established for disease, monitoring for status and trend is needed and is described below.

Implementation and Compliance Monitoring

TBD

Effectiveness Monitoring

TBD

Critical Uncertainty Research

1. Conduct research to determine the impact of predation by out-of-ESU/DPS hatchery fish on natural origin salmon and steelhead in the subbasins, as well as the impact of non-native fish.

   Relevance: Predation by hatchery fish on natural origin spring Chinook and steelhead is listed as a secondary threat. WATER working groups are working on scoping this issue further.

   Approach: TBD

2. Compile existing invasive species information to determine which species are of threats to the health of wild salmon and steelhead

   Relevance: Needed to inform status and trend RME need #2.

   Approach: TBD

3. Research into the relationship between land management, parasitism, and the impacts of parasitism on the survival of salmon and steelhead.

   Relevance: New research conducted on Oregon Coast suggests that parasites may have a significant impact on the early ocean survival of coho salmon (Jacobson et al. 2008). Preliminary results of research being conducted by researchers at Oregon State University, Idaho State University, and ODFW suggest that the occurrence and infestation rate of certain salmonid parasites may be influenced by watershed conditions. The results of this research may be important to identifying improved land management practices and critical areas for implementing these land management practices.

   Approach: TBD

8.4.4 Decisions, Key Questions, Metrics, and RME for Listing Factor D: Adequacy of Existing Regulatory Mechanisms

Decision

Inadequacies of existing regulatory mechanisms have been addressed such that regulatory mechanisms do not, and likely will not, limit attainment of the desired status of populations relative to viability criteria stated in the Recovery Plan.

Key Questions Related to Adequacy of Existing Regulatory Mechanisms

1. Are the regulatory mechanisms in place adequate to address the limiting factors such that those limiting factors will not pose a significant threat in the future to the maintenance of the population at viability levels identified in the Recovery Plan?
2. Are the regulatory mechanisms in place adequate to prevent potential limiting factors that are not currently threats from becoming threats in the future?

Measuring Adequacy of Existing Regulatory Mechanisms

No measureable criteria have been established for this listing factor.

Analytical Procedures for Adequacy of Existing Regulatory Mechanisms

TBD

RME Needed to Assess the Adequacy of Existing Regulatory Mechanisms

Status and Trend Monitoring

None identified

Implementation and Compliance Monitoring

1. Implement a recovery plan tracking system that will be capable of recording whether local and State agencies are implementing regulatory actions needed to achieve the goals of this recovery Plan

   Relevance: Needed to provide information on whether or not regulatory actions are adequately implemented

   Approach: TBD

2. Develop a randomized sampling program to test whether permits issued under local and State regulatory actions designed to protect riparian and instream habitat are in compliance and that the provisions have been enforced.

   Relevance: Needed to assess permit compliance with riparian and instream habitat rules and regulations

   Approach: TBD

Effectiveness Monitoring

None identified.

Critical Uncertainty Research

1. Additional research is needed to continue to evaluate the adequacy of existing BMPs for forest practices, stormwater management, hydraulic permits, shoreline development, and other activities that affect the marine and aquatic areas.

   Relevance: Needed to assess if regulatory mechanisms in place are adequate to address the limiting factors such that those limiting factors will not pose a significant threat in the future to the maintenance of the population at viability levels identified in the recovery plan and whether regulatory mechanisms in place are adequate to prevent potential limiting factors that are not currently threats from becoming threats in the future

   Approach: TBD

8.4.5 Decisions, Key Questions, Metrics, and RME for Listing Factor E: Other Natural or Manmade Factors Affecting the Continued Existence of the ESU/DPS

Decisions

1. Other natural factors have been accounted for such that they do not limit attainment of the desired status of populations relative to viability criteria identified in the Recovery Plan.

2. Hatchery related threats have been ameliorated such that they do not, and will not, limit attainment of the desired status of populations relative to viability criteria stated in the Recovery Plan.

Key Listing Factor E Questions

1. Are there significant effects of natural factors not covered in listing factors A-C on the observed abundance, productivity, spatial structure, and diversity of the natural-origin fish in this population? Examples are:

   a. Ocean conditions
   b. Climate change
   c. Volcanic eruptions or earthquakes

2. Are there significant effects of hatchery operations on the observed abundance, productivity, spatial structure, and diversity of the natural-origin fish in this population? Specific hatchery related threats or limiting factors for which this question should be answered are:

   a. Broodstock collection
   b. Genetic introgression
   c. Domestication
   d. Disease
   e. Competition
   f. Predation
   g. Timing of egg take
   h. Rearing practices
   i. Release practices

3. Are there significant effects of any listing factors on ecosystem nutrient dynamics on the observed abundance, productivity, spatial structure, and diversity of the natural-origin fish in this population?

4. Does the status of the other listing factors modify the absolute risk posed by the current and potential future status of this listing factor?

Measuring Hatchery Related Threats

Hatchery Related Metrics

Annual assessments of the proportion of spawning fish that are of hatchery origin in each UWR population.

Evaluation Thresholds for Hatchery Related Metrics – Delisting

Pass – Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to that shown in Table 6-10.
Fail – Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average higher than that shown in the Table 6-10.

Evaluation Thresholds for Hatchery Related Metrics – Broad Sense Recovery

Pass – Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average less than or equal to 10%.
Fail – Over a nine-year period, the average percentage of the total number of spawners that are of hatchery origin is on average greater than 10%.

Analytical Procedures for Hatchery pHOS

As outlined in Chapter 6 (Recovery Scenarios) the pHOS rates represent a decrease of hatchery fish spawning with wild fish, that when combined with the targeted reductions in other threat categories, should lead to the long term viability of the ESU/DPS (i.e., delisting). To achieve broad sense recovery, which is achieved when all populations have a very low risk of extinction, pHOS should not exceed 10 percent in any population. While the target stray rates represent what is needed over the long term (100 years), in order to conduct more timely assessments of the status and trend in hatchery stray rates, a nine-year average was used for the analysis. This average will be calculated as a whole over nine years.

RME Needed to Assess Other Natural or Manmade Factors Affecting the Continued Existence of the ESU/DPS

Status and Trend Monitoring

1. Conduct annual assessments of the abundance, distribution, and origin of hatchery fish spawning in each UWR population.

   Relevance: Needed to assess compliance with hatchery pHOS goals, and to inform managers on sources of hatchery strays so they can take appropriate actions to limit their occurrence

   Approach: Examination for hatchery fin clips of carcasses recovered during spawning surveys. These samples will be supplemented where necessary and feasible with scale and/or otolith analyses, and capture of life fish when carcasses cannot be recovered (e.g., steelhead redd surveys).

2. Annual monitoring of the spatial and temporal distribution of juvenile fish released by hatchery programs

   Relevance: Needed to evaluate the ecological (e.g., competition, predation, disease) impacts of juvenile hatchery fish on wild populations

   Approach: TBD

3. All status and trend monitoring described for fish abundance, productivity, spatial structure, and diversity, and habitat conditions

   Relevance: Needed to provide foundation for critical uncertainty research related to Key Listing Factor E questions 1 and 4.

   Approach: See previous sections

Implementation and Compliance Monitoring

1. Provide monitoring and documentation that demonstrates that HGMPs have been implemented. This should include annual monitoring, recording, and reporting of the practices and protocols employed by hatcheries during fish culture operations.

   Relevance: Needed to assess whether or not required HGMPs have been adequately implemented

   Approach: Continue normal hatchery data collection and reporting.

Effectiveness Monitoring

See item #1 under status and trend monitoring.

Critical Uncertainty of Research

Implement recommendations of the Ad Hoc Supplementation Monitoring and Evaluation Workgroup (AHSWG 2008[103]) and develop a large scale treatment/reference design to evaluate long term trends in the abundance and productivity of supplemented populations.

Relevance: Needed to provide future guidance on best management practices for hatchery fish

Approach: See AHSWG (2008) recommendations.

1. Conduct research to determine the effects of the hatchery program on the reproductive fitness of natural origin Chinook salmon and steelhead.

   Rationale: Considerable uncertainty exists about the specific quantitative impacts that hatchery programs have on the reproductive fitness of natural origin fish. A more refined understanding is needed to insure that actions are designed to address key limiting factors and threats to the long term viability of UWR spring Chinook and winter steelhead populations.

   Approach: TBD

2. Conduct research on the impact of competition with non-native and hatchery origin fish on natural origin Chinook salmon and steelhead.

   Rationale: Competition with non-native and hatchery origin fish with natural origin salmon and steelhead was identified as an immerging issue by the Upper Willamette Recovery Planning Team. Better information is needed on the nature and magnitude of the threat in order to craft appropriate management responses.

   Approach: TBD

3. Conduct research that will provide information at the population area scale on:
   a. Potential patterns and impacts of future human population growth and climate change
   b. Identify critical areas and parameters for monitoring
   c. Recommendations for specific actions to address these impacts

   Rationale: While this Recovery Plan acknowledges that climate change and human population growth will likely have considerable negative impacts on the viability of UWR spring Chinook and winter steelhead populations in the future, it is unable to directly address these future threats because of a lack of population area specific information on the exact nature of these threats. Improved information on these future impacts will allow for enhanced efforts to address them.

   Approach: TBD

8.5 Additional RME Needs

8.5.1 Development of Integrated Monitoring Plans

Each year millions of dollars are spent to monitor the status and trend of natural resources and determine the effectiveness of restoration programs in the Pacific Northwest. While there is increasing consensus among regional Federal, private, State, and tribal organizations with respect to the need for integrated and standardized monitoring information, funding for these activities is stagnant or declining. As a result, there is an increasing need to improve the efficiency and cost effectiveness of monitoring programs.

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[103] http://www.cbfwa.org/csmep/web/documents/general/Documents/FINAL%20REPORT%20AHSWG.pdf

Although some monitoring questions are unique to particular agencies and organizations the need for comprehensive and efficient collection of information on metrics and indicators on all or certain aspects of the status and trend of fish, habitat, and watershed health is common to entities involved in monitoring in the Pacific Northwest. By applying well-coordinated monitoring approaches, technical and fiscal resources can be more effectively shared among interested parties, data can be shared, and resulting information can provide increased scientific credibility, cost-effectiveness in use of limited funds, and greater accountability to stakeholders.

Logical steps towards maximizing the cost -effectiveness of monitoring efforts include reducing duplication of effort and implementing programs that will allow data collected by multiple entities and programs to inform a larger regional monitoring framework. To do this, individual agencies and organizations will need to develop a survey design process that promotes data sharing with partner organizations, agree on a core set of monitoring questions with common indicators, coordinate activities, and develop common protocols and methods or ways to "crosswalk" data derived from disparate protocols.

8.5.2 Data Management and Access

Timely and efficient analysis and reporting on the RME described in this chapter will require improvements in the way that natural resource agencies manage and distribute information. In addition to building larger scale distributed data systems that can communicate between the various agencies involved in natural resources, the natural resource agencies should be given adequate resources to develop automated internal infrastructure to assess and evaluate their data and to report it through the various systems that require the information.

In addition to the need for a physical data management infrastructure that is adequate for managing and sharing information, in order to successfully use information collected by a variety of entities it is important that recovery entities strive to have elements of the PCSRF database dictionary within their databases and or/ adequate data mapping to be able to provide data to the database when NMFS is conducting a status review. Table 9-1 in this Plan and Appendix H will facilitate reporting of restoration efforts as defined in the PCSRF data dictionary so that the cumulative effects of restoration actions can be tracked and given proper credit.

Toward this end, Oregon will work with PNAMP, NMFS, and other entities to develop and implement a regional data management infrastructure. In addition, NMFS, ODFW, and other entities will establish a monitoring workgroup that will meet annually to review data management needs, and implementation.

Chapter 9: Implementation

The ability of this Plan to improve the status of the UWR Chinook salmon ESU and steelhead DPS depends on successful implementation. There are two distinct processes that must be initiated to implement this Plan. First, the actions identified in Chapter 7 must be implemented through a coordinated sequencing of effort with all of the various organizations and land managers/owners who have a responsibility and interest in the status of the UWR Chinook salmon ESU and steelhead DPS. Second, in order to evaluate the effectiveness of the actions that have been implemented, and to modify those actions if necessary, a functional adaptive management framework must be implemented with respect to the RME needs identified in Chapter 8, including review of the results of the RME activities. The successful implementation of these two processes will require significant funds and the coordinated work of ODFW, other State agencies, tribes, counties and other local governments, irrigation districts, agriculture and private forest land managers, USACE, NMFS, USFS, USBLM, other Federal agencies, municipalities, , utilities, other agencies, citizen groups, and individuals. The process to implement the actions identified in Chapter 7 must remain flexible, but this chapter identifies the key elements necessary for Plan action implementation and the process Oregon will use to adaptively manage the implementation of this Plan.

9.1 Action Details- Priority, Locations, Schedule, Costs, and Implementers

As noted in ESA section 4(f)(1)(A)(iii)), a recovery plan must contain "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." The implementation plan for a recovery plan serves as the guidance document that describes the time-specific implementation of actions for all programs. It also should contain benchmarks of expected milestones that allows for tracking progress of action implementation in the recovery plan. An ESA implementation plan identifies the following:

- recovery actions,
- priority for completing the actions,
- timeline and duration for completion of the actions,
- lead agency/entity to implement each action, and
- cost estimates for actions over a specified period of time.

Section 9.1.4 serves as the implementation plan for this Recovery Plan. It contains limiting factors and threats from Chapter 5, actions addressing the LFTs (with a provisional priority framework), priority locations, schedule, costs, and potential implementers. Note that many implementing entities (i.e., watershed councils, tribes, State agencies, Federal agencies) have been fully involved in developing the draft UWR Salmon and Steelhead Recovery Plan.

9.1.1 Strategic Guidance for Implementing Management Actions

<u>General Principles</u>

This Plan provides a strategic framework for prioritization of management actions to meet recovery goals for UWR Chinook and steelhead populations. The framework recognizes that improving the viability of key populations requires a comprehensive suite of actions that: 1) improve total life cycle survival, 2) remove significant life history bottlenecks, and 3) restore key life history traits. In addition, since multiple LFTs can fragment the salmonid life cycle, impair population viability, and disrupt ecosystem function, some LFTs will need to be addressed strategically and simultaneously. For example, high summer water temperature is a key threat to many UWR Chinook and steelhead populations, and one strategy is to implement actions that reduce heat input to streams. In rural areas one of the best ways to remove a heat source is to restore shade function by planting riparian areas with native trees. Over time these trees will also serve as physical structure to lessen other habitat LFTs. In urban and rural-residential areas, impervious surfaces may play a larger heat source role (IMST 2010), and "fixes" may be different than planting riparian trees. Potential *emerging* LFTs need to be recognized and managed in the present so they do not degrade viability of UWR Chinook and steelhead populations in the future. The successful application of these actions across multiple ecosystem and jurisdictional boundaries will require an adaptable approach that considers social, cultural, political, and economic constraints.

This Plan provides a comprehensive list of actions to be applied to all populations in the ESU/DPS, and actions in subbasins that focus on remediating LFTs for individual populations. Based on the LFT assessment, critical impediments to UWR ESU/DPS viability include the poor status of accessible freshwater habitat, the lack of adult access to good freshwater habitat, and insufficient juvenile migration survival from these habitats. Where remaining high quality habitat is accessible (below dams), it represents the remnant: 1) core reproduction areas, 2) source of expression and maintenance of some key life history types, and 3) migration link to other ecological zones where UWR salmonids can complete their lifecycle. Protecting these areas from further impacts will conserve the existing productive capacity, help temporarily buffer loss of productivity in other areas, and will provide a habitat foundation upon which to start restoring the normative natural ecological processes that create good freshwater habitat in other areas. In simplistic terms the order of importance for achieving freshwater and estuary habitat goals and staging effective strategies is to:

1. *Protect and conserve existing* high quality habitats that support current fish production capacity, and natural hydrologic processes that maintain these habitats and create new habitat. Protection of existing high quality habitat is one way to insure no net loss in habitat quality and is one element in the maintenance of normative ecological and hydrological processes. At the reach scale, many habitat quality objectives will likely be met through existing habitat protection and the associated natural recovery of riparian areas. At the subbasin scale, habitat protection efforts may require greater coordination and a more comprehensive vision for watershed objectives so that for example, habitat impacts in upstream areas do not compromise conservation efforts in dowstream areas. Related to this comprehensive vision of protecting high quality habitat, a coordinating forum should be in place that can prioritize and implement land acquisitions, conservation easements, cooperative agreements, and protective land designations.
2. *Enhance* impaired habitat reaches and natural processes that are currently supporting some productive capacity. Several restoration principles can be adopted on a case by case basis to enhance specific stream reaches. Improving reach function is accomplished through improved land use practices or changes in land use laws and ordinances. Improving natural habitat forming processes requires a more comprehensive approach that targets restoring healthy ecosystem function. Comprehensive land-use and water quality planning, and associated authorities are important tools by which human growth patterns and associated land use practices can be integrated into strategies to enhance watershed functions.
3. *Restore* habitat reaches, watersheds, and natural processes at those scales that *were historically* important but do not *currently* contribute to productive capacity of UWR Chinook and steelhead populations. The success of this strategy is enhanced when actions build from existing restoration efforts and incorporate a range of project types that address the many interrelated habitat impairments.

Other things being equal, implementing actions with the following attributes will lead to more efficient strategies and a greater chance of meeting recovery goals:

- Actions where certainty of implementation is high (such as many BiOp actions), or opportunity for success is high (rather than those of limited feasibility).
- Actions that likely produce a large (rather than small) and measurable improvement in viability attributes.

- Actions that support restoration of normative ecological processes rather than short-term substitutions for normative processes.
- Actions that integrate other land management, water quality, environmental management and recreational objectives as specified in fish management, conservation, recovery, TMDL implementation plans, or other plans developed with and supported by subbasin stakeholders (rather than those that are isolated, stand-alone efforts).
- Actions that have landowner/stakeholder support and that can generate increased participation.
- Actions that demonstrate cost effectiveness relative to alternative means of achieving the same objectives.
- Actions which have high degree of certainty in effectiveness and outcome.

Identifying Priorities

In an idealized society, funding for UWR Chinook salmon and steelhead conservation efforts would be available to implement all actions that are thought to eliminate every potential LFT. However, conservation funds compete with other societal priorities, and there is limit to how much our current society is willing and able to (although not explicitly defined) contribute to the recovery of UWR Chinook and steelhead. Nonetheless, it is important to prioritize, fund, and successfully implement the key actions that are believed to be crucial for ESU/DPS recovery. This will facilitate implementation because available funding follows budget cycles, authorizations, and economic conditions. Setting priorities of fish recovery actions for management and funding entities is difficult because the specific biological recovery needs of a species with a complex life cycle may not be aligned with the diverse policy strategies of these entities. Although priorities must be guided by the trial and error of the scientific method, it is ultimately a policy choice whether or how much a priority action should be implemented. For those entities that are implementing management actions intended to support the recovery of UWR Chinook and steelhead populations, this Plan provides information on how strategies and actions are prioritized from a biological recovery perspective in terms of level of importance (a VSP ranking; see column in Table 9-1) and how they are sequenced through time (via implementation schedule).

Immediate Actions

Most actions in this Plan are designed to improve VSP attributes and address listing factors over a longer time period, and some of these may have limited short-term effect. Yet, given many of the Chinook salmon populations are already at a high or very high risk of extinction, there is a need to implement now some actions that help avoid greater extinction risk until more substantial actions can begin improving VSP attributes. The following list summarizes some priority strategies and actions to be implemented immediately.

1. Increase wild fish spawning opportunities
   a. Reduce prespawn mortality.
      i. Flood Control/Hydro BiOp RPA Actions: To the fullest extent possible and until longer-term measures can be implemented, implement the interim WP BiOp RPA (NMFS 2008a) measures for: 1) emergency fish procedures and reporting, 2) water quality and quantity, 3) other flow modifications, 4) fish handling facilities and fish handling protocols.
      ii. Initiate/expand efforts to reduce harassment and poaching of adult Chinook salmon in summer holding pools. Mixture of enforcement and awareness promotion by OSP, USFS and BLM in public areas. Harassment and poaching are included as priority items during the OSP Coordinated Enforcement Program (CEP) process. OSP and ODFW staff are

currently investigating options and resources for more enforcement presence in the McKenzie

iii. Initiate/expand efforts to enforce, report water quality/ instream work violations
iv. Prioritize RME that can identify other *short-term solutions* to reduce pre-spawn mortality

b. Put more wild fish on the spawning grounds
   i. Continue to implement the new hatchery broodstock integration guidelines called for in this Plan
   ii. As opportunities exist, continue to outplant wild fish (collected at collection facilities) into remaining natural production areas

2. Increase juvenile fish survival
   a. Flood Control/Hydro BiOp RPA Actions: To the fullest extent possible, implement the interim WP BiOp RPA (NMFS 2008a) measures for emergency water quality and quantity, and other flow modifications, until longer term measures can be implemented.
   b. Where wild fish are outplanted above WP dams, implement spill measures and other interim downstream passage improvement measures. Improved operations are needed at Foster Dam and Cougar Dam. For Cougar Dam, a draft plan is in development for implementation in 2011.
   c. Where wild fish are outplanted below WP dams, increase incubation and early rearing success by adjusting dam flow releases to meet natural regimes for incubation temperature and flows.
   d. Accelerate the implementation timing for WP BiOp major milestones for Detroit Dam that will improve juvenile survival. These include advancing the timeline for structural temperature control and integrated structural downstream passage improvements, because there are limits to the benefits provide by interim flow modifications.
   e. Prior to the WP BiOp major milestones for the Middle Fork Willamette flood control/hydro structural modifications (and concurrent or prior to Head of Reservoir pilot studies), implement immediately the RME for survival effectiveness of reservoir drawdown in the Dexter/Lookout Point dam and reservoir complex. This will also require some immediate RME to guide infrastructure needs to make this work. Concurrent with this effort should be an evaluation of what kind of habitat reconstruction and restoration needs to occur in the old Lookout Point pool.
   f. Continue to outplant unmarked Chinook salmon above Fall Creek dam and assure subsequent juvenile survival with flow releases as outlined in the WP BiOp RPAs.
   g. Continue to implement FCRPS and Estuary Module actions for predation and flows in the Columbia River estuary.

Priority Population Subbasins

Although it is important to lower the extinction risk for all UWR populations to meet ESU/DPS viability criteria, some subbasins and populations represent relatively greater importance to ESU/DPS viability. In terms of prioritizing large scale habitat actions for improving subbasin conditions, this Recovery Plan applies the following population priorities:

1. McKenzie subbasin: core and genetic legacy Chinook population; good probability of recovery to desired status goal of Very Low Risk;
2. Clackamas subbasin: core Chinook population; good probability of recovery to desired status goal of Very Low Risk; actions would also benefit other listed ESUs (see LCR Plan) in the subbasin;
3. North Santiam subbasin: core Chinook and steelhead populations; large conservation gap to reach Chinook desired status goal of low risk; smaller gap to reach steelhead desired status goal of very low risk.
4. Middle Fork Willamette subbasin: core Chinook population; large conservation gap to reach desired status goal of low risk, but large recovery potential with re-introduction actions;

5. South Santiam subbasin: core steelhead population for desired status goal of very low risk, and non-core Chinook population for desired status goal of moderate risk;
6. Molalla subbasin: non-core Chinook population for desired status goal of high risk, and non-core steelhead population for desired status goal of very low risk;
7. Calapooia subbasin: non-core Chinook population for desired status goal of high risk, and non-core steelhead population for desired status goal of moderate risk.

Types of Priority Actions

This Recovery Plan applies the following principles to prioritize habitat actions:

First Priority:

- In high intrinsic potential (IP) areas for core extant populations: Actions that provide long-term protection and comprehensive restoration of habitat-forming processes.
- Flow, temperature, and physical habitat actions whose implementation can be coordinated to address several related habitat LFTs. These comprehensive suites of actions and coordination of projects are more likely to elicit a positive and detectable biological response and build long-term resilience and stability in habitat conditions. These actions are best implemented through coordinated Federal and State-wide regulatory Programs.
- Actions in locations which will result in protecting accessibility and connectivity to high quality habitat
- Actions that benefit populations which must achieve viability status (Low or Very Low extinction risk) for ESU/DPS viability status criteria.
- Actions that protect and enhance the viability of multiple Chinook salmon and steelhead populations, and multiple life history stages. Examples include actions in the mainstem Willamette River and Columbia River estuary that improve habitat quality, water quality, and flow regimes..
- Actions that support conservation of unique and rare functioning habitats, habitat diversity, life histories, and genetic attributes.
- Actions that address directly the key limiting factors and that contribute the most to closing the gap between current status and desired future status of priority populations.
- Actions that provide critical information needed for assessing success and making adaptive management decisions (RME actions).
- Actions which provide resiliency against climate change and human population growth.

Second priority:

- Actions that enhance the habitat conditions and restore natural ecological processes for core extant populations.
- Actions that enhance the viability of priority extant populations.
- Actions that are required to protect and enhance habitats for populations that are not critical for ESU/DPS viability.

Subbasin assessments are critical for providing direction to habitat strategies and projects. In a letter from NMFS letter to BPA regarding subbasin planning in 2002 there was the following passage: “As required by the Council's program, technically sound subbasin-level assessments need to be complete before credible subbasin-level management plans can be developed."[104] Also, as described earlier, assessments and plans should address the scale of the population or some analogous spatial scale.

One of the components in subbasin assessments and plans should be the identification of priority watersheds at finer scales (e.g., 6th field HUCs) for further assessment, planning, and action. In some cases, finer-scale assessments and plans may already be available and they should be used. In cases where finer scale watersheds are priorities for protection and restoration but do not have assessments and plans, those watersheds should be targeted for funding in next funding cycles and in other State and Federal watershed plan programs.

A significant step towards prioritizing the actions needed for this Plan was accomplished during the process of identifying and prioritizing the LFTs described in Chapter 5. Although ultimately all key and secondary threats and limiting factors must be addressed to achieve recovery goals, priority should be given to actions that directly address key threats and limiting factors if funds do not exist to implement all the actions simultaneously. Additional guidance on the prioritization of actions was outlined in Chapter 6, where desired status levels were defined, and where the Planning Team judged the relative importance of major actions within a scenario context. Chapter 6 described risk level goals for each UWR Chinook and steelhead population, and the scenarios scoped the relative mortality reductions needed in each of the major threat categories to close the gap between current and desired status. These projected improvements in mortality served as the side boards for determining where efforts and resources can best be allocated to achieve recovery.

9.1.2 Timeframe Considered for Schedule and Costs

The Plan is a 25-year Plan that guides conservation and recovery actions. The basis for the 25-year time frame is that actions are scheduled through this time period, as detailed in Section 9.1.3, though most actions are scheduled to be completed earlier than this. The 25-year period should not be confused with other timeframes mentioned in the Plan. These include a) the 100-year period used in population viability models to determine extinction risks (Chapter 4 and 6), b) the immediate, 5, 10, 15, or 20-year timeframes scheduled for many actions (Section 9.1.4), c) the major revision of the Plan called for after 12 years (Section 9.3), d) the required Implementation Schedules and priorities every three years (Section 9.3), or e) the ability to adaptively management specific strategies and actions on an as needed basis (Section 9.3).

In addition to 25 years being the maximum period for which actions were scheduled in Section 9.1.4, this period was also used to calculate costs for which there were recurring costs. These are also summarized in Section 9.1.3.

9.1.3 Cost Estimates

Costs were determined for many of the actions detailed in Chapter 7. Many of the actions are listed for both Chinook and steelhead. For purposes of estimating costs, we only counted costs associated with implementing new actions or increasing programs resulting from this Recovery Plan and avoided 'double counting'. Other costs, referred to as "baseline" costs, which are part of an entities base program or mission, or which are required by regulatory processes (e.g., FERC permits, TMDL implementation actions, BiOp actions), were not considered part of the recovery costs. In addition, although actions resulting from the Plan will potentially have a wide economic impact (e.g., modified land use), these "opportunistic" costs were also not considered as recovery costs since they are not direct costs to

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[104] http://www.nwcouncil.org/fw/subbasinplanning/admin/esa/esaletter.htm

implement actions, and a in-depth economic analysis would be required to assess these costs. However, it is advisable to more precisely understand or determine these wider economic benefits or detriments when recovery actions are implemented, or when seeking funding or policy changes.

The approach used to estimate costs varied based on the different threat categories, due to the nature of the actions required in these categories, and the ability to estimate the amount of actions necessary to achieve the desired statuses for populations. If there was not enough information to determine costs or make assumptions about the exact nature of the action or its quantity, cost estimates were deferred until implementation of that action (noted as "TBD" in Section 9.1.4). Table 9.1 follows the stratified organizational format of the action table in Chapter 7, and costs were subtotaled by for the strata. Some significant costs were not calculated (listed as "TBD" under the cost basis column; e.g., water conservation; easements and habitat protection) because not enough information to determine or make assumptions about unit costs, quantities, or action scope was available. In addition, costs to maintain capital projects were not included.

Costs were subtotaled across these categories and Plan elements:

1. Higher-level strategies/actions/processes to decrease general threats across ESU/DPS, or administer & support adaptive management/RME
    a. We considered many of these actions to be 'baseline' actions, therefore no costs were added for implementing these programs
    b. Some actions called for expansion of existing programs/initiatives or creation of new monitoring or other RME elements; costs were estimated based on expert opinion, a similar cost based on an Estuary Module action, or TBD.
2. Strategies and actions focused mainly on decreasing LFTs in the estuary
    a. We assume that the Estuary Module would be implemented for recovery of other Columbia Basin species, so we did not count the associated costs here. However, we did count one action because this Plan calls for expanded RME of the predation threat as it pertains to UWR populations.
3. Strategies and generalized actions focused on decreasing LFTs in freshwater
    a. It was difficult to assign costs to most of these actions. They are associated with large scale actions that are intended to improve freshwater habitat and water quality. They are mostly protective type strategies; with conservation easements, acquisitions, RME, and increased coordination among regulatory agencies.
4. Strategies and actions focused on decreasing LFTs in the mainstem Willamette River
    a. At present, there are no cost estimates for actions in this category because we don't have sufficient information yet. One of the actions in this section details a prioritization framework and better quantification and understanding of habitat restoration needs in the mainstem Willamette, specific to addressing LFTs; this should provide the needed information.
5. Strategies and actions focused on decreasing LFTs in subbasins
    a. Many, but not all, of the actions within subbasins are associated with implementing the WP BiOp, and are considered baseline costs.
    b. Clackamas Chinook action cost estimates were part of a larger cost estimate for other species in the OrLCR Plan. They are added into the costs for this Plan.
    c. Habitat restoration unit costs are established for many subbasin actions, based on the cost estimates developed for riparian buffers and instream habitat restoration in ODEQ (2010),

where costs were developed as part of TMDL implementation plans. At this time, the amount of acreage or miles of habitat that need to be improved is unknown, so quantity and total costs for some actions are TBD. Uncertainty of the survival effect of many of the habitat actions also makes estimation of the full extent of habitat action costs difficult This Plan calls for greater quantification and understanding of the amount of habitat restoration needed.

The total cost at the end of Table 9-1 ($265M) represents a minimal cost for recovery, given all of the costs and uncertainty which are not included in this Plan.

9.1.4 Action Table

Table 9-1 organizes actions identified in Chapter 7 to the LFTs and life stages and species to which they apply (from Chapter 5), their influence on VSP parameters, locations identified in the planning process where they should be implemented, time period or schedule within which they should be completed, the basis, unit cost, quantity, and total cost, and key entities that could be potential implementers. A total cost for all recovery actions is provided at the end of the table.

The schedule timeframe for individual actions was consistent with timeframes used in SLAM modeling to determine the effect of time lags for recovery actions on achievement of desired statuses. Although this modeling was based on conditions in tributaries below Willamette Falls, projections indicated that lags in tributary habitat improvement would have the most significant negative impact on extinction risk. However, the longer implementation period for most subbasin habitat actions (15 years) was used as the schedule due to the inability to actually immediately conduct the number of restoration activities needed. Thus, for subbasin habitat action schedules, as well as for all other threat categories, the number of years indicated for the action should not be considered the time when projects get implemented, but the time when all projects are implemented for that category. In most cases, action implementation should occur immediately. The three-year Implementation Schedules discussed below will determine more specific schedule timeframes, and site and action priorities. Several actions which are required for overarching coordination of Plan implementation are noted as immediate needs.

Table 9-1. Summary of actions identified in this Plan, species which benefit, locations, schedule, costs and potential implementers for conservation and recovery of UWR salmon and steelhead.

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
ESU: Higher-level Strategies/Actions/Processes to decrease General Threats across ESU/DPS, or Administer & Support Adaptive Management/RME											
ADM: Adaptive Management / Implementation / RME / Information and Education / Plan Support and Administration PHQ: Actions that decrease Physical Habitat Quality Limiting Factors WQH: Actions that decrease Water Quality / Water Quantity / Hydrograph Limiting Factors CPP: Actions that decrease Competition, Predation, and Population Trait Limiting Factors											
Listing Factor: N/A LFT: not specified	Strategy: not specified, via, Implementation Reporting, Funding to address issue of - Action Priorities	1 - ESU-ADM Priority: not specified	Develop three-year Implementation Schedules across and within populations for priority actions at a site-specific scale based on existing reach-specific habitat assessments, identified regulatory requirements, other threat reduction needs, research and monitoring needs, and adaptive management.	1. Where no reach-specific assessment or assessment information at the appropriate scale for specific limiting factors or threats, exist, find funding and conduct assessments in order to develop the Implementation Schedule.	TBD	immediate	TBD	---	---	---	ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: N/A LFT: not specified	Strategy: not specified , via, Funding/incentives to address issue of - Action Priorities	2 - ESU-ADM Priority: not specified	NMFS support coordination of organizations and funders who help provide and implement incentive programs for landowners.	1. Create incentives by matching funds for projects that meet recovery plan goals in high priority subbasins. 2. Recommend to entities that project solicitations and selection should reflect recovery plan priorities, and that the majority of funds should be directed to high priority locations and actions, while reserving funding for other appropriate actions to meet goals in all pop areas. 3. Actions resulting from funding should be reported in metrics that allow tracking of progress toward recovery goals (requires initial work with an implementation coordination entity to develop or identify appropriate metrics).	TBD	on-going	Baseline	---	---	N/A	ODFW, NMFS
Listing Factor: N/A LFT: not specified	Strategy: not specified , via, Implementation Reporting, Funding to address issue of - Adaptive Management	3 - ESU-ADM Priority: not specified	Complete annual reporting for this plan and coordinate adaptive management actions as necessary and indicated by monitoring and reporting results.	TBD	TBD	immediate	TBD	---	---	---	ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: N/A LFT: not specified	Strategy: not specified, via, Program Coordination to address issue of - Adaptive Management	4 - ESU-ADM Priority: not specified	Regularly update inventories and maps of instream habitat conditions, water quality, wetlands, and riparian conditions (including restoration projects) to more accurately capture current habitat conditions.	1. Incorporate information into 3-year implementation schedules and WS Council action plan processes to improve likelihood of achieving desired population status goals.	natal subbasins	within 15 yrs	TBD	---	---	---	ODFW, ODF, ODSL, ODEQ, ODA, USFS
Listing Factor: N/A LFT: not specified	Strategy: not specified, via, RME: Critical Uncertainty to address issue of - Population Designation	5 - ESU-ADM Priority: 3	Identify whether there are dependent and independent winter steelhead populations in West-side tributaries, and if appropriate, determine status goals for them.	1. ID threat reduction strategies and actions as appropriate.	West-Side tributaries	within 15 yrs	Baseline	---	---	---	ODFW, NMFS
Listing Factor: D LFT: not specified	Strategy: not specified, via, RME: Implementation / Compliance to address issue of - Adequacy	6 - ESU-ADM Priority: not specified	Assess adequacy of local regulatory programs to address listing threat factors within the federal ESA framework (e.g., 5-year status reviews, delisting decision, other).	TBD	TBD	within 5 yrs	Baseline	---	---	N/A	NMFS

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: D LFT: not specified	Strategy: not specified, via, Program Coordination to address issue of - Adequacy	7 - ESU-ADM Priority: not specified	Implement credible, science-based programs, policies and rules that contribute collectively to protect fish and water resources.	TBD	ESU-wide	within 15 yrs	TBD	---	---	---	ODFW, OWEB, ODF, ODSL, ODEQ, OWRD, ODLCD, ODOT, ODOGAMI, ODA, OPRD, USFS, Counties, Municipalities
Listing Factor: D LFT: not specified	Strategy: not specified, via, Program Coordination to address issue of - Adequacy	8 - ESU-ADM Priority: not specified	Provide adequate funding and staffing for existing programs to achieve their mandates.	TBD	TBD	on-going	Baseline	---	---	N/A	Legislature, other governing bodies
Listing Factor: D LFT: not specified	Strategy: not specified, via, Program Coordination /Reform to address issue of - Adequacy	9 - ESU-ADM Priority: not specified	Enhance efforts to enforce existing land use regulations, laws, and ordinances.	TBD	ESU-wide	within 15 yrs	TBD	---	---	---	ODFW, ODF, ODSL, ODEQ, ODLCD, ODOGAMI, ODA, Legislature, Counties, Metro, Municipalities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: E.1 LFT: 3a	Strategy: 13, via, RME to address issue of - Critical uncertainty in Hatchery Management	10 - ESU-ADM Priority: 1	Form a UWR-specific hatchery genetic technical group (HGTG; comprised of RIST and other experts) to conduct scientific review of current UWR hatchery programs and develop recommendations for achieving a conservation (reintroduction) hatchery program or suite of strategies that promotes and maintains a locally adapted population in the short term (until other LFT conditions are improved), and how to maintain VSP attributes and recovery goals while managing within a split basin management framework where there are hatchery mitigation goals in lower subbasins.	1. Implement the recommendations of that review and guidelines and how to identify and manage risk associated with psuedo-isolation.	TBD	immediate	TBD	---	---	---	ODFW, NMFS, USACE, technical experts
Listing Factor: E.2 (Climate Change) LFT: not specified	Strategy: not specified, via, RME to address issue of - Critical Uncertainty with Emerging Threat (Climate Change)	11 - ESU-ADM Priority: not specified	(similar to FCRPS RPA 7) To address forecasting and climate change/variability, hold annual forecast performance reviews and report on effectiveness of experimental or developing/emerging technologies.	TBD	TBD	within 25 yrs	Baseline	---	---	N/A	ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: E.2 (Climate Change) LFT: not specified	Strategy: not specified , via, RME to address issue of - Critical Uncertainty with Emerging Threat (Climate Change)	12 - ESU-ADM Priority: not specified	Conduct detailed climate change risk analysis for all populations and use this to help prioritize existing actions, or develop new ones. Incorporate these into the Implementation Schedule.	TBD	TBD	immediate	Expert Opinion (based on 50% of OrLCR Plan)	73500	2 yrs	$1,837,500	ODFW
Listing Factor: N/A LFT: not specified	Strategy: not specified , via, Funding RME to address issue of - Critical Uncertainty, Implementation / Compliance	13 - ESU-ADM Priority: not specified	Adequately fund and implement RME needed to answer critical uncertainties related to the assumptions under which the recovery plan was developed.	TBD	ESU-wide	within 15 yrs	TBD	---	---	---	ODFW, OWEB, Legislature, NMFS
Listing Factor: N/A LFT: not specified	Strategy: not specified , via, Program Development to address issue of - Implementation facilitation	14 - ESU-ADM Priority: not specified	Participate in the development of emerging ecosystem markets and ensure they are shaped to be consistent with recovery goals and actions.	TBD	ESU-wide	on-going	Baseline	---	---	N/A	ODFW, OWEB, ODF, ODSL, ODEQ, OWRD, ODLCD, ODOT, ODOGAMI, ODA, OPRD, OGNRO, NRCS, SWCD

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: N/A LFT: not specified	Strategy: not specified, via, Implementation Reporting, Funding of RME to address issue of - Implementation / Compliance	15 - ESU-ADM Priority: not specified	Fund development and maintenance of web-based data management and reporting, including tracking needs and accomplishments by entity through a map-based depiction of prioritized actions and locations.	TBD	TBD	within 5 yrs	Expert Opinion (based on 50% of OrLCR Plan)	$100,000 to develop; $50,000 / yr to maintain	25 yrs	$1,350,000	ODFW, NMFS
Listing Factor: All LFT: not specified	Strategy: not specified, via, Program Coordination /Development to address issue of - Implementation coordination	16 - ESU-ADM Priority: 1	ODFW and NMFS provide expanded staffing support as needed to develop and coordinate Recovery Plan Implementation schedules and actions with associated processes and programs (example: WP BiOP RME and other WP BiOP WATER teams).	TBD	ESU-wide	immediate	Expert Opinion (based on 50% of OrLCR Plan)	$50,000 / person / yr	25 yrs	$1,250,000	ODFW, OWEB, NMFS, Legislature

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: not specified	Strategy: not specified, via, Coordination to address issue of - Implementation facilitation	17 - ESU-ADM Priority: 2	State of Oregon agencies clearly describe the large wood goals in subbasins and potential ways to achieve these goals.	1. Develop joint ODF/ODFW/ODA/DSL team with deliverable recommendations. 2. Streamline the delivery of large wood to restoration sites. 2.1. designate coordinating entity and creating an online database of large wood that links entities that have large wood to offer with those in need of large wood for restoration projects. 2.2. develop storage/staging areas to enable storage of wood for future projects. 2.3. work with federal, state, and private forests and other land managers to ID ways to improve access to available large wood. 2.4. provide technical advice on what should be done with the large wood that is legally removed (e.g. during dredging operations). 2.5. streamline permitting process for large wood placement for streams not covered by Forest Practices Act.	within natal subbasins	within 15 yrs	Baseline	---	---	N/A	ODA, ODFW, OWEB, ODF, ODSL, ODOT, OPRD, USFS, USACE, WS Councils, Municipalities, Port of Portland

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: not specified	Strategy: not specified, via, Program Coordination to address issue of - Implementation facilitation	18 - ESU-ADM Priority: not specified	Provide liability protection for landowners that participate in restoration projects.	TBD	ESU-wide	within 15 yrs	TBD	---	---	---	Legislature, OR Attorney General
Listing Factor: A and D LFT: not specified	Strategy: not specified, via, Program Coordination to address issue of - Implementation facilitation	19 - ESU-ADM Priority: not specified	Explore land use strategies and regulations to reduce ownership fragmentation, including, but not limited to, acknowledging the importance of family owned forests and supporting actions that help sustain working family owned forests.	TBD	ESU-wide	within 15 yrs	TBD	---	---	---	ODF, ODLCD, Counties, Municipalities
Listing Factor: A LFT: not specified	Strategy: not specified, via, Program Development to address issue of - Implementation facilitation	20 - ESU-ADM Priority: not specified	Promote and provide technical support for volunteer efforts of private landowners and user groups to increase the amount of large wood in stream channels (e.g. site-specific riparian management plans, placement of large wood, reducing removal).	TBD	ESU-wide	within 5 yrs	Expert Opinion (based OrLCR Plan)	$90,000 / person / yr	6 staff; 15 yrs	$8,100,000	WS Councils, ODFW, OWEB, ODF, ODSL, ODEQ, NRCS, SWCD

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: not specified	Strategy: not specified , via, Program Development to address issue of - Implementation facilitation	21 - ESU-ADM Priority: not specified	Provide technical and financial assistance to landowners with property damage due to beavers, and provide incentives to landowners that want to manage their land to achieve the habitat benefits provided by beaver dams.	1. Develop agreements with landowners to establish benchmarks for amount of damage done by beavers. Once damage exceeded the benchmark, a management entity would remove or reduce the beaver population from the affected property.	TBD	within 15 yrs	TBD	---	---	---	ODFW, OWEB, ODA, NRCS, SWCD
Listing Factor: N/A LFT: not specified	Strategy: not specified , via, Funding/Coordination of RME to address issue of - Status/Trend	22 - ESU-ADM Priority: not specified	Expand monitoring of populations to track status and trends of VSP metrics and improve understanding of the composition of natural spawners (what type/pHOS? how many? where from? timing?), other life history information, and habitat.	1. Coordinate with WP BiOp monitoring.	within natal subbasins	expand on on-going	add WP BiOP	---	---	N/A	ODFW, WP Action Agencies
Listing Factor: N/A LFT: not specified	Strategy: not specified , via, Funding RME to address issue of - Status/Trend	23 - ESU-ADM Priority: not specified	Determine funding sources and strategies to implement monitoring needed to track progress towards achieving recovery goals.	TBD	TBD	immediate	Expert Opinion (based on 50% of OrLCR Plan)	$141,633/yr	25 yrs	$3,540,825	ODFW, USACE, BPA, NMFS, LCREP, OWEB, Legislature

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: N/A LFT: not specified	Strategy: not specified, via, I&E to address issue of - Outreach	24 - ESU-ADM Priority: not specified	Provide education on the goals of recovery plans, what is needed to achieve these goals, and how citizens can contribute.	1. Develop subbasin "guidebooks" on Plan priorities, habitat needs, BMP's, and networking/program resources.	ESU-wide	ongoing	TBD	---	---	---	NOAA, ODFW, OWEB, ODF, ODSL, ODEQ, OWRD, ODLCD, ODOT, ODOGAMI, ODA, OPRD, WS Councils
Listing Factor: N/A LFT: not specified	Strategy: not specified, via, I&E to address issue of - Outreach	25 - ESU-ADM Priority: 2	Continue to fund outreach efforts that have known success in educating and engaging landowners.	1. Evaluate effectiveness of such events as Coffee Klatches, Oregon Small Woodland Owner's Howdy Neighbor, and other venues. 1.1. fund and develop materials as appropriate	ESU-wide	on-going	TBD	---	---	---	OWEB, ODF
Listing Factor: N/A LFT: not specified	Strategy: not specified, via, Fund I&E to address issue of - Outreach	26 - ESU-ADM Priority: not specified	Fund OSU Extension Service to provide Riparian Function Workshops for all Oregon Plan participants to improve success rate of volunteer projects.	TBD	ESU-wide	within 15 yrs	TBD	---	---	---	OWEB, OSU Extension Service
Listing Factor: N/A LFT: not specified	Strategy: not specified, via, I&E to address issue of - Outreach	27 - ESU-ADM Priority: not specified	Provide education and outreach to contractors, developers, and resource owners.	1. Include education and outreach materials on the benefit of beaver dams to ecosystem function in general and specifically to juvenile rearing habitat.	ESU-wide	on-going	Baseline	---	---	N/A	WS Councils, ODFW, ODF, ODSL, ODEQ, OWRD, SWCD, Metro

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: N/A LFT: not specified	Strategy: not specified , via, I&E to address issue of - Outreach	28 - ESU-ADM Priority: 3	Implement and expand upon I&E to use demonstration sites where landowners can view the results of various types of restoration efforts. Focus on demonstration sites where the landowner was active in the restoration activity.	TBD	0	within 15 yrs	TBD	---	---	---	WS Councils, ODFW, ODF, ODSL, ODEQ, OWRD, SWCD, Metro
Listing Factor: E.1 LFT: not specified	Strategy: 13 , via, RME to address issue of - Hatchery Management	29 - ESU-ADM Priority: not specified	Mark all hatchery fish to support harvest management goals and hatchery managements goals.	TBD	PNW region	on-going	Baseline	---	---	N/A	ODFW, NMFS
Listing Factor: E.1 LFT: not specified	Strategy: 13 , via, RME to address issue of - Hatchery Management	30 - ESU-ADM Priority: 1	Support tagging efforts and different tagging types and technologies from each hatchery release to meet RME and management goals.	1. Use to ID hatchery origin of strays, evaluate rearing and/or release techniques, survival studies, etc.	natal subbasins	on-going	Baseline	---	---	N/A	ODFW, NMFS, USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	31 - ESU-PHQ Priority: 1	Develop proactive framework to minimize future development impacts in key reaches and floodplains.	1. Evaluate/synthesize existing regulatory urbanization provisions/projections relative to salmonid needs. 2: Review/revise as needed the county/municipal codes regarding development in floodplain, riparian, and meander zones. 2.1. revise/develop regulations that ensure no impact from future new development and re-development in the 100-year floodplain (including stormwater, wetlands, vegetation, etc.). 2.2. develop model code ordinances accounting for stormwater management and floodplain development 3. Prohibit new revetments, dikes, levees, and floodwalls in 100-year floodplain unless they will not increase flood volume, size, and/or intensity. 3.1. develop regulations ensuring new/existing levees and floodwalls are vegetated 4. Lessen future impact of floodplain development on listed species. 4.1.encourage Willamette Basin communities to incorporate into their land-use planning, new elements of the guidance developed	ESU-wide	within 15 yrs	TBD	---	---	---	ODLCD, ODAGAMI, ODSL, ODEQ, ODA, ODF, ODFW, Legislature, FEMA, USACE, USFS, NGO's, PUC's, Counties, Cities, WS Councils

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				under the FEMA BiOp for the Puget Sound Region (NMFS 2008h) that calls for revising how FEMA administers discretionary elements of the National Flood Insurance Program. These include: 4.1.1. update floodplain and channel migration maps, ensure revisions consider the effects on listed species, and encourage communities to identify and evaluate the risk of flooding behind 100 year levees based on anticipated future conditions and the cumulative effects from future land-use change 4.1.2. strengthen FEMA Model Floodplain Ordinance for minimum criteria to include prohibiting development in the 100 yr floodplain, and consider revisions in how permitting authorities demonstrate how proposed development in a FEMA-designated floodway does not adversely affect water quality water quantity, flood volumes, flood velocities, spawning substrate, and/or floodplain refugia for listed, salmonids. 4.1.3. change the Community Rating System (CRS) stormwater credits and criteria and associated policies and programs to a) create an incentive for the use of Low Impact Development methods that							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				decrease the need for added stormwater treatment, b) increase the number of CRS points available for preservation of open space where listed species are present, giving additional credits for areas to be preserved that have been identified in NMFS adopted salmon recovery plans, c) award points for retaining and increasing riparian functions, particularly in areas where riparian function has been identified as a limiting factor for listed ESUs by the limiting factors analysis in salmon recovery plans, d) reduce the number of points available for structural changes that reduce the amount of functional floodplain, such as levees, berms, floodwalls, diversions, and storm sewer improvements, including enclosing open channels; see additional CRS changes in NMFS (2008h). 5. Provide FEMA funding for land acquisition in 100-year floodplain; prioritize acquisitions based on recovery plan priority areas. 6. Implement other appropriate incentives and educational programs.							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	32 - ESU-PHQ Priority: 1	Where habitat restoration targets exist and progress toward them is tracked, but where targets are not being met in the first five years of implementation.	1. Develop population-specific strategies (e.g., funding, incentives, outreach, regulations, etc...) to meet those targets, with priority given to populations where desired status is low or very low extinction risk.	ESU-wide	within 15 yrs	Baseline	---	---	N/A	ODLCD, Counties, Municipalities
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	33 - ESU-PHQ Priority: 1	DSL will work within existing mandates to facilitate implementing habitat actions in this Plan.	1. Continue efforts to streamline the permitting process for fish habitat and wetland restoration projects. 2. Strengthen interagency coordination on projects that may impact natural ecological processes. 3. For restoration projects identified in this Recovery Plan, facilitate efforts to implement the action. 4. Require avoidance/minimization of impacts to State waters in priority areas identified in this Recovery Plan. 5. Work with landowners to design projects that avoid/minimize impacts to	ESU-wide	On-going	Baseline	---	---	N/A	ODSL, ODLCD, Counties, Municipalities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				wetlands and other State waters. 6. Provide education/technical assistance to implementers of voluntary wetland restoration, creation, or enhancement projects. 7. Explore opportunities to target compensatory mitigation towards areas with high intrinsic potential for UWR Chinook and steelhead and/or have been identified as priority areas for restoration in watershed assessments and this recovery plan. 8. Explore conservation easements for state-owned lands with high ESU/DPS recovery value.							
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	34 - ESU-PHQ Priority: 2	(similar to CRE-15) Reduce the introduction and spread of invasive plants by implementing education and monitoring projects that increase public awareness of exotic plant species and proper stewardship techniques.	1. Enforce existing laws. 2. Inventory exotic plant species infestations and develop a GIS layer with detailed metadata files. 2.1. Implement projects to address exotic plant infestations on public and private lands 2.2. Monitor infestation sites	ESU-wide	within 25 yrs	Estuary Module: $12,500,000 For FW: 50% of EM: $6,250,000	---	---	$6,250,000	ODFW, ODA, USACE, BPA, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	35 - ESU-PHQ Priority: not specified	Provide enhanced incentives for habitat restoration work.	1. Reward and assist landowners doing the 'extra' work needed to achieve recovery goals. 2. Develop an equitable system of recognition and rewards for regulated and non-regulated landowners.	CM: Eagle Crk; Clear Crk; mainstem Clackamas R -- R Mill Dam to Goose Crk; mainstem Clackamas R -- R Mill Dam to Abernathy Crk; Deep Crk; Johnson Cr	within 15 yrs	TBD	---	---	---	WS Councils, ODFW, OWEB, ODF, ODSL, ODA, OGNRO, Legislature, NMFS, NRCS, Counties, Municipalities, Metro
Listing Factor: A LFT: 7a Key Factor: none Secondary Factor: CHS eggs-alevins STW eggs-alevins	Strategy: 1, 2, 3, 4, 5, 6, 8 , via, Land Use Management to address issue of - Physical Habitat Quality	36 - ESU-PHQ Priority: not specified	Conduct sediment source analysis and then implement actions to reduce sediment from identified sources.	TBD	TBD	within 15 yrs	TBD	---	---	---	ODEQ, ODA

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	37 - ESU-PHQ Priority: 2	Improve coordination and streamlining of habitat restoration efforts for a) impaired instream habitat complexity, b) floodplain processes and access to off-channel habitat by increasing lateral movement with improvements in revetments, dikes and floodwalls, and c) riparian conditions	1. Make this a task of the ESU Coordination Team. 1.1 identify specific coordination and implementation barriers and entities involved 1.2 work with entities to improve coordination and project streamlining	TBD	within 15 yrs	TBD	---	---	---	USACE, FEMA, USFS, NRCS,ODFW, ODF, ODSL, ODA, SWCD, Counties, Municipalities, WS Councils

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9h Key Factor: multiple populations and life stages; refer to population-specific LFT tables in CH 5 Secondary Factor: multiple populations and life stages; refer to population-specific LFT tables in CH 5	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	38 - ESU-WQH Priority: 1	(similar to CRE-20 but expanded to include FW areas) Reduce non-point sourcing and loading of nutrients and pesticides from land use activities in subbasin streams, the Willamette River mainstem, and estuary. Implement pesticide and fertilizer BMP's to reduce loading.	1. Implement "toxin" TMDL WQMP's and identify other problem areas by reviewing findings of the USGS Water Quality Study in the Willamette Basin (Wentz et al. 1998), and the ODEQ WQ Assessment Report 2009. 2. Reduce existing impervious development on stormwater runoff effects with parking lot, rooftop, roadside treatments such as vegetation, swales, infiltration, retention, etc. 2.1. evaluate effectiveness of existing pesticide and fertilizer Agriculture BMP's and implement resulting recommendations on county and municipal lands to help reduce input from runoff to aquatic habitat. 2.2. revise and update IPM for PDX owned property. 2.3 incentivize BMP's. 2.4 increase funding for education and outreach programs targeted to professional and leisure agricultural activities and hold workshops and partner with OSU extension on education/outreach. 3. Promote development and use of natural treatment systems in urban areas. 3.1. reduce discharge of wastewater by expanding use of recycled water.	EST: see estuary Module FW: need review of WQ plans and reports	within 25 yrs (See EM and other basin WQ plans)	Estuary Module: $12,500,000 For FW: TBD	---	---	For FW: TBD	ODEQ, ODOT, ODA, SWCD, FHWA, NRCS, ACWA, LCREP, Counties, private landowners, local governments, municipalities, OSU extension

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				Identify and remove institutional barriers that diminish recycled water use opportunities. 4. Implement actions associated with SB 737 that promote effective toxic reduction programs that improve water quality for fish, such as legacy pesticide return programs or improved erosion control program. 5. Implement Oregon Association of Nurseries agricultural land spraying proposals that describe better management practices for grass seed farming in Polk, Marion, Clackamas, and Yamhill counties.							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9i Key Factor: multiple populations and life stages; refer to population-specific LFT tables in CH 5 Secondary Factor: multiple populations and life stages; refer to population-specific LFT tables in CH 5	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	39 - ESU-WQH Priority: 2	Support RME that evaluates cumulative and interactive effects of contaminants on different salmonid life stages.	TBD	ESU-wide	within 15 yrs	TBD	---	---	---	ODEQ, City of Portland, Port of Portland

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9i	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	40 - ESU-WQH Priority: 1	(CRE-23) Implement stormwater BMP's in cities, towns, and rural areas.	1. Monitor stormwater outputs to measure treatment compliance with existing local and state regulations throughout the basin. 1.1. develop a network of monitoring sites and establish a data repository that includes data collected by permittees. 2. Establish a fund source for regulatory agencies and local governments to use when insufficient resources are available to (a) access best available science, (b) develop standards beyond requirements, or (c) adequately enforce regulations. 3. Evaluate adequacy of best management practices and update as needed. 4. Provide incentives for low impact development practices.	ESU-wide	within 25 yrs	Estuary Module: $19,500,000 For FW: Assume same as EM	---	---	$19,500,000	ODEQ, ODOT, FHWA, LCREP, Municipalities
Listing Factor: A LFT: 9i	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	41 - ESU-WQH Priority: 2	Provide more technical resources and incentives to small (non-metropolitan) communities so they have the infrastructure to better manage runoff from impervious surfaces.	TBD	ESU-wide	within 15 yrs	TBD	---	---	---	WS Councils, OWEB, ODEQ, small municipalities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9i	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	42 - ESU-WQH Priority: 1	(similar to CRE-21) Identify and reduce terrestrially and marine-based industrial, commercial, and public sources of pollutants.	1. Identify sources, loads, and pathways of point and non-point pollutants and take enforcement actions where needed. 2. Provide cost-share incentives for National Pollution Discharge Elimination System (NPDES) permit holders to upgrade effluent above their permit requirements. 3. Study and establish threshold treatment standards for pharmaceuticals and other unregulated substance discharges; update existing NPDES permits to reflect the new standards. 4. Provide grants and low-cost loans to permit holders required to treat effluent to standards established in the study above.	mostly in Estuary	within 25 yrs	Estuary Module: $46,000,000 FW: TBD	---	---	---	ODEQ, LCREP, Counties, Municipalities
Listing Factor: A LFT: 9i	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	43 - ESU-WQH Priority: not specified	Develop, update, implement stormwater management plans for urban areas and roads.	1. Revise and update stormwater management manuals.	PDX Metro: Pork Chop and Portland-wide CM: Deep Crk; Johnson Crk; all areas within urban growth boundaries	within 15 yrs	FW: # Plans TBD Expert Opinion (from OrLCR Plan) 1yr-$90,000	$90,000 / yr /each plan	---	---	WS Councils, ODFW, ODEQ, NRCS, SWCD, Counties, Municipalities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9, not specific	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	44 - ESU-WQH Priority: not specified	Develop recommendations for land management scenarios that address hydrograph changes due to climate change, impervious surfaces, and other factors that result in altered water runoff.	TBD	ESU-wide	within 15 yrs	Baseline	---	---	N/A	ODFW, ODF, OWRD, ODLCD, ODA, Counties, Municipalities
Listing Factor: A LFT: 9, not specific	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	45 - ESU-WQH Priority: not specified	Develop options for water banking and implement.	TBD	ESU-wide	within 15 yrs	TBD	---	---	---	OWRD, Counties, Municipalities
Listing Factor: E.1 LFT: 4a, 4c juveniles	Strategy: 7, 10, 13 , via, Hatchery Management to address issue of - Competition	46 - ESU-CPP Priority: 1	Continue the release of hatchery fish as smolts to reduce competition and predation with wild fish in tributaries and estuaries.	TBD	mostly in natal subbasins	on-going	Baseline	---	---	N/A	ODFW, (WDFW)

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: E.1 LFT: 4a, 4c juveniles	Strategy: 7, 10, 13 , via, Hatchery Management to address issue of - Competition	47 - ESU-CPP Priority: not specified	Investigate the feasibility of coordinated release timing among hatcheries, to reduce the numbers of out-migrating hatchery fish in-river at any one time.	TBD	mostly in natal subbasins	within 15 yrs	Baseline	---	---	N/A	ODFW, NMFS, (WDFW)
Listing Factor: E.1 LFT: 4a, 4c juveniles	Strategy: 7, 10, 13 , via, Hatchery Management to address issue of - Competition	48 - ESU-CPP Priority: not specified	Eliminate/reduce/shift hatchery programs to decrease mainstem and estuary competition and predation and reduce straying of hatchery fish onto natural spawning grounds	1. Investigate and/or implement hatchery release reductions or program shifts to lower river terminal areas. 1.1 include out-of-ESU programs and programs with surplus hatchery fish returns which are not harvested.	PNW region	on-going	Baseline	---	---	N/A	ODFW, NMFS, (WDFW)
								Sub Total		**$41,828,325**	

EST: Strategies and Actions focused mainly on decreasing LFT's in the Estuary											
ALL: All populations											
Listing Factor: A LFT: 5a Key Factor: CHS and STW parr-smolt Secondary Factor:	Strategy: 5, 7, 9 , via, Flood Control / Hydropower & Land Use Management to address issue of - Physical Habitat Quality	50 - EST-ALL Priority: 1	(see Estuary Module actions that improve habitat and flows)	TBD	Estuary	within 25 yrs (See EM)	see other EM costs	---	---	N/A	see other EM entities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
none											
Listing Factor: A LFT: 5b Key Factor: CHS and STW parr-smolt Secondary Factor: none	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	51 - EST-ALL Priority: 1	(see Estuary Module actions that improve flows)	TBD	Estuary	within 25 yrs (See EM)	see other EM costs	---	---	N/A	see other EM entities
Listing Factor: A LFT: 8a Key Factor: CHS parr smolt	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat	52 - EST-ALL Priority: 2	Work with various stakeholders to restore and develop complex habitat for rearing juveniles in the lower Willamette River.	TBD	Estuary	within 15 yrs	Baseline	---	---	N/A	ODFW, NMFS, Counties, City of Portland, Metro, Municipalities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
STW smolt Secondary Factor: none	Quality										
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	53 - EST-ALL Priority: not specified	Protect remaining shallow water habitat in estuary, especially high quality habitat in the lower estuary.	TBD	Estuary	within 15 yrs	Baseline	---	---	N/A	LCREP
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	54 - EST-ALL Priority: not specified	Coordinate with the Portland Harbor Natural Resource Damage Assessment and Restoration process to implement restoration in the Lower Willamette River that will aid salmon and steelhead recovery.	TBD	lower Willamette River	within 15 yrs	Baseline	---	---	N/A	ODFW, NMFS, Counties, City of Portland, Metro

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	55 - EST-ALL Priority: not specified	Identify and acquire conservation flexibility in key salmonid habitats in the estuary.	TBD	lower Willamette River	within 15 yrs	TBD	---	---	---	ODFW, OWEB, City of Portland, Metro
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	56 - EST-ALL Priority: not specified	Expand upon current efforts to remove invasive plant species where they inhibit natural or deliberate re-establishment of native riparian plant species.	TBD	lower Willamette River	within 15 yrs	TBD	---	---	---	City of Portland, Metro
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	57 - EST-ALL Priority: not specified	Acquire conservation management flexibility for priority sites in the PDX Metro area.	1. Fund and implement the Gray2Green program.	Pork Chop and Portland-wide	within 15 yrs	TBD	---	---	---	City of Portland

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	58 - EST-ALL Priority: not specified	As feasible, re-establish connection between Columbia Slough and Columbia River to improve flushing and water quality.	TBD	Columbia Slough	within 15 yrs	TBD	---	---	---	ODFW
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	59 - EST-ALL Priority: not specified	(CRE-10) Breach or lower dikes and levees to establish or improve access to off-channel habitats.	1. Breach or lower the elevation of dikes and levees to create and/or restore tidal marshes, shallow-water habitats, and tide channels. 2. Vegetate dikes and levees. 3. Remove tide gates to improve the hydrology between wetlands and the channel and to provide juvenile fish with physical access to off-channel habitat. 3.1. use a habitat connectivity index to prioritize projects. 4. Upgrade tide gates or perched culverts where (a) no other options exist, (b) upgraded structures can provide appropriate access for juveniles, and (c) ecosystem function would be improved over current conditions.	Estuary	within 25 yrs (See EM)	Estuary Module $75,000,000	---	---	N/A	ODFW, ODSL, USACE, BPA, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	60 - EST-ALL Priority: not specified	(similar to CRE-11) Reduce the square footage of over-water structures in the estuary and lower mainstem Willamette River. Where possible, modify remaining overwater structures to provide beneficial habitat.	1. Inventory over-water structures in the estuary and develop a GIS layer with detailed metadata files. 2. Initiate a planning process to evaluate existing and new over-water structures for their economic, ecological, and recreational value. 3. Remove or modify over-water structures to provide beneficial habitats. 4. Establish criteria for new permit applications to consider the cumulative impacts of over-water structures in the estuary. 5. Conduct research, monitoring, and evaluation of modifications that can be made to overwater structures to assess ecological benefits.	Estuary, Lower Willamette Mainstem	within 25 yrs (See EM)	Estuary Module $5,800,000	---	---	N/A	ODSL, ODLCD, USACE, LCREP, ODSL, City of Portland

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	61 - EST-ALL Priority: not specified	(CRE-6) Reduce the export of sand and gravels via dredge operations by using dredged materials beneficially.	1. Establish a forum to develop a region-wide sediment plan for the estuary and littoral cell. 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. 3. Dispose of dredged materials using techniques identified through the demonstration projects and region-wide planning.	Estuary	within 25 yrs (See EM)	Estuary Module $6,000,000	---	---	N/A	ODSL, NMFS, USACE, LCREP, Port of Portland
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	62 - EST-ALL Priority: not specified	(CRE-12) Reduce the effects of vessel wake stranding in the estuary.	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. 2. Implement projects identified in analysis above that are likely to result in the reduction of ship wake stranding events. 3. Use existing and new research results documenting stranding by ship wakes to estimate juvenile mortality throughout the estuary. Modeling could	Estuary	within 25 yrs (See EM)	Estuary Module $13,000,000	---	---	N/A	ODFW, USACE, LCREP, Port of Portland

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				use newly emerging Light Detection and Ranging (LIDAR) satellite imagery to conduct analyses.							
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	63 - EST-ALL Priority: not specified	(CRE-7) Reduce entrainment and habitat effects resulting from main and side-channel dredge activities and ship ballast intake in the estuary.	1. Identify and evaluate dredge operation techniques designed to reduce entrainment and other habitat effects. 2. Initiate demonstration projects designed to test and evaluate dredge operations. 3. Implement best management techniques for dredging. 4. Study the effects of entrainment of juvenile salmonids from ship ballast water intake. 5. Implement a demonstration project to evaluate the feasibility of reducing entrainment of juvenile salmonids from ship ballast intake.	Estuary	within 25 yrs (See EM)	Estuary Module $4,500,000	---	---	N/A	ODFW, ODSL, USACE, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	64 - EST-ALL Priority: not specified	(CRE-8) Remove or modify pilings and pile dikes when removal or modification would benefit juvenile salmonids and improve ecosystem health.	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. 2. Implement demonstration projects designed to test working hypotheses and guide future program priorities. 3. Remove or modify priority pilings and pile dikes. 4. Monitor the physical and biological effects of pile dike removal and modification.	Estuary	within 25 yrs (See EM)	Estuary Module $27,250,000	---	---	N/A	ODFW, ODSL, USACE, BPA, LCREP
Listing Factor: A LFT: 7h Key Factor: CHS parr-smolt; STW smolt Secondary Factor: none	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	65 - EST-ALL Priority: not specified	(CRE-5) Study and mitigate the effects of entrapment of fine sediment in Columbia basin reservoirs, to improve nourishment of the littoral cell.	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, littoral cell erosion and accretion, and habitat availability. 2. Develop region-wide sediment plan for the estuary and littoral cell to address salmonid habitat-forming processes. 3. Implement projects recommended in the plan to mitigate the effects of sediment entrapment.	Estuary, FCRPS	within 25 yrs (See EM)	Estuary Module $8,000,000	---	---	N/A	USACE, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 10f Key Factor: CHS parr-smolt; STW smolt Secondary Factor: none	Strategy: 1, 5, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	66 - EST-ALL Priority: not specified	(CRE-3) Establish minimum instream flows for the lower Columbia River mainstem that would help prevent further degradation of the ecosystem.	1. Explore technical options and develop policy recommendations on instream flows. 1.1. implement instream flow regulations in accordance with the policy recommendations.	Estuary	within 25 yrs (See EM)	Estuary Module $44,500,000	---	---	N/A	USACE, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 10f	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	67 - EST-ALL Priority: not specified	(CRE-4) Adjust the timing, magnitude and frequency of 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, plume, and littoral cell.	1. Conduct a flood study to determine the risks and feasibility of returning to more normative flows in the estuary. 2. Conduct a study to determine the habitat effects of increasing the magnitude and frequency of flows (i.e., how much access of river to off-channel habitats would increase). 3. Conduct additional studies to determine the extent of other constraints (international treaties, system-wide fish management objectives, and power management). 4. Make policy recommendations to action agencies on flow (consider beneficial estuary flows, flood management, power generation, irrigation, water supply, fish management, and other interests). 5. Implement modified estuary flow regime (all reaches and plume) annually in concert with other interests (including hydroelectric, flood control, water withdrawals.	Estuary, FCRPS	within 25 yrs (See EM)	Estuary Module $10,000,000	---	---	N/A	USACE, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 10f	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	68 - EST-ALL Priority: not specified	(FCRPS RPA's 10-13) Columbia River Treaty and non-Treaty storage management, agreements, and coordination.	TBD	FCRPS	within 25 yrs	Baseline	---	---	N/A	USACE
Listing Factor: A LFT: 10f	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	69 - EST-ALL Priority: not specified	(FCRPS RPA 14) Manage flow during dry years to maintain and improve habitat conditions for ESA-listed species.	TBD	FCRPS	within 25 yrs	Baseline	---	---	N/A	USACE
Listing Factor: A LFT: 10f	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	70 - EST-ALL Priority: not specified	(OrLCR Plan) Draft storage reservoirs to meet lower Columbia summer flow and velocity equivalent objectives on a seasonal and weekly basis.	TBD	FCRPS	within 25 yrs	Baseline	---	---	N/A	USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 10f	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	71 - EST-ALL Priority: not specified	(OrLCR Plan) Operate reservoirs at rule curves and seek additional flow augmentation volumes from Snake River and Canadian reservoirs to better meet spring and summer flow and velocity objectives.	TBD	FCRPS	within 25 yrs	Baseline	---	---	N/A	USACE
Listing Factor: A LFT: 10f	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	72 - EST-ALL Priority: not specified	(FCRPS RPA 4) Operate the FCRPS storage projects for flow management to aid anadromous fish.	TBD	FCRPS	within 25 yrs	Baseline	---	---	N/A	USACE
Listing Factor: A LFT: 10f	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	73 - EST-ALL Priority: not specified	(FCRPS RPA 5) Operate the FCRPS run-of-river mainstem lower Columbia River and Snake River projects to minimize water travel time through the lower Columbia River to aid in juvenile fish passage.	TBD	FCRPS	within 25 yrs	Baseline	---	---	N/A	USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 10f	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	74 - EST-ALL Priority: not specified	(FCRPS RPA 6) In-season water management via water management plans and by the Regional Forum.	TBD	FCRPS	within 25 yrs	Baseline	---	---	N/A	USACE
Listing Factor: A LFT: 9i Key Factor: multiple populations and life stages; refer to population-specific LFT tables in CH 5 Secondary Factor: multiple populations and life stages; refer to	Strategy: 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	75 - EST-ALL Priority: not specified	(CRE-22) Monitor the estuary for contaminants and restore or mitigate contaminated sites.	1. Implement contamination monitoring recommendations identified in the Federal Columbia River Estuary Research, Monitoring, and Evaluation Program (Pacific Northwest National Laboratory 2006). 2. Develop criteria/process for evaluating contaminated estuarine sites to establish their restoration potential. 3. Develop an integrated multi-state funding strategy to address contamination cleanup in the estuary from non-identifiable upstream sources. 4. Restore those contaminated estuarine sites that will yield the greatest ecological and economic benefits.	mostly in Estuary	within 25 yrs (See EM)	Estuary Module $60,500,000	---	---	N/A	ODFW, ODEQ, NMFS, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
population-specific LFT tables in CH 5											
Listing Factor: A LFT: 9i	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	76 - EST-ALL Priority: not specified	Incorporate and coordinate Recovery Plan actions in lower Willamette River with habitat mitigation actions to be funded with the Port of Portland Superfund Clean-Up.	TBD	lower Willamette River	within 15 yrs	Baseline	---	---	N/A	Trustee Council
Listing Factor: A LFT: 9j Key Factor: none Secondary Factor: CHS parr-smolt STW smolt	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	77 - EST-ALL Priority: not specified	(CRE-2) Operate Columbia basin hydrosystem to reduce the effects of reservoir surface heating, or conduct mitigation measures.	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. 2. Implement hydrosystem operational changes to reduce temperature effects; if no change is possible, mitigate effects by restoring tributary riparian areas.	FCRPS	within 25 yrs (See EM)	Estuary Module $20,000,000	---	---	N/A	USACE, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: not specified	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	78 - EST-ALL Priority: not specified	(FCRPS RPA's 8-9) Manage the FCRPS for operations and fish emergencies.	TBD	FCRPS	within 25 yrs	Baseline	---	---	N/A	USACE
Listing Factor: A, C, and D LFT: undefined for UWR ESU's	Strategy: not specified , via, not defined to address issue of - Other species	79 - EST-ALL Priority: 2	(CRE-19) Prevent new introductions of aquatic invertebrates and reduce the effects of existing infestations.	1. Assemble existing technical information on introduced aquatic invertebrates in the estuary and develop a plan for managing existing infestations and preventing new infestations. 1.1. implement recommendations from the plan above for managing existing and preventing new infestations	Estuary	within 25 yrs (See EM)	Estuary Module: $3,000,000	---	---	N/A	ODFW, ODA, LCREP, Port of Portland
Listing Factor: E.1 LFT: 4a Key Factor: none Secondary Factor: CHS parr-smolt	Strategy: 7, 10, 13 , via, Hatchery Management RME to address issue of - Competition	80 - EST-ALL Priority: not specified	To decrease juvenile salmonid competition in the estuary and straying by adults, investigate other hatchery release strategies, reductions, or program shifts to lower river terminal areas for commercial and/or sport harvest, including those from out-of-ESU and especially if there are surplus hatchery fish which are not harvested.	1. Evaluate impact of competition with hatchery origin fish on wild salmon and steelhead in the estuary. 1.1. develop a plan to reduce competition with hatchery origin fish if evaluation shows significant impact	Estuary	within 25 yrs (See EM)	Estuary Module	---	---	N/A	ODFW, NMFS, WDFW, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
STW smolt											
Listing Factor: E.1 LFT: 4 (similar to 4a, but from shad introductions, not hatchery fish) not ID'd as key or secondary threat to UWR populations	Strategy: 10 , via, Other RME to address issue of - Competition	81 - EST-ALL Priority: not specified	(similar to CRE-18) Reduce competition with non-native fish in the estuary.	1. Organize existing technical information about shad and other invasive fishes and identify data gaps and potential control methods. 1.1. implement demonstration projects to evaluate effective management methods 1.2. implement shad population management techniques 1.3. monitor and evaluate shad management techniques	Estuary	within 25 yrs (See EM)	Estuary Module: $5,500,000	---	---	N/A	ODFW, NMFS, WDFW, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A and C.1 LFT: 6b Key: CHS fry-winter parr (SSA) Secondary: uncertainty of CHS and STW juveniles in other areas	Strategy: 11, via, Land Use / Introductions to address issue of - Predation	82 - EST-ALL Priority: not specified	(similar to CRE-13) Manage pikeminnow and non-native piscivorous fishes to reduce predation on juvenile salmonids.	1. Initiate status/trend monitoring of abundance and occurrence of pikeminnow, centrarchids, walleye, and channel catfish. 2. Initiate diet studies to resolve critical uncertainty regarding impact on UWR Chinook and steelhead. 2.1. as needed and feasible, implement habitat actions that are known to prevent population growth of these fish or that reduce their interactions with juvenile salmonids. 3. Increase the northern pikeminnow bounty program in the estuary. 3.1. evaluate relative effectiveness of expanding this program to other areas 4. Promote liberal sport fish regulations of exotic game fish where co-occurring with UWR Chinook and steelhead.	Estuary	within 25 yrs (See EM)	Estuary Module: $13,000,000 FW (assume same as EM)	---	---	13000000	ODFW, USACE, LCREP, Metro
Listing Factor: A and C.1 LFT: 6e Key: CHS parr-	Strategy: 11, via, Land Use Management to address issue of - Predation	83 - EST-ALL Priority: not specified	(CRE-16) Implement projects to redistribute part of the Caspian tern colony currently nesting on East Sand Island.	1. Enhance or create tern nesting habitat at alternative sites in Washington, Oregon, and California. 1.1. reduce tern nesting habitat on East Sand Island to 1 to 1.5 acres 1.1.1. monitor the regional tern population	Estuary	within 25 yrs (See EM)	Estuary Module $10,000,000	---	---	N/A	ODFW, USACE, USFWS, LCREP

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
smolt STW smolt Secondary: none											
Listing Factor: A and C.1 LFT: 6e Key: CHS parr-smolt STW smolt Secondary: none	Strategy: 11, via, Land Use Management to address issue of - Predation	84 - EST-ALL Priority: not specified	(CRE-17) Implement projects to reduce double-crested cormorant habitats and encourage dispersal to other locations.	1. Identify, assess, and evaluate methods of reducing double-crested cormorant abundance numbers. 1.1. implement demonstration projects resulting from assessment above (i.e., decoys and audio playback methods) 1.1. 1. implement projects resulting in reduced predation by cormorants	Estuary	within 25 yrs (See EM)	Estuary Module: $10,500,000	---	---	N/A	ODFW, USACE, USFWS, LCREP
Listing Factor: B.1 LFT: 11a adults	Strategy: 12, via, Harvest Management to address issue of - Population Traits	85 - EST-CM Priority: not specified	Shift mainstem commercial spring Chinook harvest to terminal areas during low return years (de facto "sliding scale").	TBD	Estuary	within 20 yrs	Baseline	---	---	N/A	ODFW, WDFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: B.1 LFT: 11a adults	Strategy: 12 , via, Harvest Management to address issue of - Population Traits	86 - EST-CM Priority: not specified	Monitor harvest levels in all fishery areas for all species (direct and indirect mortality).	TBD	Estuary	on-going; modify as needed	Baseline	---	---	N/A	ODFW, PFMC, WDFW
								Sub Total		**$13,000,000**	

FW: Strategies and Generalized Actions focused on decreasing LFT's in Freshwater											
ALL: All populations											
Listing Factor: A.2 LFT: 2b Key Factor: CHS adult STW adult Secondary Factor: none LFT: 10b Key Factor: none	Strategy: 4, 8 , via, Land Use Management to address issue of - Habitat access & Water Quality / Quantity / Hydrograph	87 - FW-ALL Priority: 3	Improve the maintenance of fish screens and fish passage structures.	1. Implement best fish management practices on all new hydropower generating facilities on water diversion canal(s) developed in the future in Willamette subbasins. 2. ID if any current diversion projects need better maintenance or additions. 2.1. prioritize diversions for improvements and screen diversions appropriately to reduce fish mortality	ESU-wide	on-going	Baseline	---	---	N/A	owners, ODFW, local governments, NMFS, Water Control Districts

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Secondary Factor: CHS summer parr STW fry-summer parr											

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS parr-smolt Secondary Factor: CHS parr-smolt STW parr-smolt	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	88 - FW-ALL Priority: 1	(similar to CRE-1 but for FW areas above Willamette Falls) Protect and restore riparian areas on private lands throughout the rearing zones for Chinook and steelhead that are not covered by of riparian actions in TMDL implementation plans.	1. Assure adequate regulations are in place to protect existing high quality habitat and eliminate/reduce and fully mitigate, impacts of future development (within cities, rural-residential, and rural-agriculture zones). 1.1. encourage and provide incentives for local, state, and federal regulatory entities to maintain and restore key riparian areas 1.2. enforce consistent riparian area protections throughout the Willamette River basin. 2. Actively purchase key 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 (a) are intact, or (b) are degraded but have good restoration potential. 3. Maintain and restore ecological benefits in key riparian areas with active management. 3.1. manage vegetation on dikes and levees to enhance ecological function and adding shoreline/instream complexity for juvenile salmonids	above Willamette Falls	within 25 yrs	Assume same estimate as in Estuary Module: $38,000,000	---	---	38000000	ODA, ODFW, OWEB, ODLCD, ODSL, ODEQ, USACE, SWCD, BPA, LCREP, Counties, Municipalities, WS Councils

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS parr-smolt Secondary Factor: CHS parr-smolt STW parr-smolt	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	89 - FW-ALL Priority: 1	(similar to CRE-9 but for FW areas above Willamette Falls) Protect remaining high-quality off-channel habitat from degradation and restore degraded areas with high intrinsic potential for high quality habitat.	1. Encourage and provide resources for local, state, and federal regulatory entities to maintain, improve (where needed), and consistently enforce habitat protections throughout the Willamette River basin. 2. Actively purchase off-channel habitats in urban and rural settings that (a) cannot be effectively protected through regulation, (b) are degraded but have good restoration potential, or (c) are highly degraded but could benefit from long-term restoration solutions. 3. Restore degraded off-channel habitats with high intrinsic potential for increasing habitat quality.	above Willamette Falls	within 25 yrs	Assume same estimate as in Estuary Module: $68,000,000	---	---	68000000	WS Councils, ODFW, OWEB, ODSL, ODLCD, NMFS, USACE, SWCD, BPA, LCREP, Counties, Municipalities
Listing Factor: A LFT: 8a Key Factor: CHS parr-smolt Secondary Factor: CHS parr-smolt	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	90 - FW-ALL Priority: 1	Where population-level habitat monitoring indicates statistically-significant temporal degradation of key habitat features, encourage new/revised regulatory measures for key habitat feature(s) that eliminate further degradation, protect existing high quality areas, and allow long-term/"passive" restoration in other areas.	TBD	TBD	within 15 yrs	Baseline	---	---	N/A	NRCS, FSA, USACE, OWEB, ODFW, OPRD, SWCD, ODLCD, land trusts, NGOs, private landowners, WS Councils, Counties, Municipalities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
STW parr-smolt											
Listing Factor: A LFT: 8a Key Factor: CHS parr-smolt Secondary Factor: CHS parr-smolt STW parr-smolt	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	91 - FW-ALL Priority: 1	Restore substrate recruitment to the mainstem Willamette River from tributary areas using a combination of peak flows and substrate supplementation.	1. Provide substrate supplementation downstream of dams and for the revetments blocking recruitment.	above Willamette Falls	within 15 yrs	TBD	---	---	---	USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	92 - FW-ALL Priority: 1	Maintain and restore the best available spawning, rearing, and migration habitats, and acquire reaches or management flexibility where ecological processes (function) and salmonid historical habitat are impaired or lost.	1. Available Habitat: ID existing core spawning and rearing areas, and ID reaches in these areas that are vulnerable to existing point source or upslope activities through modification to riparian structure/function or water quality impacts. 1.1. Maintain/protect them by evaluating/implementing/enforcing existing land management guidelines and protections, to result in no net loss in structure/function and water quality 2. Impaired Habitat: improve long-term productivity and capacity by improving reach processes, and link restored reaches to regain some subbasin function 2.1. ID low-cost, high-return restoration areas of the lower subbasin floodplains. Use USACE floodplain restoration study or other plans to help ID candidate reaches 2.2. ID reach-specific opportunities and treatments to improve riparian structure/function to a reference condition 2.3. Develop cooperative agreements, habitat conservation plan and/or habitat improvement projects with land owners to protect and improve fish	SS: Hamilton, Crabtree, McDowell, Wiley, Thomas Creeks CA: Adults and early juveniles: upper subbasin older juveniles: subbasin-wide MO: Majority of current CHS spawning occurs on the mainstem Molalla from Glen Avon Bridge to Henry Creek Falls. The most concentrated spawning occurs from Gawley Creek to Henry Creek (Schmidt et al. 2008).	within 15 yrs	TBD	---	---	---	USFS, USBLM, NRCS, FSA, USACE, OWEB, ODFW, SWCD, McKenzie River Trust, NGOs, local governments, WS Councils, Molalla River Watch, Molalla River Stewards, private landowners

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				habitat. 2.4. improve instream habitat structure (LWD, etc), in situ water quality, and fish access to these areas 2.5. ID criteria by which reach improvement is prioritized at a subbasin scale to serve as building blocks for restoring and linking processes (see reach slice approach developed by the PNW Ecosystem Research Consortium and related framework developed by the WATER HTT) 3. Lost Habitat: Regain habitat capacity through conservation easements and reach acquisitions.							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	93 - FW-ALL Priority: 1	Remediate adverse effects of rural roads and trails on aquatic physical habitat quality and water quality. Develop funding methods for retiring USFS/USBLM roads and private roads.	1. On federal lands in upper subbasins, support implementation of the USFS Willamette NF Legacy Roads and Trails and other Federal watershed restoration efforts to improve or decommission roads on Federal forest and private roads. 2. On non-federal lands, support implementation of projects that reduce negative effects of rural roads 2.1. ID these projects or problem areas through WS Action Plans (see provisional MF Willamette WS Council Action Plan) and other resources related to roads and public ordinances. 3. ID and fix constraints with out-of-jurisdiction domain areas where known problems exist.	upper reaches in natal subbasins	within 15 yrs	TBD	---	---	---	USFS, USBLM, WS Councils, counties, private landowners, local governments
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Second	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	94 - FW-ALL Priority: 3	When reviewing new permits or activities, apply road and bridge fluvial performance standards that allow free passage of fish, sediment, and flows.	TBD	ESU-wide	on-going	baseline	---	---	N/A	ODOT, USBLM, USFS, OWEB, SWCD, NRCS, FHWA, County Road departments

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
ary Factor: CHS fry-summer parr											
Listing Factor: A LFT: 8a Key Factor: CHS winter parr STW winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	95 - FW-ALL Priority: 3	Work with landowners on alternatives to installing riprap along the banks of rivers and streams.	1.1. Provide technical support to WS Councils to explore different approaches.	CA: Middle reaches of the Calapooia River, Brush Creek and Courtney Creek sub-basins	within 15 yrs	TBD	---	---	---	WS Councils, OWEB

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr STW winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	96 - FW-ALL Priority: 2	Protect and conserve rare and unique functioning habitats that may exert different selective pressures on segments of the population, thereby increasing genetic and life history diversity.	TBD	NS: Opal Creek Wilderness area is protected, focus action elsewhere (Little N. Santiam)	within 15 yrs	TBD	---	---	---	USFS, private landowners, Watershed councils, OWEB, ODFW, SWCD
Listing Factor: A LFT: 8a Key Factor: CHS winter parr STW winter parr Secondary Factor: CHS fry-summer	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	97 - FW-ALL Priority: not specified	Support WS Councils to conduct watershed education and outreach activities for landowners and in schools.	1. Set up demonstration sites where landowners can view the results of various types of restoration efforts. 1.1. emphasize importance of channel meandering for maintaining healthy habitat for fish. 1.2. focus on demonstration sites where the landowner was active in the restoration activity. 1.3. involve middle school and high school classes in monitoring and restoration efforts within the watershed 2: Provide elementary teachers with printed materials about the ecology of fish and wildlife in the	Long term I&E	within 15 yrs	TBD	---	---	---	WS Councils, OWEB

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
parr				watershed. 2.1. help arrange field trips to interesting sites along the river, streams, and wetlands.							
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	98 - FW-ALL Priority: not specified	Develop methodology to assess and identify, and then protect, stream reaches and population strongholds which will be resilient/resistant to climate change impacts.	TBD	TBD	within 15 yrs	TBD	---	---	---	WS Councils, ODFW, ODSL, Counties, Municipalities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	99 - FW-ALL Priority: not specified	ID and restore priority non-functioning wetlands.	1. ID strategic wetland areas that would contribute to connectivity and hyporheic processes. 2. Encourage farmers and other landowners to restore or release non-functioning wetlands on marginally productive land through the use of wetland banks or other measures.	Best suited for former wetland areas located near remnant/residual stream channels so that hyporheic processes are linked	within 15 yrs	TBD	---	---	---	NRCS, WS Councils, private landowners
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	100 - FW-ALL Priority: 1	Restore natural riparian communities and their function.	1. ID impacted areas that are strategic reaches where expansion of riparian width would increase stream shading. 2. Plant riparian forest at historic confluences. 2.1. determine feasible riparian width and work with constituents to develop specific riparian vegetation actions 3. Look for further improvements of riparian habitat and increase instream habitat complexity over the long-term through forest management on federal and private lands.	TBD	within 15 yrs	ODEQ Rpt (2010 Table 4) For Ag DMA	$4700 / acre (w/o fence) $1100 / (w fence)	TBD	---	USFS, USBLM, NRCS, FSA, SWCD, counties, local governments, WS Councils, private landowners

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 10b Key Factor: none Secondary Factor: CHS summer parr STW fry-summer parr	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	101 - FW-ALL Priority: not specified	Support local governments to meet future water allocation and treatment needs, and stormwater management to minimize human population growth impacts on listed Chinook and steelhead.	1. (In coordination with supporting actions for LFT 9a) Focus future water rights on the mainstem Willamette, not on the over-allocated subbasins. 2. (In coordination with supporting actions for LFT 9a) Municipalities and counties develop and adopt BMP's and incentives for water conservation such as gray water use, low flow appliances, etc. 3. Improve stormwater management in municipalities and counties by enacting guidance developed by the Stormwater Solutions Team convened by the Oregon Environmental Council, or other tools.	undetermined	within 15 yrs	TBD	---	---	---	ODEQ, ODFW, local governments, private landowners
Listing Factor: A LFT: 10b Key Factor: none Secondary Factor: CHS summer parr STW fry-	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	102 - FW-ALL Priority: 1	(In coordination with supporting actions for LFT 9a) Increase protection and implementation of appropriate instream flows for UWR salmonids by a) removing barriers to coordinating with relevant management agencies on water withdrawals, b) encouraging BMP's to conserve water and reduce pollution loads, and c) not issuing anymore water rights within subbasins.	1. Designate instream flow targets at the mouth of the tributaries (or other appropriate passage bottleneck) to ensure sufficient water is available for fish. 1.1. Planning Team subgroup to ID priority or problem reaches and future designation of target flows 1.2. ID process to get designation established 1.3. Encourage RME of flow needs for various life stages 2. OWRD to pass rules to enforce and protect stored	needs to be established; maybe be reach specific MO: Mouth of Molalla to confluence of NF Molalla, Trout Creek. Major water right holders include Cities of Molalla, Silverton, Canby CO: With	within 15 yrs	TBD	---	---	---	NRCS, OWRD, USBOR, USACE, ODFW, SWCD, Molalla Water Division, Freshwater Trust, Santiam Water Control District, Cities of Salem/Stayton, WS

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
summer parr				water released from USACE reservoirs for fish purposes, and ensure that water is not diverted by water users with natural water rights or by illegal water use. 3. Monitor diversions in real-time to ensure OWRD can enforce instream flows. 4. Restrict use of water rights during work windows to reduce impacts on spawners and rearing juveniles. 5. Revise integrated flow management or water diversion plan to ensure sufficient water remains instream for fish during critical periods. Plan should define coordination among the management agencies and users (USACE, USBOR, OWRD, ODFW, irrigation districts, and local water users). 5.1. ensure future USBOR water service contracts do not reduce instream flow protections. 5.2. USBOR water service contracts should allow for interruption of service during low water years to protect instream flows 5.3. release additional flows from storage dams to meet USBOR water service contracts while still meeting instream flows	CWC's partnership in the Willamette Model Watershed Program, focus of outreach and monitoring is Courtney Creek sub-basin and middle Calapooia River NS: Lower mainstem side channels (dewatered when juveniles are present)						Councils, landowners

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				5.4. for non USBOR contracts, OWRD stop issuing new live flow rights 6. OWRD to complete conversion of Minimum Perennial Streamflows for stored water (in USACE/USBOR reservoirs) to instream water rights in NS, SSA, MK, and MF subbasins. 7. Promote voluntary flow restoration options with incentives. 7.1. ID "low hanging fruit" in problem areas 7.2. ID who will promote or develop these incentives 8. Purchase or lease strategic water rights							
Listing Factor: A LFT: 9a,c, h, i	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	103 - FW-ALL Priority: 1	Work with ODEQ TMDL program (DMA Implementation Plans) to improve temperature and other water quality standards, to prioritize implementation on high priority CHS and STW areas. Also incorporate other reporting to ID other priority reaches for LFT's 9h and 9i (toxins and nutrients)	1. See other LFT's 9a and 9c (Temperature). 2. for toxins and nutrients, review relevant TMDL's for 303 (d) reaches, and other WQ reports to ID priority reaches. 3. for toxins, review Pesticides BiOp for effects, and USGS reports on reaches with high levels.	All subbasins and Mainstem Willamette	within TMDL WQMP timelines	TBD	---	---	---	ODEQ, Designated Management Agencies (DMA's)

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9a Key Factor: CHS summer parr for MO, NS, SSA, CA Secondary Factor: STW fry-summer parr; CHS summer parr for CM, MK, MF	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	104 - FW-ALL Priority: not specified	Implement RME of headwater springs to investigate the concern that they may be drying up due to land management practices.	TBD	All subbasins	within 15 yrs	TBD	---	---	---	ODFW, OWRD
Listing Factor: A LFT: 9a	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	105 - FW-ALL Priority: not specified	Inventory and protect seeps, springs, and other coldwater sources.	TBD	natal subbasins	within 15 yrs	TBD	---	---	---	WS Councils, ODFW, USFS, USBLM

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9, not specific	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	106 - FW-ALL Priority: not specified	Limit future in-river and groundwater withdrawals so that they do not impede achievement of recovery goals.	TBD	ESU-wide	on-going	Baseline	---	---	N/A	OWRD, Legislature, Counties, Municipalities
								Sub Total		**$106,000,000**	

OC: Strategies and Actions focused on decreasing LFT's in the Ocean

ALL: All populations

Listing Factor: B.1 LFT: 11a, 11g adults	Strategy: 12 , via, Harvest Management to address issue of - Population Traits	107 - OC-ALL Priority: not specified	Implement the new Pacific Salmon Treaty (reduce ocean fisheries on Chinook).	TBD	ocean	on-going	Baseline	---	---	N/A	ODFW, PSC, WDFW
Listing Factor: B.1 LFT: 11a, 11g adults	Strategy: 12 , via, Harvest Management to address issue of - Population Traits	108 - OC-ALL Priority: not specified	Support mark-selective ocean fisheries when a new PST is negotiated in 10 years.	TBD	ocean	~2017	Baseline	---	---	N/A	ODFW, NMFS, WDFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
								Sub Total		$0	

MST: Strategies and Actions focused on decreasing LFT's in the Mainstem Willamette River **MST/SUB: Flow actions focused in subbasins to decrease LFT's in the Mainstem Willamette River for multiple populations**
ALL: All populations AMO: Actions for populations upstream of the Molalla River (NS, SSA, CA, MK, MF)

Listing Factor: A.2 LFT: 2n Key Factor: none Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat access	109 - MST-ALL Priority: 3	Maintain safe passage of juvenile and adult Chinook and steelhead at Willamette Falls.	1. Ensure conditions for passage of juvenile and adult fish will remain adequate so that passage mortality does not become a concern in the future.	Sullivan Plant	on-going	Baseline	---	---	N/A	PGE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS parr-smolt Secondary Factor: CHS parr-smolt STW parr-smolt	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	110 - MST-ALL Priority: 2	Look for opportunities to remove unnecessary revetments or increasing setbacks in the Mainstem Willamette and in subbasins. Minimize new ones in the future.	1. For sites that were funded or placed by the USACE, the WP BiOp Action Agencies conduct assessment to identify high priority revetment through WP BiOp RPA 7.4, and fund restoration at these sites. 2. Replace revetment segments with bioengineering and natural features such as vegetation, and large wood structures.	First Priority: Modify or remove up to 43 miles of USACE revetments and with more natural bank treatments containing large wood, riparian vegetation, and altered slope. Other priority areas for revetment removal or setback are: 1) Eugene-Corvallis, 2) Albany-Salem.	within 15 yrs	TBD	---	---	---	USACE, NOAA, ODLCD, cities, counties, private landowners
Listing Factor: A LFT: 10c Key Factor: STW adult Secondary Factor: none	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	111 - MST-ALL Priority: 1	Release flows from WP dams and other storage dams to meet flow targets in mainstem Willamette River for rearing and migration.	1. Ensure sufficient spring flows to allow downstream migration of juveniles, including those in side channels. 2. Coordinate annual flow operations with ODFW and NMFS and other parties to optimize project operations for UWR ESU's, while meeting flood control and other mandatory project purposes.	At Albany: USACE proposed minimum and maximum flow objectives At Salem: USACE proposed minimum and maximum flow objectives	within 15 yrs	TBD	---	---	---	USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS parr-smolt Secondary Factor: CHS parr-smolt STW parr-smolt	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	112 - MST-AMO Priority: 1	Restore structure and function to strategic natural riparian reaches in the mainstem Willamette River	1. Develop a prioritization framework and ID strategic reaches specific to UWR salmonids by collating work from several sources, including the Willamette River Basin Planning Atlas (Hulse et al. 2002), TNC Synthesis Mapping, Willamette Subbasin Plan (WRI 2004), WATER HTT selection process, ODEQ 303 (d) reaches, and others. Some principles include: - integrating project "reach" objectives to larger basin scale objectives - focus on spatial strategies that link coldwater refugia for salmonids. - look for opportunities to reconnect river reaches with remnant gravel pits. - increase short term aquatic habitat complexity by increasing the amount of large wood, boulders, or other structures at appropriate locations. - increase long term channel complexity, floodplain connectivity, and flood storage capacity by restoring riparian structure and function, and reconnecting main channel to side-channels, wetlands and other floodplain features. - look for reaches where there is opportunities to expand riparian width and increase shading in areas	Emphasize restoration in already identified "candidate focal areas" by the Willamette Planning Atlas in the area around Harrisburg (e.g. Harkens Lake).	Within 15 yrs	TBD	---	---	---	NRCS, FSA, USACE, OWEB, ODFW, OPRD, SWCD, land trusts, WR, NGOs, Private landowners, WS Councils

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				that have been degraded by human actions. - focus on areas where other plans or programs have implementation plans (example: TMDL plans) that would also ameliorate efforts to restore function. 2. Plant, protect, maintain, and restore native riparian vegetation using combination of setbacks, easements, or acquisition. 3. Provide meaningful financial incentives to landowners for riparian protection (e.g. increase Oregon's tax credit)							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	113 - MST-AMO Priority: 1	Increase overall channel complexity, floodplain connectivity, and flood storage to the mainstem Willamette River to increase and improve salmonid rearing and migration habitat.	1. Work with regional federal and state entities to resolve larger issues related to future increased channel meandering and the factors that inhibit it now. 2. Use multiple analytical and planning sources to ID the type of projects and reaches where restoration success will be high. 3. Find opportunities within these priority reaches with willing landowners by offering economic incentives, conservation easements, leases, or acquisition. Provide technical assistance and analyses on risks and benefits to landowners.	Priority reaches in Willamette Planning Atlas for increasing channel complexity, flood water storage, and floodplain forest restoration are 1) Eugene-Corvallis, 2) mouth of the Santiam River, 3) Salem-Newburg.	within 15 yrs	TBD	---	---	---	NRCS, FSA, USACE, OWEB, ODFW, SWCD, land trusts, WR NGOs, WS Councils, private landowners
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	114 - MST-AMO Priority: 1	Protect existing highest quality salmonid rearing and migration habitats through conservation measures, acquisition, and/or regulation.	1. Increase floodplain and riparian vegetation, and reduce development in existing functional riparian/ floodplain vegetation. 1.1. restrict new floodplain development with impervious surfaces unless water quality treatment and runoff volume reduction are addressed with stormwater treatments 2. Encourage cities/counties to adopt zoning regulations that provide setbacks from streams to protect riparian habitat and to restrict new floodplain development.	TBD	within 15 yrs	TBD	---	---	---	NMFS, NRCS, FSA, OWEB, USACE, ODFW, ODLCD, OPRD, SWCD, , land trusts, NGOs, counties, cities, Private landowners, WS Councils

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				2.1. adopt ODLCD Goal 5 land use planning guidelines							
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	115 - MST-AMO Priority: 1	Consistently apply BMP's and existing regulations to protect and conserve natural ecological processes, with a focus on those that affect UWR CHS and STW and the LFT's identified in this Recovery Plan.	1: ID any constraints or coordination issues that limit full protective intent of BMP's and regulations. 1.1. specify which BMP's are not being consistently applied and under what conditions 1.2. determine and correct impediments to implementation of BMP's	ESU-wide	within 15 yrs	TBD	---	---	---	Federal, state, local governments and private landowners

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1 , via, Land Use Management & Flood Control / Hydropower to address issue of - Physical Habitat Quality	116 - MST-AMO Priority: 1	Protect and restore aquatic habitat function at confluence areas of Willamette River tributaries.	1. Prioritize some BPA funding of the WP BiOp habitat restoration projects (WATER HTT) to these areas. See WP-RPA's 7.1.2 and 7.1.3. 2: Identify other funding or coordination opportunities so that restoration at confluence sites is substantial enough to provide meaningful ecological benefits to anadromous fishes.	Willamette mainstem	within 15 yrs	Baseline	---	---	N/A	NRCS, FSA, USACE, OWEB, ODFW, OPRD, SWCD, land trusts, WR, NGOs, private landowners, WS councils
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	117 - MST-AMO Priority: 3	Use road and bridge fluvial performance standards that allow free passage of fish, sediment, and flows in the Mainstem Willamette River and subbasins.	TBD	ESU-wide	within 15 yrs	TBD	---	---	---	ODOT, FHWA

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9h Key Factor: multiple populations and life stages; refer to population-specific LFT tables in CH 5 Secondary Factor: multiple populations and life stages; refer to population-specific LFT tables in CH 5	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	118 - MST-ALL Priority: 2	Implement and evaluate the effectiveness of the "Agricultural Water Quality Management Area Rules" (SB 1010 plans) for the mainstem Willamette River and subbasins.	1. Monitor at appropriate scale to evaluate the sufficiency of these plans to reduce erosion and other stated objectives. 2. ID known problem areas and pursue getting them fixed, especially if near salmon and steelhead production areas. 2.1. enforce set back requirements where fields are adjacent to river	ESU-wide	on-going	Baseline	---	---	N/A	DMA's, NRCS, ODEQ, ODA, SWCD, private landowners

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9h	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	119 - MST-AMO Priority: 1	(see other actions involving TMDL's) Support implementation plans associated with TMDL compliance and focus salmonid habitat restoration efforts in those reaches where other LFT's are being improved and productivity can be restored	TBD	ESU-wide	on-going	Baseline	---	---	N/A	ODEQ, ACWA, private landowners, local governments
Listing Factor: A LFT: 10d Key Factor: CHS fry-winter parr Secondary Factor: none	Strategy: 1, 5, 6, 7, 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	120 - MST/SUB-AMO Priority: 1	Evaluate the potential for releasing habitat-forming flows from WP Project storage dams to complement habitat restoration activities in the mainstem Willamette River.	1. WP BiOp RPA 2.7; Work through WATER Flow Management Team to identify opportunities to provide environmental pulse flows that can create new and sustain existing fish habitat in the lower subbasins and the mainstem Willamette River 1.1. these types of flows may not be met in low flow years, so evaluate the likely occurrence and magnitude of these flows. 2. Complete The Nature Conservancy's Sustainable Rivers study process. 2.1. implement and evaluate the study recommendations in Coast Fork and Middle Fork, and conduct similar Nature Conservancy studies in other subbasins where flows have been significantly modified	above Willamette Falls	Type 1 flows: MF 2009 other schedules dependant upon WATER Flow Team	Baseline	---	---	N/A	USACE, Nature Conservancy
								Sub Total		**$0**	

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
SUB: Strategies and Actions focused on decreasing LFT's in subbasins											
ALL: All populations CM: Clackamas; MO: Molalla; NS: North Santiam: SSA: South Santiam: SAN: North and South Santiam STW populations; CA: Calapooia; MK: McKenzie; MF: Middle Fork Willamette; SSB: all STW subbasins											
Listing Factor: A.2 LFT: 2a Key Factor: none Secondary Factor: STW fry-adult	Strategy: 4 , via, Land Use Management to address issue of - Habitat access	121 - SUB -ALL Priority: 2	ODFW District staff lead the coordination and updating of ODFW's Fish Passage Program database to document status of remaining high priority barriers or passage problem areas.	1. Objective is to identify and fix ESU-specific "high priority" fish passage impediments, with priority projects being those where success is high for restoring STW spawning and rearing capacity and productivity into productive areas above barriers. 1.1. continue to coordinate with WS Councils and other subbasin entities to update, refine, and expand fish passage assessments 1.1.1. ID funding constraints or other factors that limit WS Council participation 1.1.2. develop partnerships and funding opportunities for small private landowners to improve passage in high priority areas 2. Ensure the database is available and useable to municipalities, counties, and state and federal agencies to inform their passage prioritization processes.	CA: middle CA subbasin assessment complete (2004 Calapooia WS Council); used by ODFW and Linn Co. Road Dept. SSA: The SSA and NS WS Councils have worked with OSU to assess and prioritize passage barriers. The SSA WS Council has a list of ~40 to date, within which a prioritization process is established	on-going	Baseline	---	---	N/A	ODFW, ODF, ODOT, WS Councils, private landowners, local governments

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr STW winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	122 - SUB -ALL Priority: 1	Pursue development of a cooperative agreement or habitat conservation plan with land owners to further protect fish habitat in the future.	1. Evaluate the utility of a Habitat Conservation Plan, or something similar.	above Willamette Falls	within 15 yrs	TBD	---	---	---	Private landowners, OWEB, ODFW, SWCD
Listing Factor: A LFT: 8a	Strategy: 1, 3, 4, 8, 9 , via, Land Use Management to address issue of - Physical Habitat Quality & Water Quality / Quantity / Hydrograph	123 - SUB -ALL Priority: 1	Protect and restore headwater rivers and streams (salmon and non-salmon bearing) to protect the sources of cool, clean water and normative hydrologic conditions.	TBD	upper reaches in natal subbasins	within 15 yrs	TBD	---	---	---	WS Councils, ODFW, ODF, ODSL, OWRD, ODA, USFS, Counties, Municipalities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9a Key Factor: CHS summer parr for MO, NS, SSA, CA Secondary Factor: STW fry-summer parr; CHS summer parr for CM, MK, MF	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	124 - SUB -ALL Priority: 1	Evaluate allocation policies and legal and illegal water withdrawals, and look for opportunities to keep more water instream.	1. OWRD evaluate their policy regarding whether a basin is over-allocated or under-allocated. - Policy should protect instream flows by accounting for fish and/or reflect a smaller HUC size - Protection is limited if instream rights are junior to other rights 1.1. identify and implement flow improvements 2. Ensure future USBOR water service contracts do not reduce instream flow protections. 2.1. USBOR water service contracts should allow for interruption of service during low water years to protect instream flows 2.2. release additional flows from storage dams to meet USBOR water service contracts while still meeting instream flows 2.3. ID priority areas for increased instream flows 3. Eliminate illegal water withdrawals. 3.1. ID constraints to enforcing illegal withdrawals, and fix them 3.1.1. increase reporting of violations-fishing guides, citizen groups 3.1.2. increase enforcement capabilities 3.2. consider flow monitoring program to	All subbasins and Mainstem Willamette	within 15 yrs	Baseline	---	---	N/A	OWRD, SWCD, ODFW, USBLM, Private landowners, interest groups, WS Councils, Freshwater trusts

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				assure that flow from leased water rights is not used by holders of junior rights 4. Evaluate existing rights for conservation outreach opportunities 4.1. explore options with landowners along selected tributaries for leasing their water rights to the State to have more water in the stream during summer for fish - focus leasing options on cooler streams with higher quality habitat							
Listing Factor: A LFT: 9a	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	125 - SUB -ALL Priority: 1	Support the funding and implementation of Water Quality Management Plans (TMDL Implementation Plans) of Designated Management Agencies (DMA's) to meet their objective of restoring riparian vegetation as part of a larger strategy to restore and protect streams.	1 Expand cool water zones within the Willamette River mainstem and tributary reaches in the lower subbasins by meeting TMDL temperature load allocations for approved TMDL's (see ODEQ Willamette basin and Molalla basin TMDL reports). 1.1. conduct analysis to ID strategic and priority reaches for the purposes of this Recovery Plan and specific LFT's 1.1.1 provide resources to conduct this analysis, then fund and fix these reaches first 2. Increase amount of riparian forest buffer to improve shading function, and restore hyporheic function and capacity. 2.1. protect and restore	ODEQ 303 (d) temperature reaches: MO: -Lower Molalla Mainstem (mouth to Henry Creek), Table Rock Fork, Pudding River	within TMDL WQMP timelines	Baseline ODEQ Rept 2010 (Average Method, Table 16 = $902,666,575) To fund priority review Expert Opinion $100,00	---	---	100000	NRCS, FSA, ODEQ, OWEB, SWCD, DMA's

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				extensive vegetative riparian shade buffers in lower subbasins. 2.1.1. use fencing, weed control, and planting of native conifers and other species at appropriate sites 2.2. increase conservation easements through incentive programs or land retirement programs (CREP) throughout subbasins 3. Evaluate further the extent to which gravel augmentation or channel reconnection will increase hyporheic capacity. 4. Examine feasibility of building greater water retention capacity with side channel reservoirs to augment summer flows. 5. Assure through separate actions that instream flows are protected and that future allocations do not increase summer water temperatures.							
Listing Factor: A.2 LFT: 1a Key Factor: CHS smolts	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat access	126 - SUB -CM Priority: not specified	Provide / improve fish passage in Clackamas subbasin tributaries.	TBD	Miller Crk confluence, Tryon Crk-Highway 43 Culvert, Clear Crk, Deep Crk, Johnson Crk	within 15 yrs	Expert Opinion (from OrLCR Plan)	$2,500,000 / site	5 sites	12500000	ODFW, ODOT

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Secondary Factor: none											
Listing Factor: A.2 LFT: 1a Key Factor: CHS smolts Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat access	127 - SUB -CM Priority: not specified	Implement all measures in the Clackamas River Hydroelectric Project (FERC Project No. 2195) Fish Passage and Protection Plan, including measures for downstream fish passage (3% or less mortality at River Mill and North Fork dams), Oak Grove Mitigation and improvements to North Fork fish ladder/trap.	TBD	PGE's Clackamas R Hydroelectric Project	within 15 yrs	Baseline	---	---	N/A	ODFW, PGE
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	128 - SUB -CM Priority: not specified	Breach, lower, remove, or relocate dikes and levees to establish or improve access to off-channel habitats; vegetate dikes and levees.	TBD	Columbia Slough; Joslin Property	within 15 yrs	Expert Opinion (from OrLCR Plan)	---	---	3300000	WS Councils, ODFW, City of Portland, Metro

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	129 - SUB -CM Priority: not specified	Review land use plans in context of salmon recovery needs (i.e., forest lands of higher value to salmon recovery than urbanized lands).	TBD	Eagle Crk; Clear Crk; mainstem Clackamas R -- R Mill Dam to Goose Crk; mainstem Clackamas R -- R Mill Dam to Abernathy Crk; Deep Crk; Johnson Cr	within 15 yrs	Baseline	---	---	N/A	ODFW, ODLCD, USFS, Counties, City of Portland, Metro, Municipalities
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	130 - SUB -CM Priority: not specified	Finish Clackamas Fish Habitat Analysis.	TBD	subbasin-wide	within 15 yrs	TBD	---	---	---	WS Councils, ODFW, USFS

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	131 - SUB -CM Priority: not specified	Protect remaining high-quality off-channel habitat from degradation.	TBD	Priority urban areas in lower watershed; Cathedral Park; Centennial Mills; Johnson Crk confluence; Columbia Slough; Johnson Crk confluence; Linnton Neighborhood; Saltzman Crk; Willamette Cove; Forest Park area; Stephens Crk confluence	within 15 yrs	TBD	---	---	---	WS Councils, ODFW, ODSL, Counties, City of Portland, Metro, Municipalities
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	132 - SUB -CM Priority: not specified	Restore or create off-channel habitat and/or access to off-channel habitat: side channels.	TBD	TBD	within 15 yrs	Calculated	$330,000 / mi	114 miles	37620000	WS Councils, ODFW, NRCS, SWCD, City of Portland, Metro

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	133 - SUB -CM Priority: not specified	Restore or create off-channel habitat and/or access to off-channel habitat: alcoves, wetlands, and floodplains. - Restoration includes revegetation.	TBD	Linnton Neighborhood; Owens-Corning Banks and Floodplain; Ross Island; Swan Island lagoon; Columbia Slough confluence; Ramsey lake wetland; Tryon Slough confluence; Powerline Corridor; Forest Park area; Kelley Point Park; Miller Crk confluence; Oaks Bottom Wildlife Refuge; West Hayden Island; Willamette Cove; Willamette Park; Cathedral Park; Centennial Mills; Johnson Crk confluence; Saltzman Crk; watershed-wide	within 15 yrs	Calculated	$53/m2	34,738 m2	1841114	WS Councils, ODFW, NRCS, SWCD, PGE, City of Portland, Metro

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	134 - SUB -CM Priority: not specified	Improve or regrade/revegetate streambanks.	TBD	Linnton Neighborhood; Oaks Bottom Wildlife Refuge; Owens-Corning Banks and Floodplain; Swan Island lagoon; Tryon Cr confluence; West Hayden Island; Willamette Cove; Willamette Park; Balch Cr confluence; Cathedral Park	within 15 yrs	TBD	---	---	---	ODFW, Counties, City of Portland, Metro, Municipalities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	135 - SUB -CM Priority: not specified	Protect intact and functioning riparian areas through riparian easements and acquisition	TBD	Eagle Crk; Clear Crk; mainstem Clackamas R (River Mill Dam to Goose Crk, R Mill Dam to Abernathy Cr); tributaries below R Mill Dam; Deep Crk; Johnson Crk; Forest Park area; Willamette R; West Hayden Island	within 15 yrs	Expert Opinion (from OrLCR Plan)	---	---	7500000	WS Councils, ODFW, OWEB, ODSL, USFS, NRCS, SWCD, City of Portland, Metro
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	136 - SUB -CM Priority: not specified	Restore (plant and/or fence) and protect (conservation easements, acquisition) riparian areas that are degraded.	TBD	Eagle Crk; Clear Crk; mainstem Clackamas R (River Mill Dam to Goose Crk, R Mill Dam to Abernathy Cr); tributaries below R Mill Dam; Deep Crk; Johnson Crk; Forest Park area; Willamette R; West Hayden Island	within 15 yrs	Calculated	$330,000 / mi (with fence); $310,000 / mi (without fence)	8 miles (with fence); 54 miles (without fence)	19380000	WS Councils, ODFW, OWEB, ODSL, NRCS, SWCD, City of Portland

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	137 - SUB -CM Priority: not specified	Annually place 8,000 yd3 of spawning sized gravel below River Mill Dam as per FERC settlement agreement.	TBD	Mainstem Clackamas R below R Mill Dam	within 15 yrs	Baseline	---	---	N/A	PGE
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	138 - SUB -CM Priority: not specified	Utilize the Clackamas Hydroelectric Project Mitigation and Enhancement Fund to provide for habitat mitigation and enhancements in the Clackamas Basin.	TBD	subbasin-wide	within 15 yrs	Baseline	---	---	N/A	ODFW, PGE
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	139 - SUB -CM Priority: not specified	Restore instream habitat complexity, including large wood placement (mitigate for loss of spring Chinook habitat complexity due to Clackamas hydropower dams).	TBD	High intrinsic potential rearing areas for spring Chinook; subbasin-wide	within 15 yrs	TBD	---	---	---	ODFW, PGE, City of Portland

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	140 - SUB -CM Priority: not specified	Restore instream habitat complexity, including large wood placement.	TBD	Johnson Crk confluence; Tryon Crk confluence; Eagle Crk; Clear Crk; mainstem Clackamas R -- R Mill Dam to Goose Crk; mainstem Clackamas R -- R Mill Dam to Abernathy Crk; Johnson Cr)	within 15 yrs	Calculated	$80,000 / mi	192 miles	15360000	WS Councils, ODFW, USFS, NRCS, SWCD, PGE, Metro
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	141 - SUB -CM Priority: not specified	Daylight stream.	TBD	lower Doane Crk/Railroad Corridor; lower Saltzman Crk, Centennial Mills	within 15 yrs	TBD	---	---	---	City of Portland
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat	142 - SUB -CM Priority: not specified	Create confluence habitat with cool water, restore channel and reconnect upper creek.	TBD	Doane Crk/Railroad Corridor; Saltzman Crk	within 15 yrs	TBD	---	---	---	ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
	Quality										
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	143 - SUB -CM Priority: not specified	Reconnect tributary to Willamette River and create high quality habitat at tributary junction.	TBD	Historical Swan Island channel; Saltzman Crk; Miller Crk confluence	within 15 yrs	TBD	---	---	---	ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 7i Key Factor: none Secondary Factor: CHS egg-alevin	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	144 - SUB -CM Priority: not specified	(similar to LFT 7f [MF] and 7e [MK]) Within authority of current FERC license, increase retention and sourcing of gravels and other materials below PGE facilities with a combination of habitat improvements, targeted flows, and augmentation.	1. Improve channel complexity below dams with existing habitat restoration and enhancement program on PGE lands. 2. Augment depleted areas below dams with most appropriate source and size composition. 2.1. provide appropriate channel complexity to retain material. 3. Prioritize some projects within the comprehensive habitat restoration program to include projects that improve incubation habitat. 4. Implement to collect large wood in PGE reservoirs, and strategically promote placement of this wood in areas below dams that promote sourcing of incubation gravels. 5. Couple these improvements with pulse flows to distribute gravel and other materials.	lower subbasin	see FERC agreement	---	---	---	---	PGE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9a Key Factor: CHS summer parr for MO, NS, SSA, CA Secondary Factor: STW fry-summer parr; CHS summer parr for CM, MK, MF	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	145 - SUB -CM Priority: not specified	Establish minimum ecosystem-based instream flows.	TBD	Johnson Crk	within 15 yrs	TBD	---	---	---	ODFW, OWRD
Listing Factor: A LFT: 8a	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	146 - SUB -CM Priority: not specified	Reduce impact that roads have on impaired hydrograph.	TBD	upper Clackamas and Collawash rivers	within 15 yrs	TBD	---	---	---	WS Councils, ODFW, USFS, Counties, City of Portland, Municipalities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9k Key: none Secondary: CHS summer parr, adults	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	147 - SUB -CM Priority: not specified	Implement all water quality and hydrograph measures in the Clackamas River Hydroelectric Project (FERC Project No. 2195) Fish Passage and Protection Plan.	TBD	lower subbasin	see FERC agreement	---	---	---	---	PGE
Listing Factor: E.1 LFT: 3a Key Factor: CHS and STW adult Secondary Factor: none	Strategy: 4, 13 , via, Hatchery Management to address issue of - Population Traits	148 - SUB -CM Priority: not specified	Maintain existing wild fish sanctuary.	1. Sort fish at North Fork Dam.	upper subbasin	on-going	Baseline	---	---	N/A	ODFW, PGE
Listing Factor: E.1 LFT: 3a Key Factor: CHS adult Second	Strategy: 4, 13 , via, Hatchery Management to address issue of - Population Traits	149 - SUB -CM Priority: not specified	Operationally open the hatchery trap for a longer period.	TBD	Eagle Crk Nat'l Hatchery	within 15 yrs	Expert Opinion (from OrLCR Plan)	$20,000 / yr	25 yrs	500000	ODFW, USFWS

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
ary Factor: none											
Listing Factor: A, C, and D LFT: not specified	Strategy: not specified , via, not defined to address issue of - Other species	150 - SUB -CM Priority: not specified	(Purchase a freezer trailer to aid the logistical disposition to carcass placement, tribes, and food banks if program is maintained).	TBD	Eagle Crk Nat'l Hatchery	within 15 yrs	Expert Opinion (from OrLCR Plan)	$5,000 / unit	1 unit	5000	ODFW, USFWS
Listing Factor: A.2 LFT: 2a Key Factor: none Secondary Factor: STW fry-adult	Strategy: 4 , via, Land Use Management to address issue of - Habitat access	151 - SUB -MO Priority: 1	Improve known high priority STW passage impediments in the Molalla subbasin	1. Improve the entrance to the fish ladder at City of Silverton's water diversion on Abiqua Creek and evaluate effectiveness. 2. Where ladders exist in the subbasin, evaluate their effectiveness consistent with established standards. 3. Fix known unscreened diversions. 4. Where culverts in the subbasin are known to restrict juvenile access to juvenile rearing habitat, work with appropriate entity to replace or improve culvert.	1: Abiqua Creek 2: Butte, Abiqua, Silver creeks 3: mainstem Molalla (Shady Cove), Labish Ditch	within 15 yrs	Expert Opinion	$2,500,000 / site	3 sites	7000000	NRCS, other entities

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr STW winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	152 - SUB -MO Priority: 1	Identify priority reaches in Molalla subbasin where habitat restoration projects can be implemented and monitored.	1. Develop a prioritization framework and ID strategic reaches specific to UWR salmonids by collating work from several sources, including the Willamette Subbasin Plan (WRI 2004), WS Council Action Plans, watershed assessments, ODEQ 303 (d) reaches, and others. 2. Provide meaningful financial incentives to landowners (e.g. increase Oregon's tax credit) in priority locations to implement riparian protection and habitat improvement projects. 2.1. advertise ODFW's Wildlife Habitat Conservation and Management Program (WHCMP) and Riparian Tax Incentive Program (RTIP) 2.2. Explore other opportunities to acquire setbacks, easements, or acquisition. 3. Implement priority projects. 3.1. initiate restoration by increasing instream habitat complexity, including use of large wood and other strategies 3.2. provide for long-term restoration by planting, protecting, maintaining, and restoring native riparian vegetation	Mouth of Molalla to confluence of NF Molalla, Focus reaches include: Table Rock Fork to Cooper Creek, Copper Creek to Henry Creek, Pine Creek to Table Rock Fork, Glen Avon Bridge to Pine Creek	within 15 yrs	TBD	---	---	---	Private landowners, USBLM, Molalla River Watch, Molalla River Stewards, OWEB, ODFW, SWCD

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	153 - SUB -MO Priority: 1	Reconnect floodplains to channels.	1. Within the Molalla mainstem, reconnect side channels and off-channel habitats to stream channels. 2. Use outreach to encourage cities and county to not approve development in known floodplains.	Focus on mouth of Molalla to confluence of NF Molalla, with focus groups being non-forest age landowners that comprise the majority ownership here	within 15 yrs	Calculated	$330,000 / mi	TBD	---	USBLM, Molalla River Watch, Molalla River Stewards, OWEB, ODFW, SWCD, Private landowners
Listing Factor: A LFT: 8b Key Factor: CHS adult Secondary Factor: none	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	154 - SUB -MO Priority: 1	Reduce harassment of adult spring Chinook while they are holding during the summer.	1. Determine where the problems exists. 1.1. work with appropriate entities to reduce interaction by limiting access, increasing enforcement, and increasing public awareness 2. Increase law enforcement in the Molalla River Recreation Corridor. 3. Continue and increase public outreach and education. 3.1. increase signage on the river 3.2. work with Trout Creek landowners to minimize impacts at Trout Creek	upper subbasin	on-going	---	---	---	---	OSP, ODFW, Molalla River Watch, Molalla River Stewards

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9c	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	155 - SUB -MO Priority: 1	Improve summer water quality of headwater areas for oversummering Chinook by implementing sufficient riparian buffers .	1. ID strategic areas in coordination with actions for LFT 9a, but focus on problem areas in upper subbasin.	upper subbasin	within 15 yrs	TBD	---	---	---	ODEQ, OWEB, ODFW, ODF, SWCD, USBLM, Molalla River Watch, Molalla River Stewards, Private landowners
Listing Factor: E.1 LFT: 3a Key Factor: CHS and STW adult Secondary Factor: none	Strategy: 4, 13 , via, Hatchery Management to address issue of - Population Traits	156 - SUB -MO Priority: 1	Reform the existing harvest augmentation hatchery CHS program (non-local stock) into separate augmentation and conservation programs. (See Molalla Reintroduction proposal, Appendix E)	1. Evaluate how to implement a new hatchery Program. 2. After Recovery Plan adoption, develop new HGMP for this new program that specifies goals and objectives of the program.	subbasin-wide	within 15 yrs	TBD	---	---	---	ODFW, Molalla River Stewards, Native Fish Society

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 1d Key Factor: CHS smolt STW smolt Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat access	157 - SUB -NS Priority: 1	Implement WP-RPA's 4.12.3 and 4.13 to provide safe and effective downstream passage through Detroit reservoir and Detroit and Big Cliff dams for juveniles and kelts.	1: Study conceptual alternatives for downstream passage through dam complex and fish distribution in reservoir(s). 1.1. based on studies and design alternatives, construct and operate new downstream fish passage facility by 2023 or sooner	Detroit/Big Cliff complex	Major Milestone go/no go decision: Complete construction: Operation: 2023	WP BiOP	---	---	N/A	WP BiOp action agencies
Listing Factor: A.2 LFT: 2a Key Factor: none Secondary Factor: STW fry-adult	Strategy: 4 , via, Land Use Management to address issue of - Habitat access	158 - SUB -NS Priority: 2	Work with and assist landowners with grants, funding, and design to screen the known water diversions.	TBD	1: Salem Ditch / Mill Creek 2: Rock Creek 3: Sydney Ditch	immediate	TBD	---	---	---	1: City of Salem, Santiam Water Control District 2: NRCS, NSWCouncil 3: Sidney Ditch Cooperative, ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2a Key Factor: none Secondary Factor: STW fry-adult	Strategy: 4 , via, Land Use Management to address issue of - Habitat access	159 - SUB -NS Priority: 2	As needed, evaluate effectiveness of success of upstream passage of adults at the Salem Ditch / Mill Creek headgate structure.	Comments: The City of Salem invested between $700-$800 K in fish screening for the Mill Race and fish passage improvements to Waller Dam in 2004. What more is currently needed for Waller Dam?	Salem Ditch/Mill Creek	on-going	---	---	---	---	Santiam Water Control District, ODFW
Listing Factor: A.2 LFT: 2a Key Factor: none Secondary Factor: STW fry-adult	Strategy: 4 , via, Land Use Management to address issue of - Habitat access	160 - SUB -NS Priority: 2	Evaluate juvenile fish passage efficiency at the Mill Creek millrace diversion dam and modify the existing fishway if necessary.	TBD	Mill Creek	within 15 yrs	TBD	---	---	---	City of Salem, ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2b Key Factor: CHS adult STW adult Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	161 - SUB -NS Priority: 1	(see relation to LFT 2k) Reduce pre-spawn mortality by reducing injury and stress related to fish handling at and above USACE facilities.	1. WP-RPA 4.6 to rebuild, operate, and maintain the Minto Adult Fish Collection and handling facility below Big Cliff Dam for expanded and improved sorting and handling of wild and hatchery fish. 1.1. support objective WP-RPA 4.6 with other RPA's 1.1.1. implement WP-RPA's 4.3, 4.4, and 4.5 to improve and standardize handling and transport protocols 1.1.2. implement WP- RPA 4.7 to improve and increase the number of suitable outplanting sites above Detroit Dam. 1.2. assess through RME whether these show demonstrable improvement	Detroit/Big Cliff complex	RPA 4.6: Completion date 2012, begin operation in March 2013	WP BiOP	---	---	N/A	WP BiOp action agencies, ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2b Key Factor: CHS adult STW adult Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	162 - SUB -NS Priority: 1	Until downstream passage facilities are completed and have demonstrated safe and timely passage, supplement natural production in the subbasin by implementing the interim trap-and-haul measures described in the 2008 WP BiOp to outplant adult fish into historical habitat above the Big Cliff/Detroit flood control/hydropower complex.	1. Continue to implement and evaluate the experimental Outplant Program (described in WP-RPA 4.1), using hatchery fish to seed habitat above Detroit Dam, and evaluate outplant strategies and levels relative to best way to transition to a more formal reintroduction program using only NOR fish. 2. Based on Outplant evaluation studies, develop timelines and measurable criteria within the COP for eventual transition to a reintroduction program whereby above-dam natural fish production makes a significant contribution to overall population abundance and productivity to meet recovery goals. 3. Once the above conditions have been met, implement reintroduction of NOR fish to meet TRT diversity criteria and Recovery Plan diversity and spatial structure criteria. 3.1. discontinue hatchery outplants	Detroit/Big Cliff complex	on-going	WP BiOP	---	---	N/A	WP BiOp action agencies, ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2f Key Factor: CHS adult Secondary Factor: none	Strategy: 4 , via, Land Use Management to address issue of - Habitat Access	163 - SUB -NS Priority: 1	Reduce fish loss and migration delays of juvenile and adult fish at Santiam Water Control District irrigation canal/hydro projects.	Comments: Mill Creek Irrigation canal?	0	within 5 yrs	TBD	---	---	---	Santiam Water Control District, City of Stayton
Listing Factor: A.2 LFT: 2f Key Factor: CHS adult Secondary Factor: none	Strategy: 4 , via, Land Use Management to address issue of - Habitat Access	164 - SUB -NS Priority: 1	(related to LFT 9a coordination action) Ensure adequate streamflows exist for upstream migration of salmon during summer low flow periods at Geren/Stayton Island, and evaluate if there are other stream flow-related passage barriers in the subbas in summer.	1. Determine minimum instream flows needed downstream of Geren/Stayton Island complex. 2. Evaluate best way to coordinate subbasin water withdrawals and flows to keep the minimum amount of water needed for successful adult passage in the river. 2.1. develop an integrated plan with a conservation component for all water right holders withdrawals (as part of LFT 9a actions), including integration with WP BiOp flows	0	within 20 yrs	TBD	---	---	---	OWRD, ODFW, USBOR, USACE, NMFS, Cities of Salem and Stayton, SWCD

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2f Key Factor: CHS adult Secondary Factor: none	Strategy: 4 , via, Land Use Management to address issue of - Habitat Access	165 - SUB -NS Priority: 1	Improve fishway function and efficiency at Lower Bennett dams for both juvenile and adult fish.	1. Fund redesign, reconstruction, and evaluation of fish ladder at Lower Bennett dam. 2. Salem headgate at Mill Creek/NSR??	0	within 20 yrs	TBD	---	---	---	City of Salem, ODFW, Santiam Water Control District
Listing Factor: A.2 LFT: 2i Key Factor: none Secondary Factor: STW kelt	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	166 - SUB -NS Priority:	(see related LFT 1d actions for NS juveniles)	TBD	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2k Key Factor: none Secondary Factor: CHS adult	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	167 - SUB -NS Priority: 1	(see LFT 2b for handling actions) Resolve uncertainty of any remaining pre-spawn mortality not associated with injury and stress associated with Minto Collection facility.	1: Improve water quality in subbasin below Big Cliff Dam by implementing the WP RPA's 5.1, 5.2 and 5.3 for water quality to meet adult fish needs by resolving inadequacies of temperature and TDG profiles. 1.1. build temperature control structure at Detroit Dam; WP- RPA 5.3. 2. Monitor metrics of fish health at different times and locations above Willamette Falls to further delineate whether the problem is solely related to Flood Control/hydropower effects, or is exacerbated by other issues that impact fish condition and maturity (i. e. disease, toxins). - this is not a current WP BiOp RPA)	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies
Listing Factor: A LFT: 7b Key Factor: none Secondary Factor: CHS egg-alevin STW	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	168 - SUB -NS Priority: 2	(see actions associated with LFT 7c) Restore substrate recruitment and reduce streambed coarsening below dam projects.	TBD	Below Big Cliff Dam	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
egg-alevin											

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 7c Key Factor: none Secondary Factor: CHS egg-alevin STW egg-alevin	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	169 - SUB -NS Priority: 2	(same as for LFT 7f [MF] and 7e [MK]) Increase retention and sourcing of gravels and other materials below USACE facilities with a combination of habitat improvements, targeted flows, and augmentation.	1. (WP RPA 7.2) Improve channel complexity below dams with existing habitat restoration and enhancement program on USACE lands. 2. Augment depleted areas below dams with most appropriate source and size composition. - Provide appropriate channel complexity to retain material. 3. (WP RPA 7.1.2) Prioritize some projects within the comprehensive habitat restoration program to include projects that improve incubation habitat. 4. (WP RPA 7.3) Implement to collect large wood in USACE reservoirs, and strategically promote placement of this wood in areas below dams that promote sourcing of incubation gravels. 5. To the extent that restoration at revetment sites implemented through WP RPA 7.4 leads to greater interaction and movement of floodplain substrates, fund as high priority projects those that produce incubation gravels. 6. Couple these improvements with	Below Big Cliff Dam	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				Environmental Flow opportunities as described in RPA 2.7. to distribute gravel and other materials.							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr STW winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	170 - SUB -NS Priority: 1	Identify priority reaches in North Santiam subbasin where habitat restoration projects can be implemented and monitored.	1. Develop a prioritization framework and ID strategic reaches specific to UWR salmonids by collating work from several sources, including the Willamette Subbasin Plan (WRI 2004), WS Council Action Plans, watershed assessments, ODEQ 303 (d) reaches, and others. 1.1. map existing intact areas for protection 1.2. map degraded priority areas for restoration/enhancement 1.3. update and implement the NSA WS Council's Work Plan to cross-walk priority projects with Recovery Plan 2. ID willing landowners and local governments to protect intact areas through BMPs, incentives, and other mechanisms. 3. Streamline incentive programs and process. 3.1. provide meaningful financial incentives (e.g. increase Oregon's tax credit) in priority locations to implement riparian protection and habitat improvement projects 3.2. advertise ODFW's Wildlife Habitat Conservation and Management Program (WHCMP) and Riparian Tax Incentive Program (RTIP) 3.3. explore other	natal subbasin	within 15 yrs	see action 175 ODEQ Rpt (2010 Table 4) For Ag DMA (fencing)	$6,308 / acre (fencing)	TBD	---	NRCS, FSA, OWEB, SWCD, North Santiam Watershed Council, private landowners

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				opportunities to acquire setbacks, easements, or acquisition.							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	171 - SUB -NS Priority: 1	In priority moderate-gradient stream reaches in the NS subbasin, increase habitat complexity to provide juvenile fish refugia during high flows, and to augment other channel forming processes and habitat/water quality actions in this Plan.	1. Implement priority projects. 1.1. initiate restoration by increasing instream habitat complexity, including use of large wood and ther bank stabilization strategies 1.2. provide for long-term restoration by planting, protecting, maintaining, and restoring native riparian vegetation	Good candidate streams include Bear Branch, Stout, Rock, Mad, Sinker, Elkhorn, LNF Santiam.	within 15 yrs	ODEQ Rpt (2010 Table 4) For Ag DMA	$12,333 / acre	TBD	---	North Santiam WS Council, USBLM, OWEB, private landowners
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	172 - SUB -NS Priority: 1	Restore natural function of the North Santiam River near Stayton Ponds	1. Use a controlled diversion of water from the N. Santiam River to restore side channel habitat and floodplain function. 1.1. ensure upstream passage through this channel	Stayton Ponds	within 15 yrs	TBD	---	---	---	North Santiam Watershed Council, ODFW
Listing Factor: A LFT: 10a Key Factor: STW eggs-alevin Secondary Factor: none	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	173 - SUB -NS Priority: 1	(WP BiOp Water Quality RPA's) Release flows from Detroit/Big Cliff dams to meet flow targets in the North Santiam River that protect spawning, incubation, rearing and migration of salmonids.	1. Operate facilities to minimize adverse effects of ramping on fish stranding, redd desiccation, and loss of habitat.	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 10b Key Factor: none Secondary Factor: CHS summer parr STW fry-summer parr	Strategy: 5 , via, Land Use Management & Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	174 - SUB -NS Priority: 1	Modify dam operations for multiple diversions at Geren/Stayton Island, e.g. Upper and Lower Bennett, SWCD pill dam.	TBD	0	within 10 yrs	TBD	---	---	---	City of Salem
Listing Factor: A LFT: 9b Key Factor: CHS egg-alevin Secondary Factor: none	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	175 - SUB -NS Priority: 1	(WP RPA 5.2) Construct, operate, and evaluate a temperature control structure at Detroit Dam to release water that more closely resembles normative water temperatures, reduces TDG exceedences, and meets TMDL temperature targets downstream of NS dams and operating dams to maximize benefits to Chinook and steelhead	1. Operate facility to provide cooler water in the fall for Chinook egg and alevin life stages. 2. Operate facility to provide warmer water during steelhead early life stages.	0	Operational by 2019	WP BiOP	---	---	N/A	WP BiOp action agencies, NMFS

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 9d Key Factor: none Secondary Factor: STW egg-alevin	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	176 - SUB -NS Priority: 1	(see WP RPA 5.2 to address LFT 9b; temperature control facility action)	1. Resolve any potential conflicts between meeting TMDL temperature targets downstream of dams and operating dams to maximize benefits to steelhead.	reaches below Big Cliff Dam	Operational by 2019	WP BiOP	---	---	N/A	WP BiOp action agencies, ODEQ

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: E.1 LFT: 3a Key Factor: CHS and STW adult Secondary Factor: none	Strategy: 4, 13 , via, Hatchery Management / RME / WP BiOP RPA's to address issue of - Population Traits	177 - SUB -NS Priority: 1	Manage current CHS Harvest Mitigation Hatchery Program (HMP) facilities and broodstock to meet mitigation goals, but do so in a manner that the genetic and demographic impacts of program do not pose unacceptable risk to extant NOR fish populations or compromise long term productivity of a reintroduction stock that would preclude success of conservation reintroduction/supplementation program above Detroit Dam.	1. In the long term the VSP diversity target is to maintain an average total basin pHOS rate <10%, which is coupled with improvements in access and passage and other LFT's affecting capacity and productivity. 1.1. promote a short and long term conservation hatchery strategy that will lead to a viable naturally-produced population. 2. In the short term, implement actions and associated RME below Minto facility that will reduce genetic and demographic risk to extant NOR population 2.1. improve trap attraction, operation, and sorting at new Minto facility; (open earlier and longer) 2.2. modify hatchery fish recycling program (end sooner)? 2.3. acclimate, release, or evaluate other rearing strategy modifications 2.4 modify other hatchery rearing practices 2.5. encourage greater harvest of hatchery fish above Upper Bennett Dam 2.6. maintain HOR tagging efforts and CHS spawning surveys to support above efforts 2.7. adopt new ODFW recommendations for level of integration of NOR	0	on-going	---	---	---	---	ODFW, NMFS, USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				broodstock 2.8. look for annual opportunities to "outplant" NOR fish to other locales in lower subbasin 3. Over long term, increase NOR production below Minto through WP BiOp RPA water quality/quantity improvements at Detroit, and other actions addressing LFT's. 3.1. further develop a conservation supplementation (reintroduction) program (CSP) or set of strategies to be implemented above Detroit dam 3.2. adopt as template the new ODFW recommendations for reintroduction and modify as needed based on results of scientific review of program type 4: If above actions and WP BiOp RPA actions related to access, temperature, and flow do not get pHOS to acceptable levels below Minto, and after a period of 2 life cycles (depending on ocean conditions) install and operate sorter at Upper and Lower Bennett Dams and modify angling regulations accordingly. 5: After Recovery Plan is adopted, develop a new							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				HGMP with conservation details.							
Listing Factor: E.1 LFT: 3a Key Factor: CHS and	Strategy: 4, 13 , via, Hatchery Management to address issue of - Population Traits	178 - SUB - SAN Priority: 1	For Steelhead, conduct RME to identify most effective means to reduce inter-basin pHOS, so that over the long term average total basin pHOS < 5% (for the out-of-ESU stock).	1. Potential strategies include modifying hatchery STS rearing and release practices. - pHOS goal is coupled with passage and other LFT improvements	0	on-going	WP BiOP	---	---	N/A	ODFW, NMFS, WP BiOp Action Agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
STW adult Secondary Factor: none											
Listing Factor: E.1 LFT: 4c Key Factor: STW fry-winter parr Secondary Factor: none	Strategy: 7, 10, 13 , via, Hatchery Management to address issue of - Competition	179 - SUB - SAN Priority: 1	Ensure hatchery summer steelhead smolts migrate quickly to the ocean by evaluating a suite of acclimation and release strategies.	TBD	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies
Listing Factor: E.1 LFT: 4c	Strategy: 7, 10, 13 , via, Hatchery Management to address issue of - Competition	180 - SUB - SAN Priority: 1	Convene a BiOp WATER working group to further examine the competition risk of STS on NOR STW fry and winter parr.	TBD	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: E.1 LFT: 4d Key Factor: STW summer parr-winter parr Secondary Factor: none	Strategy: 7, 10, 13 , via, Hatchery Management to address issue of - Competition	181 - SUB - SAN Priority: 1	Allow retention of fin-clipped trout in areas open to fishing to reduce residual STS smolts.	TBD	0	within 10 yrs	Baseline	---	---	N/A	ODFW
Listing Factor: C.1 LFT: 6c Key Factor: none Secondary Factor: CHS fry-winter parr	Strategy: 10, 11, 13 , via, Hatchery Management to address issue of - Predation	182 - SUB - SAN Priority: 1	Reduce natural spawning of non-native summer steelhead.	1. Increase harvest of adult summer steelhead. 2: Stop recycling adult summer steelhead and remove them. 3: Scatterplant smolt releases so that returning adults are more spread out to increase harvest.	0	within 10 yrs	Baseline	---	---	N/A	ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 1e Key Factor: CHS smolt STW smolt Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat access	183 - SUB - SSA Priority: 1	Improve downstream passage through Foster reservoir and dam for juveniles and kelts.	1. Implement WP-RPA's 2.8 and 2.10) to evaluate the Foster Dam Spring Spill window for improved passage of CHS and STW. 1.1. based on these studies, implement WP-RPA 4.8 requiring interim downstream fish passage measures 1.2. if more extensive improvements are needed, WP BiOP Action Agencies will proceed with evaluation through COP process, described in WP-RPA 4.13	0	within 5 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies
Listing Factor: A.2 LFT: 1e Key Factor: CHS smolt STW smolt Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat access	184 - SUB - SSA Priority: 2	Evaluate further whether safe and effective downstream passage through Green Peter reservoir and dam is a viable alternative and highly beneficial in supporting improvements in VSP criteria for desired status risk level (CHS-Moderate, STW-Very Low).	1. Evaluate within the WP BiOp COP process. - there are no WP BiOp RPA's for downstream passage improvements at Green Peter Dam 1.1. as other LFT's are improved, monitor STW population status to determine whether it is necessary to have STW upstream passage at Green Peter as identified in WP-RPA 4.2, in which case some STW collected at Foster Dam facility are "outplanted" above Green Peter. 1.2. in support of this effort, implement WP-RPA's 4.10 and 4.11. that require juvenile downstream passage assessments	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2a Key Factor: none Secondary Factor: STW fry-adult	Strategy: 4 , via, Land Use Management to address issue of - Habitat Access	185 - SUB - SSA Priority: 2	Provide technical and funding assistance to the SSA Watershed Council in restoring consistent fish passage into Ames Creek.	TBD	0	within 10 yrs	TBD	---	---	---	SSA WS Council, OWEB
Listing Factor: A.2 LFT: 2a Key Factor: none Secondary Factor: STW fry-adult	Strategy: 4 , via, Land Use Management to address issue of - Habitat Access	186 - SUB - SSA Priority: 1	Evaluate whether juvenile fish can pass the breached Jordan Dam on Thomas Creek.	1. Remedy if necessary.	Jordan Dam (Thomas Creek)	within 10 yrs	TBD	---	---	---	SSA Watershed Council, ODFW
Listing Factor: A.2 LFT: 2a Key Factor: none Secondary Factor:	Strategy: 4 , via, Land Use Management to address issue of - Habitat Access	187 - SUB - SSA Priority: 1	As needed, finalize evaluation of velocity testing and adjustment of baffles at the Lebanon diversion, to assure screen is still working within intent of NMFS design criteria.	1. Maintain and test as necessary.	Lebanon Dam	on-going	---	---	---	---	City of Albany

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
STW fry-adult											
Listing Factor: A.2 LFT: 2a Key Factor: none Secondary Factor: STW fry-adult	Strategy: 4 , via, Land Use Management to address issue of - Habitat Access	188 - SUB - SSA Priority: 3	Determine whether the diversion screen on Lacomb Creek meets current juvenile fish standards.	TBD	0	within 10 yrs	TBD	---	---	---	owner, SSA WS Council, ODFW
Listing Factor: A.2 LFT: 2c Key Factor: CHS adult STW adult Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	189 - SUB - SSA Priority: 1	(see relation to LFT 2l) Reduce pre-spawn mortality by reducing injury and stress related to fish handling at and above USACE facilities.	1. Implement WP-RPA 4.6 to rebuild, operate, and maintain the Foster Adult Fish Collection and handling facility below Foster Dam for expanded and improved sorting and handling of wild and hatchery fish. 1.1. support objective of WP-RPA 4.6 by implementing WP-RPA's 4.3, 4.4, and 4.5 to improve and standardize handling and transport protocols, and by implementing WP- RPA 4.7 to improve and increase the number of suitable outplanting sites above	0	RPA 4.6: Completion Date 2013, Begin Operation by March 2014	WP BiOP	---	---	N/A	WP BiOp action agencies, ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				Foster Dam (and potentially above Green Peter Dam) 1.1.1. assess through RME whether these show demonstrable improvement							
Listing Factor: A.2 LFT: 2c Key Factor: CHS adult STW adult Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	190 - SUB - SSA Priority: 2	Within the WP BiOp COP process, evaluate further whether access to and production above Green Peter Dam is a viable alternative and highly beneficial in supporting improvements in VSP criteria for desired status risk level (CHS-Moderate, STW-Very Low).	1. Determine whether it is necessary to have steelhead upstream passage at Green Peter Dam as identified in WP-RPA 4.2, in which case some steelhead collected at Foster Dam facility are "planted" above Green Peter. In support of this effort, implement the juvenile downstream passage assessments described in WP-RPA's 4.10 and 4.11. 1.1. use these data and results within language of WP-RPA 4.12 to support SLAM modeling to reduce uncertainty regarding need to improve downstream survival in the future - evaluation is needed to support decisions regarding need to construct and	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies, ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				operate new downstream fish passage facility at Green Peter Dam in next term of the WP BiOp							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2c Key Factor: CHS adult STW adult Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	191 - SUB - SSA Priority: 1	Until downstream passage facilities are completed and have demonstrated safe and timely passage, supplement natural production in the subbasin by implementing the interim trap-and-haul measures described in the 2008 WP BiOp to outplant adult fish into historical habitat above Foster Dam.	1. Continue to implement and evaluate the experimental Outplant Program (described in WP-RPA 4.1), using hatchery fish to seed habitat above Foster Dam. 1.1. evaluate outplant strategies and levels relative to best way to transition to a more formal reintroduction program using only NOR fish 1.2. based on Outplant evaluation studies, develop timelines and measurable criteria within the COP for eventual transition to a reintroduction program whereby above-dam natural fish production makes a significant contribution to overall population abundance and productivity to meet recovery goals. 2. Once the above conditions have been met, discontinue hatchery outplants and implement reintroduction of NOR fish to meet TRT diversity criteria and Recovery Plan diversity and spatial structure criteria.	0	on-going	WP BiOP	---	---	N/A	WP BiOp action agencies, ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2g Key Factor: CHS adult Secondary Factor: none	Strategy: 4 , via, Land Use Management to address issue of - Habitat Access	192 - SUB - SSA Priority: 3	Clarify if passage criteria are being met, or if further RME is needed for the new fishways at Lebanon Dam.	Comment: These fishways were built to NMFS hydraulic design criteria and appear to be working well, and NOAA considers passage evaluation a low priority given other needs.	Lebanon Dam	within 5 yrs	TBD	---	---	---	City of Albany. ODFW
Listing Factor: A.2 LFT: 2j Key Factor: none Secondary Factor: STW kelt	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	193 - SUB - SSA Priority: 1	(see related LFT 1e actions for SSA juveniles)	TBD	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2l Key Factor: none Secondary Factor: CHS adult	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	194 - SUB - SSA Priority: 2	(see LFT 2c for handling actions) Resolve uncertainty of any remaining pre-spawn mortality not associated with injury and stress associated with Foster Dam Collection facility.	1. Improve water quality in subbasin below Foster Dam by implementing the WP RPA's 5.1 and 5.2 for water quality to meet adult fish needs by resolving inadequacies of temperature and TDG profiles. 2. Monitor metrics of fish health at different times and locations above Willamette Falls to further delineate whether the problem is solely related to Flood Control/hydropower effects, or is exacerbated by other issues that impact fish condition and maturity (i. e. disease, toxins). - this is not a current WP BiOp RPA	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 7d Key Factor: none Secondary Factor: CHS egg-alevin STW egg-alevin	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	195 - SUB - SSA Priority: 2	(WP RPA 2.7) Implement environmental pulse flows and combine with WP RPA actions below to restore substrate recruitment and reduce streambed coarsening below dam projects.	1. (WP RPA 7.2) Improve channel complexity below dams with existing habitat restoration and enhancement program on USACE lands. 2. (WP RPA 7.1.2) Prioritize some projects within the comprehensive habitat restoration program to include projects that improve incubation habitat. 3. (WP RPA 7.3) Implement to collect large wood in USACE reservoirs, and strategically promote placement of this wood in areas below dams that promote sourcing of incubation gravels. 4. To the extent that restoration at revetment sites implemented through WP RPA 7.4 leads to greater interaction and movement of floodplain substrates, fund as high priority projects those that produce incubation gravels. 5. Couple these improvements with Environmental Flow opportunities as described in RPA 2.7 to distribute gravel and other materials.	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	196 - SUB - SSA Priority: 1	Identify priority reaches in South Santiam subbasin where habitat restoration projects can be implemented and monitored.	1. Develop a prioritization framework and ID strategic reaches specific to UWR salmonids by collating work from several sources, including the Willamette Subbasin Plan (WRI 2004), WS Council Action Plans, watershed assessments, ODEQ 303 (d) reaches, and others. 1.1. map existing intact areas for protection 1.2. map degraded priority areas for restoration/enhancement 1.3. update and implement the SSA WS Council's Work Plan to cross-walk priority projects with Recovery Plan 2. ID willing landowners and local governments to protect intact areas through BMPs, incentives, and other mechanisms. 3. Streamline incentive programs and process. 3.1. provide meaningful financial incentives (e.g. increase Oregon's tax credit) in priority locations to implement riparian protection and habitat improvement projects 3.2. advertise ODFW's Wildlife Habitat Conservation and Management Program (WHCMP) and Riparian Tax Incentive Program (RTIP) 3.3. explore other	0	within 15 yrs	ODEQ Rpt (2010 Table 4) For Ag DMA (fencing)	$6,308 / acre	TBD	---	NRCS, FSA, South Santiam WS Council, private landowners

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				opportunities to acquire setbacks, easements, or acquisition.							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr STW winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	197 - SUB - SSA Priority: 1	In priority moderate-gradient stream reaches in the South Santiam subbasin, increase habitat complexity to provide juvenile fish refugia during high flows, and to augment other channel forming processes and habitat/water quality actions in this Plan.	1. Implement priority projects. 1.1. initiate restoration by increasing instream habitat complexity, including use of large wood and other bank stabilization measures 1.2. provide for long-term restoration by planting, protecting, maintaining, and restoring native riparian vegetation Comments: Although focus in reaches below Foster Dam, some of the best remaining habitat is above Foster Dam, and in need of further enhancement. "high" priority (Sweet Home Ranger District)	Tributaries include Canyon Cr., Owl Cr., and Soda Fk. The SSA WS Council and USFS implemented a LWD project on Moose Cr. In 2008/2009.	within 15 yrs	ODEQ Rpt (2010 Table 4) For Ag DMA	$12,333 / acre	TBD	---	South Santiam WS Council, OWEB, USFS, private landowners
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	198 - SUB - SSA Priority: 2	Work with landowner adjacent to Waterloo Park to reestablish a long abandoned side channel for rearing and spawning.	TBD	0	within 15 yrs	Calculated	$330,000 / mi	TBD	---	??

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	199 - SUB - SSA Priority: 1	(WP BiOp WQ RPA's) Release flows from Foster/Green Peter dams to meet flow targets in the South Santiam River that protect spawning, incubation, rearing and migration of salmonids.	1. Operate facilities to minimize adverse effects of ramping on fish stranding, redd desiccation, and loss of habitat.	0	within 5 yrs	WP BiOP	---	---	N/A	WP BiOp Action Agencies, NMFS
Listing Factor: A LFT: 7a Key Factor: none Secondary Factor: CHS eggs-alevins STW eggs-alevins	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	200 - SUB - SSB Priority: 2	(no specific actions for LFT 7a; see relevant riparian actions under LFT code 8a)	TBD	0	on-going	---	---	---	---	ODEQ, ODF, USFS, USBLM, Forest Industry

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 10e Key Factor: STW eggs-alevin Secondary Factor: none	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	201 - SUB - SSA Priority: 1	(WP RPA's 5.1, 5.1.2, and potentially 5.1.3) Evaluate feasibility and effectiveness of interim operational temperature control at Foster and Green Peter dams.	1. Consider temperature control structure at most appropriate dam in next term of the WP BiOp, if not effective at restoring normative conditions or reducing the LFT. 1.1. resolve potential conflicts between meeting TMDL temperature targets downstream of dams and operating dams to maximize benefits to Chinook and steelhead	0	phased timeline in WP BiOp	WP BiOP	---	---	N/A	WP BiOp action agencies, ODEQ
Listing Factor: E.1 LFT: 3a Key Factor: CHS and STW adult Secondary Factor: none	Strategy: 4, 13 , via, Hatchery Management to address issue of - Population Traits	202 - SUB - SSA Priority: 1	Manage current CHS Harvest Mitigation Hatchery Program (HMP) facilities and broodstock to meet mitigation goals, but do so in a manner that the genetic and demographic impacts of program do not pose unacceptable risk to extant NOR fish populations or compromise long term productivity of a reintroduction stock that would preclude success of conservation reintroduction/supplementation program above Foster Dam.	1. In the long term the VSP CHS diversity target is to maintain an average total basin pHOS rate <30%, which is coupled with improvements in access and passage and other LFT's affecting capacity and productivity. 1.1. promote a short and long term conservation hatchery strategy that will lead to a viable naturally-produced population 2. In the short term, implement actions and associated RME below Foster facility that will reduce genetic and demographic risk to extant NOR population: 2.1. improving trap attraction, operation, and sorting at new Foster facility 2.2. minimize the recycling of HOR fish entering trap,	0	on-going	---	---	---	---	ODFW, NMFS, USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				maximize the recycling of "true" NOR fish 2.3. adjust juvenile rearing and release strategies as feasible 2.4. modifying other hatchery rearing practices 2.5. increase harvest of HOR fish while minimizing risk to NOR fish 2.6. maintain HOR tagging efforts and CHS spawning surveys to support above efforts 2.7 adopt new ODFW recommendations for level of integration of NOR broodstock and look for annual opportunities to "outplant" NOR fish to other locales in lower subbasin 3. Over long term, increase NOR production below Foster through WP BiOp RPA water quality/quantity improvements and other actions addressing LFT's. Further develop a conservation supplementation (reintroduction) program (CSP) or set of strategies to be implemented above Foster and Green Peter dams. 3.1. adopt as template the new ODFW recommendations for reintroduction and modify as needed based on results of scientific review of program type							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				4. After Recovery Plan is adopted, develop a new HGMP with conservation details.							
Listing Factor: A.2 LFT: 2h Key Factor: CHS adult Secondary Factor: STW adult	Strategy: 4 , via, Land Use Management to address issue of - Habitat access	203 - SUB -CA Priority: 1	Continue to work with agencies and private parties for a solution on the passage of adult CHS over Sodom and Shear dams that are associated with the Thompson's Mill State Park site.	1. OPRD to maintain timeline for developing a surrender application, including a draft EA and draft BA, to submit to FERC in Fall 2010 for FERC's approval. - as funds are currently available to help with Sodom Dam and Shear Dam removal, but expire after December 2011, OPRD needs to stay on the current timeline for submitting its application to FERC in order to ensure all permitting is completed for the 2011 in-water work period. - subsequently, FERC will have to complete its NEPA process, as well as ESA consultation with NMFS and USFWS prior to approving this action. 2. Also, OPRD will have to obtain an USACE 404 permit for these actions.	Lower-Middle Calapooia Construction complete: 2011	within 5 yrs	TBD	---	---	---	Calapooia Watershed Council, OPRD, ODFW, USACE, FERC and other permit agencies, local governments, OWEB

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	204 - SUB -CA Priority: 1	In priority moderate-gradient stream reaches in the Calapooia subbasin, increase habitat complexity to provide juvenile fish refugia during high flows, and to augment other channel forming processes and habitat/water quality actions in this Plan.	1. Implement priority projects. 1.1. initiate restoration by increasing instream habitat complexity, including use of large wood and other bank stabilization strategies 1.2. provide for long-term restoration by planting, protecting, maintaining, and restoring native riparian vegetation - other priority issues in the lower subbasin are temperature and other WQ issues, related to water withdrawal and lack of riparian function (i.e. shading) from agricultural practices.	- Select cool streams with gradients <4% - focus first on streams with year-round flow. - Brush Creek is a good example	within 15 yrs	ODEQ Rpt (2010 Table 4) For Ag DMA	$12,333 / acre	TBD	---	NRCS, FSA, OWEB, Calapooia Watershed Council, private landowners
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	205 - SUB -CA Priority: 1	Identify for protection and restoration, reaches in upper Calapooia River where deep pools can be maintained or created, for target summer water temperature < 70°F.	1. Reduce water temperature further through channel modification and increased riparian shading. 2. Add multiple large logs with root wads and engineer for log stability during flood flows.	upstream of Hands Creek (on-going)	within 15 yrs	ODEQ Rpt (2010 Table 4) For Private Forest DMA	$4,700 / acre (riparian shading) $13,333 / acre (instream improvement)	TBD	---	Calapooia Watershed Council, private landowners, namely Weyerhauser

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	206 - SUB -CA Priority: 1	Eliminate parking areas along main line roads, and decrease harassment near those pools where investments in spring Chinook holding pools have been made to minimize disturbance to the fish.	1. Maintain new Weyerhauser restricted access to upper subbasin. 2. Promote creation of dispersed additional resting/holding pools with specific stream habitat actions. 3. Increase OSP presence and protocols.	0	on-going	---	---	---	---	Weyerhauser, Calapooia Watershed Council, local governments
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	207 - SUB -CA Priority: 1	Identify priority reaches in Calapooia subbasin where habitat restoration projects can be implemented and monitored.	1. Develop a prioritization framework and ID strategic reaches specific to UWR salmonids by collating work from several sources, including the Willamette Subbasin Plan (WRI 2004), WS Council Action Plans, watershed assessments, ODEQ 303 (d) reaches, and others. 1.1. map existing intact areas for protection 1.2. map degraded priority areas for restoration/enhancement 1.3. update and implement the Calapooia WS Council's Work Plan to cross-walk priority projects with Recovery Plan - ID the width of buffer feasible in priority reaches - increase shade along stream sections that have maximum temperatures close to 70°F for purposes of expanding the amount of cool water habitat for juvenile fish	Calapooia WS Council focus areas are the middle reaches of the mainstem, Brush Creek and Courtney Creek sub-basins	within 15 yrs	ODEQ Rpt (2010 Table 4) For Ag DMA ODEQ Rpt (2010 Table 4) For Ag DMA (fencing)	$6,308 / acre $4700 / acre (w/o fence) $1100 / (w fence)	TBD	---	NRCS, FSA, Calapooia Watershed Council, private landowners

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				- suggestion to plant trees and buffers that are 50' wide, at least on the south banks 2. ID willing landowners and local governments to protect intact areas through BMPs, incentives, and other mechanisms. 3. Streamline incentive programs and process. 3.1. provide meaningful financial incentives (e.g. increase Oregon's tax credit) in priority locations to implement riparian protection and habitat improvement projects 3.2. advertise ODFW's Wildlife Habitat Conservation and Management Program (WHCMP) and Riparian Tax Incentive Program (RTIP) 3.3. explore other opportunities to acquire setbacks, easements, or acquisition							
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	208 - SUB -CA Priority: 1	Work in a priority up or downstream direction, eliminating even small breaks in shading to increase and expand cool water zones and fish bearing habitat.	Comments: ID'd "medium" priority (Calapooia WS Council). Because water takes on heat it loses it very slowly, therefore temperature reduction actions should proceed from the upstream direction down. The valley and headwaters could be separated to take different restoration approaches.	Calapooia WS Council focus areas are the middle reaches of the mainstem, Brush Creek and Courtney Creek sub-basins	within 15 yrs	ODEQ Rpt (2010 Table 4) For Ag DMA	$4700 / acre (w/o fence) $1100 / (w fence)	TBD	---	NRCS, FSA, local governments, Calapooia Watershed Council, private landowners

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	209 - SUB -CA Priority: 1	Use fencing, weed control, and planting of native conifers at appropriate sites.	TBD	Focus most of the conifer restoration efforts on the middle portion of the watershed	within 15 yrs	ODEQ Rpt (2010 Table 4) For Ag DMA (fencing)	$6,308 / acre	TBD	---	NRCS, FSA, OWEB, Calapooia Watershed Council, private landowners
Listing Factor: A LFT: 9c	Strategy: 8 , via, Land Use Management to address issue of - Water Quality / Quantity / Hydrograph	210 - SUB -CA Priority: 1	Improve summer water quality of headwater areas for oversummering Chinook by implementing sufficient riparian buffers.	1. ID strategic areas in coordination with actions for LFT 9a, but focus on problem areas in upper subbasin.	upper subbasin	within 15 yrs	TBD	---	---	---	ODEQ, OWEB, ODF, private landowners, Weyerhauser
Listing Factor: E.1 LFT: 3a Key Factor: CHS and STW adult Secondary Factor: none	Strategy: 4, 13 , via, Hatchery Management to address issue of - Population Traits	211 - SUB -CA Priority: 1	Modify hatchery CHS program practices in other subbasins of the ESU to minimize pHOS in the Calapooia subbasin.	1. As this population is likely extirpated, correct the LFT's and make a decision whether to allow natural seeding to occur from strays from other UWR populations, or to initiate a demographic boost with an appropriate conservation hatchery stock.	0	on-going	Baseline	---	---	N/A	ODFW, USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2d Key Factor: none Secondary Factor: CHS adults	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	212 - SUB -MK Priority: 1	Restore adult access of natural origin fish to historic habitat blocked by large dams.	Cougar Dam 1. Finish construction, evaluate, and maintain the new adult trap below Cougar Dam. 2. Once downstream passage issues are resolved through WP-RPA 4.12.1, and agreement is made on reintroduction strategy (number and composition of adults), decrease or eliminate HOR outplants and reintroduce NOR fish collected at Cougar Dam adult trap. 3. Implement WP-RPA's 4.3, 4.4, and 4.5 to improve handling and transport protocols. 4. Implement WP-RPA 4.7 to improve and increase the number of suitable "outplanting=release" sites above Cougar Dam. 5. Continue to provide appropriate temperatures to attract adults into the SF Mckenzie River. Trail Bridge Dam 6. Specify protocols for handling and transporting adult fish above EWEB facilities prior to use of new fish ladder at Trail Bridge Dam. 7. Build a ladder and tailrace	0	Cougar adult trap ~2010 Trail Bridge adult ladder Completion date: within 6 years of license issuance (likely 2016 or 2017)	WP BiOP	---	---	N/A	WP BiOp action agencies, ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				barrier that meets NMFS hydraulic design criteria.							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2d Key Factor: none Secondary Factor: CHS adults	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	213 - SUB -MK Priority: 2	(see related Leaburg action for LFT 3a to improve facility sorting) Provide safe and effective upstream passage of adult salmon migration at the Leaburg Dam left and right bank fish ladders.	1. Update recommendations on how to achieve this based on recent attraction studies and other information, and develop and implement appropriate operational and/or facility improvements.	0	within 10 yrs	TBD	---	---	---	EWEB
Listing Factor: A.2 LFT: 2d Key Factor: none Secondary Factor: CHS adults	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	214 - SUB -MK Priority: 2	Provide safe and effective upstream passage of adult salmon at Walterville tailrace.	1. Study in 2008 to quantify (attraction) and delay of adult salmon at the tailrace and assess impact on spawning distribution. 1.1. based on study results, develop and implement appropriate operational and/or facility improvements	0	See FERC	---	---	---	---	EWEB

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 1b Key Factor: none Secondary Factor: CHS smolts	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	215 - SUB -MK Priority: 1	Provide safe and effective downstream passage through Cougar reservoir and dam.	1. Implement WP-RPA 4.12.1 that studies and reports on conceptual alternatives for downstream passage through dam complex and fish distribution in Cougar Reservoir. 1.1. based on studies and design alternatives, construct and operate a new downstream fish passage facility	0	Major Milestone go/no go decision: 2010 Complete construction: Dec 2014 Operation: 2015	WP BiOP	---	---	N/A	WP BiOp action agencies
Listing Factor: A.2 LFT: 1b Key Factor: none Secondary Factor: CHS smolts	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	216 - SUB -MK Priority: 2	Continue to operate and maintain the Walterville fish screen to provide safe and effective fish passage.	TBD	0	on-going	---	---	---	---	EWEB
Listing Factor: A.2 LFT: 1b Key Factor: none Secondary Factor:	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	217 - SUB -MK Priority: 1	Provide safe and effective downstream passage through Trail Bridge reservoir and dam.	1. Study conceptual alternatives for downstream passage through dam complex and fish distribution in reservoir(s). 1.1. based on studies and design alternatives, construct and operate new downstream fish passage facility at appropriate dam as agreed to in FERC agreement	0	on-going	---	---	---	---	EWEB

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
CHS smolts											
Listing Factor: A.2 LFT: 1b Key Factor: none Secondary Factor: CHS smolts	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	218 - SUB -MK Priority: 1	Ensure new fish screen functions appropriately for Chinook salmon at the Leaburg Diversion	1. Assure that O&M funding is maintained to meet desired functionality.	0	on-going	---	---	---	---	EWEB

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 7e Key Factor: none Secondary Factor: CHS egg-alevin	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	219 - SUB -MK Priority: 1	(same as for LFT 7c [NS] and 7f [MF]) Increase retention and sourcing of gravels and other materials below USACE facilities with a combination of habitat improvements, targeted flows, and augmentation.	1. (WP RPA 7.2) Improve channel complexity below dams with existing habitat restoration and enhancement program on USACE lands. 2. Augment depleted areas below dams with most appropriate source and size composition. 2.1. provide appropriate channel complexity to retain material. 3. (WP RPA 7.1.2) Prioritize some projects within the comprehensive habitat restoration program to include projects that improve incubation habitat. 4. (WP RPA 7.3) Implement to collect large wood in USACE reservoirs, and strategically promote placement of this wood in areas below dams that promote sourcing of incubation gravels. 5. To the extent that restoration at revetment sites implemented through WP RPA 7.4 leads to greater interaction and movement of floodplain substrates, fund as high priority projects those that produce incubation gravels. 6. Couple these improvements with	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				Environmental Flow opportunities as described in RPA 2.7. to distribute gravel and other materials.							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	220 - SUB -MK Priority: 1	Continue to support implementation of Goal 1 restoration actions described in "The McKenzie Watershed Conservation Strategy" (2002), stated as to protect and restore key fish and wildlife habitats.	1. Support Implementation of Strategy 2 that protects and restores aquatic habitats 2. Implement Strategy 3 that protects and restores floodplain and riparian vegetation 2.1. use EDT watershed assessment results to prioritize and implement best restoration actions in lower subbasin - the McKenzie River strategy specifies the goals and actions for protection and restoration of the subbasin. Where appropriate, each goal identifies priority actions and river reaches.	Lower McKenzie basin; see detailed locations in document	within 15 yrs	TBD	---	---	---	McKenzie Watershed Council
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	221 - SUB -MK Priority: 1	Identify priority sites in the lower McKenzie River subbasin where habitat protection is needed and restoration is desirable, design restoration projects, implement work, and monitor.	1. Use the McKenzie WS Council Conservation Strategy (2002) and the Subbasin Assessment (2000), and maps therein, to identify high priority reaches for conservation and restoration actions. - restoration projects include: reconnect side channels and wetlands to increase channel complexity, place large wood, boulders or other structures, restore riparian habitat, add gravels to restore spawning habitat. - restore ecological function to the extent possible - modify revetments to	0	within 15 yrs	Depends on Project type	---	---	---	USACE, EWEB, Watershed council, private landowners

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				replace hardened bank structures with more natural bank treatments.							
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	222 - SUB -MK Priority: 1	Protect and enhance the McKenzie/Willamette Confluence Area and lower river.	1. Implement the "Land use, Flood Control, and Habitat Enhancement Guidelines for the confluence area of the McKenzie and Willamette rivers" (2001).	Lower McKenzie and mainstem Willamette.	within 15 yrs	TBD	---	---	---	Lane County, ODFW, EWEB, McKenzie Watershed Council, aggregate industry

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	223 - SUB -MK Priority: 1	Continue to implement the McKenzie WS Council's "Action Plan for Recreation and Human Habitat".	1. Support "possible actions" in Chapter 5, Goals 1 and 3 of the plan. 1.1. ID planning or zoning actions that would minimize future urbanization impacts in lower subbasin	0	within 15 yrs	TBD	---	---	---	McKenzie Watershed Council, local governments, private landowners
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	224 - SUB -MK Priority: 2	Implement the "Lane County Riparian Development Ordinance."	1. Evaluate and correct barriers to implementation. 2. Evaluate sufficiency of existing Ordinance for future urbanization and climate change impacts.		within 15 yrs	TBD	---	---	---	Lane County, USBLM

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	225 - SUB -MK Priority: 2	Coordinate projects of the McKenzie River Trust to implement priority habitat restoration projects.	1. Align/crosswalk MRT projects with Recovery Plan priorities.	Lower McKenzie and mainstem Willamette.	within 15 yrs	TBD	---	---	---	McKenzie River Trust, Watershed Council, ODFW, USBLM
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	226 - SUB -MK Priority: 3	Coordinate projects with the "Friends of the Mohawk" to implement priority habitat restoration projects.	1. Align/crosswalk FOM projects with Recovery Plan priorities.	Mohawk subbasin	within 15 yrs	TBD	---	---	---	ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 10d Key Factor: CHS fry-winter parr Secondary Factor: none	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	227 - SUB -MK Priority: 1	Operate Trail Bridge Dam to minimize adverse effects of ramping on fish stranding, redd desiccation, and loss of habitat in the McKenzie River downstream of Trail Bridge.	1. Identify appropriate ramping rates at various flows below Trail Bridge. 1.1. OWEB to implement FERC agreement and operate Trail Bridge dam to meet downstream ramping rate limits	0	See FERC	---	---	---	---	EWEB
Listing Factor: A LFT: 9g Key Factor: none Secondary Factor: CHS egg-alevin	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	228 - SUB -MK Priority: 1	Operate McKenzie subbasin WP flood control/hydropower projects to mimic natural temperature regime, while at the same time complementing the downstream passage benefits of spilling, and minimizing exceedence of TDG (total dissolve gas) below projects, and managing ramping rates to minimize stranding of early Chinook life stages.	1. Temperature control is now possible at Cougar Dam with the Selective Withdrawal Tower installed in 2005 1.1. use RME under WP RPA 5.4 to evaluate the effects of the Cougar temperature structure operation on TDG 1.2. resolve remaining issues with ODEQ regarding TMDL temperature targets 1.3. evaluate whether temperature control at other WP facilities in the subbasin are needed in the future 2: Monitor TDG below each large dam to identify the operating and background conditions causing high TDG. 2.1. based on monitoring TDG, design structural and/or operational	0	on-going	---	---	---	---	USACE, EWEB, ODEQ

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				modifications to dams to reduce project-related TDG exceedences							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: E.1 LFT: 3a Key Factor: CHS adult Secondary Factor: none	Strategy: 4, 13 , via, Hatchery Management to address issue of - Population Traits	229 - SUB -MK Priority: 1	Until the Cougar downstream passage facility is completed and has demonstrated safe and timely passage, continue to supplement natural production in the subbasin by implementing the interim trap-and- haul measures described in the 2008 BiOp to outplant adult fish into historical habitat above the USACE Cougar flood control/hydropower complex.	1. Continue to implement and evaluate the experimental Outplant Program (as described in RPA 4.1), using hatchery fish to seed habitat above Cougar Dam, and evaluate outplant strategies and levels relative to best way to transition to a more formal reintroduction program using only natural-origin fish. 2. Based on Outplant evaluation studies, develop timelines and measurable criteria within the COP for eventual transition to a reintroduction program whereby above-dam natural fish production makes a significant contribution to overall population abundance and productivity to meet recovery goals. 3: Once above conditions are met, discontinue hatchery outplants and implement reintroduction of natural-origin fish to meet TRT diversity criteria and Recovery Plan D and SS criteria.	0	on-going	---	---	---	---	USACE, NMFS, ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: E.1 LFT: 3a Key Factor: CHS adult Secondary Factor: none	Strategy: 4, 13 , via, Hatchery Management to address issue of - Population Traits	230 - SUB -MK Priority: 1	Manage current CHS Harvest Mitigation Hatchery Program (HMP) facilities and broodstock to meet mitigation goals, but do so in a manner that the genetic and demographic impacts of program do not pose unacceptable risks to the remaining wild fish population or impede long term recovery goals of the McKenzie CHS population.	1. In the long term the VSP diversity target is to maintain an average total basin pHOS rate <10%, which is coupled with improvements in access and passage and other LFT's affecting capacity and productivity. To achieve this, promote a wild fish management zone for the subbasin above Leaburg Dam that has a feasible pHOS target of <5%. 2. In the short term, implement actions and associated RME at and below Leaburg Dam that will reduce the number of HOR fish that need to be sorted at Leaburg, and reduce the pHOS in the spawning areas below Leaburg Dam. 2.1. adopt new ODFW recommendations for lower level of integration of NOR broodstock, and pass only NOR fish above Leaburg Dam. 2.2. improve attraction flows and entry to McKenzie Hatchery 2.3. modify Leaburg Hatchery ladder facility to assist in removing HOR CHS and collecting NOR CHS for passage above Leaburg 2.4. minimize the recycling of HOR adults entering traps at Leaburg ladder and the hatcheries 2.5. increase harvest of	0	on-going	---	---	---	---	ODFW, NMFS, USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				HOR fish below Leaburg dam while minimizing risk to NOR fish 2.6. evaluate pHOS reduction effectiveness of the on-going partial program relocation (SAFE) 2.7. explore opportunities/feasibility of acclimating and releasing juvenile CHS at sites in lower McKenzie subbasin; modify harvest regulation zones as needed to shift fishery effort to those areas. 2.8. resolve technical/feasibility issues of upgrading Leaburg Dam EWEB facility with engineering subgroup to achieve better sorting and handling of wild fish, resolve any funding uncertainties with BPA 2.9. maintain HOR tagging efforts and CHS spawning surveys to support above efforts 3. Over long term, increase NOR fish production below and above Leaburg through WP BiOp RPA water quality/quantity improvements and other actions addressing LFT's. 3.1. once adult and juvenile passage issues are resolved at Cougar Dam through WP BiOP RPA's, develop a conservation strategy and allocation schedule where it is defined under what							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				demographic conditions and passage improvement conditions the HOR outplants above Cougar Dam could be phase out and replaced with reintroduction of NOR fish that enter the South Fork Mckenzie River. 4. Further program relocation or reduction will be considered if above measures do not meet long term pHOS goal.							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: C.1 LFT: 6c Key Factor: none Secondary Factor: CHS fry-winter parr	Strategy: 10, 11, 13 , via, Hatchery Management to address issue of - Predation	231 - SUB -MK Priority: 1	Reduce number of hatchery STS released.	TBD	0	within 10 yrs	Baseline	---	---	N/A	ODFW
Listing Factor: C.1 LFT: 6d Key Factor: none Secondary Factor: CHS fry-winter parr	Strategy: 10, 11, 13 , via, Hatchery Management to address issue of - Predation	232 - SUB -MK Priority: 1	Evaluate the potential for reduction of predation on juvenile Chinook by reducing or discontinuing releases of hatchery trout in the McKenzie River upstream of Leaburg Dam.	TBD	0	within 10 yrs	Baseline	---	---	N/A	ODFW
Listing Factor: C.1 LFT: 6d Key Factor: none	Strategy: 10, 11, 13 , via, Hatchery Management to address issue of -	233 - SUB -MK Priority: 1	Release hatchery trout in areas and during periods when Chinook are not as susceptible to predation.	TBD	0	within 10 yrs	Baseline	---	---	N/A	ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Secondary Factor: CHS fry-winter parr	Predation										
Listing Factor: C.1 LFT: 6d Key Factor: none Secondary Factor: CHS fry-winter parr	Strategy: 10, 11, 13 , via, Hatchery Management to address issue of - Predation	234 - SUB -MK Priority: 1	Evaluate predation by hatchery trout and conduct a net benefit analysis on the effects of hatchery trout releases on bull trout population size in Trail Bridge Reservoir.	TBD	0	within 10 yrs	Baseline	---	---	N/A	ODFW

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2e Key Factor: CHS adult Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	235 - SUB -MF Priority: 2	Within the 2008 BiOp COP process and BRT activities, evaluate further whether eventual reintroduction and production above Hills Creek Dam is a viable alternative to other remedies for improving VSP criteria to meet desired status risk level (Chinook-Low).	- Current WP BiOp does not formalize specific passage improvements for Hills Creek Dam, but indicates outplant sites may be established above dam, presumably from collections at new Dexter facility. In support of determining future passage needs in next term of BiOp, implement actions in current WP BiOp: 1. As other LFT's improve and NOR abundance increases above Lookout Pt., monitor adult fish movement below Hills Creek dam to determine if large numbers of Chinook congregate below Hills Creek. 1.1. if so, evaluate within COP studies the feasibility of a future adult fish facility below the dam, relative to the benefits of continued trap-and-haul from the new Dexter facility 1.2. in support of this effort, implement the juvenile downstream passage assessments described in WP-RPA's 4.10 and 4.11 2. Use these data and results within language of WP-RPA 4.12 to support BRT SLAM modeling to reduce uncertainty regarding need to improve downstream survival at Hills		within 25 yrs	TBD	---	---	---	USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				Creek - needed to support decisions regarding need to construct and operate new downstream fish passage facility at Hills Creek Dam in next term of the WP BiOp							
Listing Factor: A.2 LFT: 1f Key Factor: CHS smolt	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat	236 - SUB -MF Priority: 1	Provide safe and effective downstream passage through the Dexter/Lookout Point flood Control/hydropower complex to benefit all size classes of juvenile migrants produced above Lookout Pt. Dam.	1. Manage reservoir levels for more normative flows (pre-dam flows) to pass inflow year round, except during flood control operations. Alternatives to be considered in the WP BiOp 2008 are: 1.1. WP-RPA 4.8: Evaluates interim measures to improve	0	RPA 4.8: Interim downstream measures within COP process, including full reservoir drawdown (but not specific to	WP BiOp	---	---	---	USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Secondary Factor: none	Access			downstream passage within Project constraints, within COP process. Measures could include partial or full reservoir drawdown, and use of spillway. Includes evaluating dam & facility constraints on how far down the reservoirs could be dropped. Need to assess cost/benefits of this action, relative to authorizations, storage loss for flow augmentation, and pollution abatement. Therefore it is unclear that a drawdown alternative will be chosen method to aid downstream migrants and that WP-RPA 4.8 will result in meaningful improvements. 2. WP-RPA 4.9: Build, evaluate, and report on effectiveness of Head of Reservoir (HOR) prototype above Lookout Pt. Dam. Permanent HOR does not occur if not effective at increasing overall productivity above Lookout Point. 3. WP-RPA's 4.10 and 4.11: Supporting studies to evaluate passage improvement alternatives through Lookout Pt/Dexter reservoirs and dams 4. WP-RPA 4.12.2: Investigate feasibility of fish passage at Lookout Pt.		this dam complex). Implement chosen interim measures by 5-2011 RPA 4.9: HOR prototype report by 12-2016 (See BiOp 2008 timelines for assessing/reporting options)					

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				Dam. Based on studies and design alternatives, construct new downstream fish passage facility by 2021. - does not secure guarantee structural downstream passage improvements at Lookout Pt. Dam							
Listing Factor: A.2 LFT: 1f Key Factor: CHS smolt Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	237 - SUB -MF Priority: 1	Provide safe and effective downstream passage through Fall Creek reservoir and dam.	1. Implement WP-RPA 4.8.1 to drawdown in autumn as an operational measure to reduce smolt injury, supported by effectiveness RME. 1.1. WP BiOp entities clarify timeline and standard for evaluating this drawdown option. 2. If drawdown is deemed insufficient to provide safe and effective passage, evaluate other operational measures through WP-RPA 4.8 and WP-RPA 4.13 (COP process). 2.1. study conceptual alternatives for downstream passage through dam complex based on fish distribution in the reservoir. 2.2. based on COP studies and design alternatives, consider construction and operation of structural protections and/or fish bypass facilities	0	on-going start fall flow modifications in 2008	Baseline	---	---	N/A	USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 1f Key Factor: CHS smolt Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	238 - SUB -MF Priority: 1	Provide safe and effective downstream passage through Hills Creek reservoir and dam.	1. Within WP-RPA's 4.10 and 4.11, assess passage through Hills Creek reservoir and dam. 2. Use these data and results within language of WP-RPA 4.12 to support SLAM modeling to reduce uncertainty regarding need to improve downstream survival in the future - needed to support decisions regarding need to construct and operate new downstream fish passage facility at Hills Creek Dam in next term of the WP BiOp	0	within 25 yrs	Baseline	---	---	N/A	USACE
Listing Factor: A.2 LFT: 2e Key Factor: CHS adult Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	239 - SUB -MF Priority: 1	(see relation to LFT 2m) Reduce pre-spawn mortality by reducing injury and stress related to fish handling at and above USACE facilities.	1. WP-RPA 4.6 to rebuild, operate, and maintain the Adult Fish Collection and handling facilities below Dexter and Fall Creek dams for expanded and improved sorting and handling of wild and hatchery fish. 2. Support objective of WP-RPA 4.6 by implementing WP-RPA's 4.3, 4.4, and 4.5 to improve and standardize handling and transport protocols, and by implementing WP- RPA 4.7 to improve and increase the number of suitable outplanting sites above Lookout Pt. Dam, Hills Creek Dam, and Fall Creek dams. 2.1. assess through RME whether these show demonstrable improvement	0	RPA 4.6 Dexter facility operational by March 2015 Falls Creek facility operational by March 2016	Baseline	---	---	N/A	USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.2 LFT: 2e Key Factor: CHS adult Secondary Factor: none	Strategy: 4 , via, Flood Control / Hydropower to address issue of - Habitat Access	240 - SUB -MF Priority: 1	Until downstream passage facilities are completed and have demonstrated safe and timely passage, supplement natural production in the subbasin by implementing the interim trap-and-haul measures described in the 2008 WP BiOp to outplant adult fish into historical habitat above Fall Creek, Dexter/Lookout Pt, and Hills Creek Dams	1. Continue to implement and evaluate the experimental Outplant Program (described in WP-RPA 4.1), using hatchery fish to seed habitat above Foster Dam, and evaluate outplant strategies and levels relative to best way to transition to a more formal reintroduction program using only NOR fish. 2. Based on Outplant evaluation studies, develop timelines and measurable criteria within the COP for eventual transition to a reintroduction program whereby above-dam natural fish production makes a significant contribution to overall population abundance and productivity to meet recovery goals. 3. Once the above conditions have been met, discontinue hatchery outplants and implement reintroduction of NOR fish to meet TRT diversity criteria and Recovery Plan diversity and spatial structure criteria.	0	on-going	---	---	---	---	USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A.1 and A.2 LFT: 2m Key Factor: CHS adult Secondary Factor: none	Strategy: 4, 8 , via, Flood Control / Hydropower to address issue of - Habitat access & Water Quality	241 - SUB -MF Priority: 1	(see LFT 2e for handling actions) Resolve uncertainty of any remaining pre-spawn mortality not associated with injury and stress associated with Middle Fork Willamette Collection facilities.	1. Improve water quality in subbasin below MF Willamette dams by implementing WP RPA's 5.1 and 5.2 for water quality to meet adult fish needs by resolving inadequacies of temperature and TDG profiles. 2. Monitor metrics of fish health at different times and locations above Willamette Falls to further delineate whether the problem is solely related to Flood Control/hydropower effects, or is exacerbated by other issues that impact fish condition and maturity (i. e. disease, toxins). - this is not a current WP BiOp RPA)	0	within 25 yrs	TBD	---	---	---	USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 7f Key Factor: CHS egg-alevin Secondary Factor: none	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	242 - SUB -MF Priority: 1	(same as for LFT 7c [NS] and 7e [MK]) Increase retention and sourcing of gravels and other materials below USACE facilities with a combination of habitat improvements, targeted flows, and augmentation.	1. (WP RPA 7.2) Improve channel complexity below dams with existing habitat restoration and enhancement program on USACE lands. 2. Augment depleted areas below dams with most appropriate source and size composition. 2.1. provide appropriate channel complexity to retain material. 3. (WP RPA 7.1.2) Prioritize some projects within the comprehensive habitat restoration program to include projects that improve incubation habitat. 4. (WP RPA 7.3) Implement to collect large wood in USACE reservoirs, and strategically promote placement of this wood in areas below dams that promote sourcing of incubation gravels. 5. To the extent that restoration at revetment sites implemented through WP RPA 7.4 leads to greater interaction and movement of floodplain substrates, fund as high priority projects those that produce incubation gravels. 6. Couple these improvements with	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				Environmental Flow opportunities as described in RPA 2.7. to distribute gravel and other materials.							

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 7g Key Factor: none Secondary Factor: CHS egg-alevin	Strategy: 1, 2, 5, 6 , via, Flood Control / Hydropower to address issue of - Physical Habitat Quality	243 - SUB -MF Priority: 2	(see actions associated with LFT 7f) Restore substrate recruitment and reduce streambed coarsening below dam projects.	TBD	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp action agencies
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	244 - SUB -MF Priority: 1	If it does not exist, develop proactive framework to minimize future urbanization impacts in Lower Middle Fork Willamette Basin	1. Evaluate and synthesize existing regulatory urbanization provisions and projections relative to salmonid needs.	Eugene/Springfield urban interface	within 15 yrs	TBD	---	---	---	Lane County Council of Governments

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	245 - SUB -MF Priority: 1	Evaluate the restoration opportunities identified in the Lower MF Willamette Watershed Assessment (2002) for riparian and aquatic habitat, with emphasis on CHS.	TBD	0	within 15 yrs	TBD	---	---	---	SWCD, NRCS, MF Watershed Council
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	246 - SUB -MF Priority: 1	Implement the "high priority actions" that benefit CHS identified under each of the six Goals in MF Willamette Watershed Council's Action Plan.	TBD	0	within 15 yrs	TBD	---	---	---	MF Watershed Council

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: A LFT: 8a Key Factor: CHS winter parr Secondary Factor: CHS fry-summer parr	Strategy: 1, 2, 3, 4, 5, 6 , via, Land Use Management to address issue of - Physical Habitat Quality	247 - SUB -MF Priority: 2	Identify priority sites in the Lower Middle Fork Willamette subbasin where habitat protection is needed and restoration is desirable, design restoration projects, implement work, and monitor.	1. Use the Middle Fork Willamette WS Council Action Plan to identify high priority reaches for conservation and restoration actions. - Restoration projects include: reconnect side channels and wetlands to increase channel complexity, place large wood, boulders or other structures, restore riparian habitat, add gravels to restore spawning habitat. - Modify revetments to replace hardened bank structures with more natural bank treatments.	TBD	within 15 yrs	TBD	---	---	---	USACE, MFW WS Council, landowners, Cities of Eugene and Springfield
Listing Factor: A LFT: 9f Key Factor: CHS egg-alevin Secondary Factor: none	Strategy: 1, 5, 6, 7, 8 , via, Flood Control / Hydropower to address issue of - Water Quality / Quantity / Hydrograph	248 - SUB -MF Priority: 1	Operate WP flows in MF subbasin to mimic the natural temperature regime in the fall	- A water Temperature Control Facility would presumably need to be constructed, which is not a certainty in current term of the WP BiOp	0	within 25 yrs	WP BiOP	---	---	N/A	WP BiOp Action agencies, NMFS

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
Listing Factor: E.1 LFT: 3a Key Factor: CHS adult Secondary Factor: none	Strategy: 4, 13 , via, Hatchery Management to address issue of - Population Traits	249 - SUB -MF Priority: 1	Manage current CHS Harvest Mitigation Hatchery Program (HMP) facilities and broodstock to meet mitigation goals, but do so in a manner that the genetic and demographic impacts of program do not pose unacceptable risk to extant NOR fish populations or compromise long term productivity of a reintroduction stock that would preclude success of conservation reintroduction/supplementation program above MF Willamette dams.	1. In the long term the VSP CHS diversity target is to maintain an average total basin pHOS rate <10%, which is coupled with improvements in access and passage and other LFT's affecting capacity and productivity. Promote a short and long term conservation hatchery strategy that will lead to a viable naturally-produced population, focused in the area above MF Willamette dams. 2. Actions and goals to control pHOS are modest below Dexter and Falls Creek dams (unless pseudo-isolation becomes an issue) but to minimize further genetic risk impacts for a future reintroduction effort using MF Willamette HMP stock, actions in the short term could include: 2.1. improve trap attraction, operation, and sorting at new Dexter facility 2.2. adjust juvenile rearing and release strategies as feasible 2.3. evaluate and Implement HGTG guidelines for reducing genetic impacts 2.4. maintain HOR tagging efforts and CHS spawning surveys to support above efforts 2.5 adopt new ODFW recommendations for level	0	on-going	---	---	---	---	ODFW, NMFS, USACE

CH 3 Listing Factor and CH 5 LFT	CH 7 Strategy or CH 6 VSP objective	Action ID and Priority	Recovery Action	Sub Action or Task	Focal Locations or Program	Schedule	Cost Basis	Unit Cost	Quantity	Total Cost	Key Entities / Potential Implementers
				of integration of NOR broodstock 3. Over long term, further develop a conservation supplementation (reintroduction) program (CSP) or set of strategies to be implemented above Fall Creek, Lookout Pt., and Hills Creek dams. 3.1. improve other LFT's associated with passage and pre-spawn mortality, then commence reintroduction 3.2. adopt as template the new ODFW recommendations for reintroduction and modify as needed based on results of scientific review of program type 4: After Recovery Plan is adopted, develop a new HGMP with conservation details.							
								Sub Total		**$105,106,114**	
								Total		**$265,934,439**	

9.2 Action Implementation

ODFW and NMFS acknowledge the many organizations that have been active in supporting habitat protection and restoration in the Willamette Basin, including local, State, tribal and Federal government and numerous non-governmental entities. Some have resources to contribute, some need additional resources. We also understand that implementing the ESA is not the only priority in the Basin, so the Plan will be most successful if it partners with and supports ongoing efforts that contribute to a functioning ecosystem that will support native species and human society, together, for the long term

The Plan used a comprehensive approach to identify the most important recovery strategies and actions that would reduce the LFTs that inhibit the recovery of UWR Chinook and steelhead. Section 9.1.1 describes a number of criteria for establishing priorities that an guide ODFW, NMFS and the numerous recovery implementation partners. This Plan relies on existing legal mandates to fund and implement many of the actions, but also relies on voluntary implementation of other proposed recovery actions. Within existing laws, regulations and agreements, ODFW and NMFS assume that that regulatory agencies will use this Plan to guide their decisions. This Plan is not a regulatory document, in that it does not require other agencies to implement actions. However, we assume that existing regulatory programs will continue to be funded and implemented and that regulatory agencies will use the Plan as a resource as they implement existing laws, regulations and agreements. If assessments and monitoring indicate that the status of the fish and the threats is not improving, more restrictive management, and possibly new or enhanced regulatory programs, may be necessary.

Given the numerous years that UWR Chinook salmon and steelhead have been listed under the federal ESA (Table 1-1), many entities have already implemented and continue to implement recovery actions based on: 1) draft versions of this Plan, and 2) the known conservation and recovery need of these ESUs. This Plan helps guide and prioritize the actions already being implemented at the population and ESU/DPS scales, and identifies other necessary actions at those scales to meet the recovery goals identified in Chapters 6 and 10.

Implementation Challenges

Despite the projection that desired status objectives for most, if not all, UWR Chinook and steelhead populations are achievable, there are significant challenges with respect to implementing enough actions and with enough intensity, to reach recovery goals. In addition, the developers of this Plan acknowledge that there may be alternative recovery actions to those proposed in this Plan, and it is anticipated that actions designed to meet a specific recovery objective may vary due to logistics, funding constraints, or an organization's authorities and administrative processes. Due to the voluntary nature of many of the actions in this Plan, there is uncertainty how long it will take to meet full implementation.. Factors beyond the control of this Plan include: 1) the funding obstacles and actual costs associated with recovery actions as they compete with other societal objectives in times of economic hardship at the local, State, and Federal level for both private and public entities, 2) the associated timeliness necessary to improve the status of certain populations, 3) the social feasibility of some actions where there is conflict with other societal goals and uncooperative or uninterested potential partners, and 4) initial uncertainty of technological feasibility and evaluation of some actions. In addition, as highlighted elsewhere in this Plan, there are projections of significant emerging threats to the listed ESU/DPS, manifested through climate change and human population growth.

Funding Strategies

Given the challenges of Plan implementation, and the large price tag associated with this and other recovery plans, and the limited funding available to address conservation and recovery actions within and across populations, and the region, ODFW and NMFS recommend that agencies take an integrated, strategic approach to funding to the extent possible. Project solicitations and selection for funds from the NPCC Fish and Wildlife Program/BPA, OWEB, NMFS Mitchell Act program, and others should take Plan priorities into consideration to address limiting factors and threats identified in the Plan to the extent possible. In addition, these funding entities should adopt overarching strategies consistent with the following:

- within the ESU and DPS, place a majority of funds in high priority actions and locations
- within the ESU and DPS, reserve some proportion of funds for lower priority actions and locations to encourage and engage ESU/DPS-wide conservation and recovery participation and achieve local Plan goals
- report funding activities in order to measure progress toward Plan objectives
- coordinate and standardize reporting metrics to assure they are appropriate for tracking purposes
- encourage innovative funding approaches such as targeted Requests for Proposals (RFPs) and Strategic Investment Partnerships (SIPs).

Decision Making and Implementation Structure

As discussed earlier, ODFW and NMFS acknowledge the numerous forums, groups, formal and informal partnerships, and involved citizens involved in some aspect of land and fish/wildlife conservation efforts. However, it is unclear how well these entities are functioning, coordinated, or governed within a conservation network, and there is some uncertainty on best approach for integrating UWR ESU/DPS actions, monitoring standards, and feedback mechanisms into such a network. To address these uncertainties, subsequent to completion of the Plan, ODFW and NMFS intend to publish an Implementation Schedule that will provide details of strategies, actions and timelines for implementation. Our goals for implementing the Plan and Implementation Schedule include establishing efficient and effective communication and coordination between and within numerous entities. On the one hand, we want to provide a structure for meeting and tracking progress towards recovery goals, linking with ongoing efforts and communicating clear policy and management messages. On the other hand, we want to avoid the formation of unnecessary standing committees and a 'recovery bureaucracy' in the Willamette.

We therefore propose the establishment of a Willamette Recovery Coordination Team (WRCT) to link:1) the many implementers of "on-the-ground" actions (including the Willamette Project BiOp WATER steering committee, State and Federal agencies, tribes, local governments, watershed councils and, non-governmental organizations (referred to here as action teams) and 2) RME programs that track results of such actions. The WRCT will be responsible for ESU/DPS-level reporting and coordinating (Figure 9-1).

The WRCT would o facilitate information exchange regarding: 1) Plan action priorities at local scales, 2) how to effectively implement those local priorities within other regional conservation efforts and coordinated funding strategies, 3) technical issues and resources, and 4) linkages to State, ESU/DPS, and regional forums. The WRCT will adapt and change the implementation schedule and coordination efforts as necessary to adjust to funding, available resources, and implementation needs.

Functionally, those involved in the plan implementation serve in two broad roles: coordination/facilitation (WRCT) and the several *Action Teams.* The WRCT will include

- ODFW Conservation and Recovery Program
- ODFW NW Region
- NMFS Salmon Recovery Branch
- NMFS Production and Inland Fisheries Branch

- OWEB
- GNRO

The WRCT provides oversight and vision to Recovery Plan implementation, serves as the sounding board for input from stakeholders on plan progress and direction, and convenes regional workgroups as needed. This team is the responsible entity for reporting ESU/DPS assessments to NMFS and shares accountability for species recovery in this Management Unit.

The following is an outline of the letter-coded functions in Figure 9-1, with a general description of the *Coordination Team* function.

A. ESU Coordination: WRCT coordinate with WATER BiOp Steering and Management teams for WP BiOp priority strategies, actions, and schedules.
   - *WP BiOp Action Teams* implement VSP and Listing Factor priority actions in WP BiOp implementation schedule

B. Priorities & Schedules: WRCT members help define priorities and coordinate 3-year implementation schedules with actions in other programs (WP BiOp habitat RPAs, TMDL WQMPlans, other) and watershed action plans. These schedules outline priorities for implementing the Plan in the upcoming years, and will be shared with habitat action teams and other entities involved in Recovery Plan implementation, including watershed councils, SWCDs, government agencies, other implementers, and the general public. First priority may be to complete a watershed assessment or a subbasin specific action Plans to determine specific locations for priority actions (if this has not already been done).

C. Funding: WRCT members (OWEB) coordinate with other funders (WATER-HTT, BPA/ODFW Wildlife mitigation, others) to package and fund acquisitions and restoration actions. The funding sources identified in the Plan or in the 3-year implementation schedule will be made aware of the schedule priorities and asked to adopt or support those priorities (Note: Many of the large WP BiOp actions are on fixed schedules within the terms of that document, but the WRCT will coordinate these schedules with non-BiOp actions).

D. Action Teams: WRCT member facilitate action implementation by managing database of potential implementers and connecting them for funding opportunities and priorities. Outreach and education is subcomponent.
   - *Habitat Action Teams* implement priority VSP and Listing Factor actions in 3-year implementation schedule. It will be up to the action teams coordinate internally to seek implementation commitment from local stakeholders and volunteers, and to regularly communicate with other implementing organizations to keep them informed on Plan implementation issues. Watershed Councils, SWCDs, cities, counties, land managers and other implementers will use the action priorities outlined in the three-year Implementation Schedules to identify projects to implement and seek funding.

E. RME Coordination: WRCT members coordinate with those implementing the Willamette Project BiOP RME and other ESA RME for program funding/development.
   - *RME Action Teams* implement WP BiOp RME program; integrate supplemental monitoring where there are gaps in other subbasins and Willamette mainstem

F. Reporting System: WRCT members coordinate development and maintenance of tracking and reporting system that is fed by four RME subcomponents. The Team will develop a reporting/tracking system for gathering information from implementers (including public agencies), and their funding entities, and develop annual reports on implementation accomplishment. These reports will be shared with implementers, funding entities, Oregon Plan Teams, and the general public. Annual reports will be used to assess the what was accomplished during the implementation period at the population and ESU level. The ESU Coordination Team will use the tracking system to periodically (quarterly or annually) review progress towards implementation of priority actions and to summarize local implementation needs for more effective progress in implementation (i.e., Watershed Council support, garnering support from key landowners or entities, resolve uncertainties in applying best approach for implementing priority actions, funding initiatives and facilitation, etc.)

G. Status Reports/Assessments: WRCT members coordinate generation of 1- and 5-year status reports and 12-year ESU assessment reports. Reports on RME results will be reported to the ESU Coordination Team to facilitate adaptive management. These results and any modifications to Plan implementation arising from the results will be conveyed to the action teams.

H. Adaptive Management: WRCT team coordinate alternative management direction, based on population performance during reporting and assessment cycles

I. Other Planning Forums: ESU-CT team coordinate with strategy and direction in other regional conservation planning efforts that have bearing on VSP and Listing Factor actions.

J. Policy Interface: WRCT team interact in policy venues in other natural resource regimes (example: Oregon Plan Core team, others)

The *Action Teams* will be comprised of various groups depending upon action type, location, or internal function. *Habitat Action Teams* will integrate their efforts with the various State agency teams associated with the Oregon Plan for Salmon and Watersheds, but priorities for UWR Chinook and steelhead projects will be guided by this implementation plan.

Habitat Action Team members will likely include members of the UWR Stakeholder Team (cities, utilities, private forest and agriculture representatives, conservation groups, Federal representatives, watershed councils, SWCD's) and other local stakeholders, interest groups, tribes and governments that are involved in land and aquatic resource management. This diverse group represents differing perspectives, missions, and geographic areas, but will function with the overall objective of collectively working together to achieve and advance Recovery Plan habitat objectives. These teams are comprised of the various local entities implementing local restoration and conservation actions via their respective authorities, mandates, missions, and work plans, and include watershed councils, SWCD's, Federal and State agencies, local governments, tribes, conservation groups, and utilities. Habitat teams will be encouraged to form informal and formal partnerships within subbasins and major reaches of the mainstem Willamette to achieve fish recovery and watershed goals. Many of these collaborative partnerships already exist. For example, many watershed councils currently function in this capacity with representation from a diverse set of interest and action groups. As appropriate, teams can form leadership roles for some members to facilitate coordination with the WRCT to support development of three-year implementation schedules, plans, and reports, and other project information. Team membership will be voluntary and the teams can determine any internal governance structure. These habitat Teams will lead the promotion of public involvement through outreach, education, and volunteer opportunities.

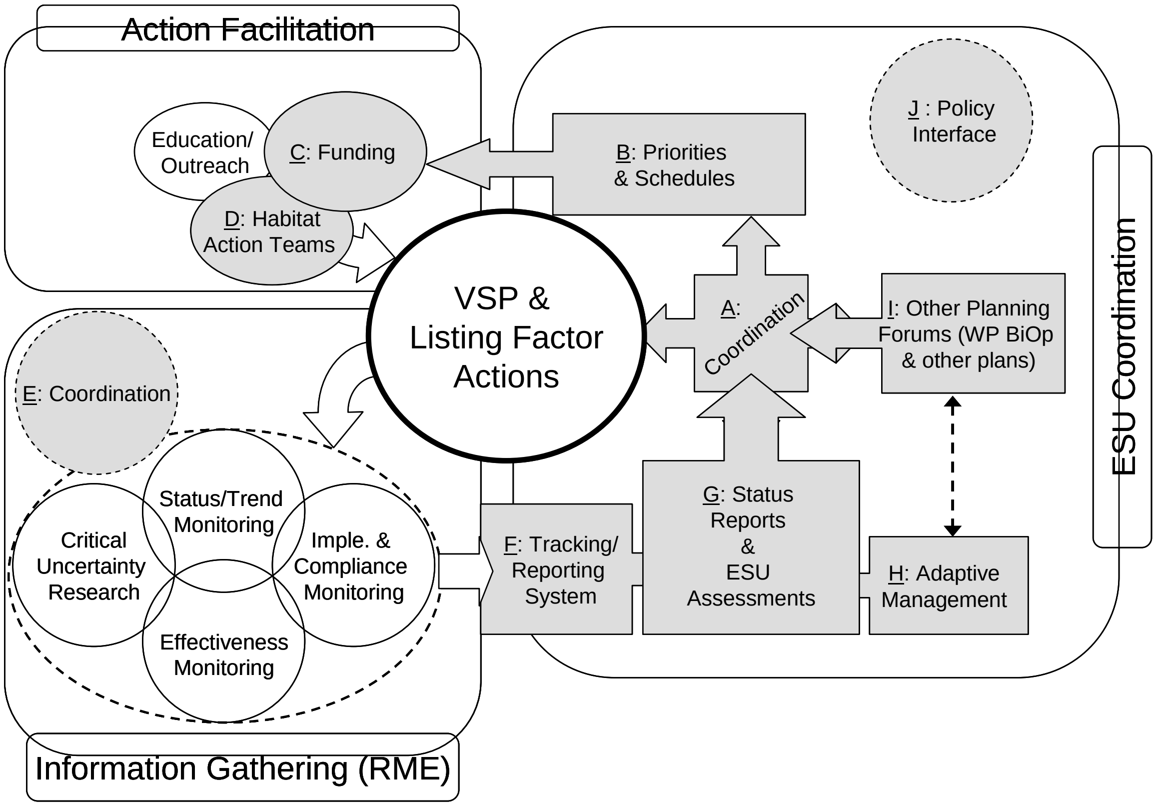

Figure 9-1. General structure and function of the implementation and adaptive management processes for the UWR Plan. See text for details.

9.3 Adaptive Management

Implementation of the Plan will be guided with an adaptive management process. UWR salmon and steelhead have complex life cycles which traverse habitats from high elevation tributaries to the open ocean. Life history strategies are diverse and life stage specific habitat requirements are complex. As described earlier in this Plan, there are many LFTs that influence the viability of UWR Chinook and steelhead at all life stages. The suite of proposed management actions to address primary limiting factors and threats across the entire life cycle is equally broad and diverse. Although the limiting factors and threats, as well as the management actions, have been developed based on best available science, there remains considerable uncertainty regarding the outcomes and effectiveness of the proposed management actions and the status of populations. It is this uncertainty which generates the essential need for an effective adaptive management process.

A successful adaptive management process requires an understanding of how and why salmon and steelhead and their associated habitats respond to the management actions taken to improve their status. In addition, success requires a decision framework and process which considers new information in the development of future management actions. This Plan does not preclude the development of future, more detailed comprehensive actions at a later date through regulatory processes (e.g., BiOp, NEPA and ESA; HGMP development), assuming they be advised by the overarching strategies identified in this Plan.

A detailed RME Plan is presented in Chapter 8 which provides the foundation for gathering and synthesizing the essential information needed for adaptive management of this salmon and steelhead recovery effort. Information needs fall into four categories: 1) status and trends monitoring; 2) implementation and compliance monitoring; 3) action effectiveness monitoring; and 4) critical uncertainty research. The RME Plan links the biological and physical responses to the management actions.

Adaptive Management Plan

The Plan is intended to describe key elements for immediate implementation and also provide a strategic means of improving management decisions in the future – in essence, to be a living document. This will be done through an adaptive management process that will allow for the continual assessment of the effectiveness of management strategies and actions to improve the status of UWR Chinook and steelhead. Through the analyses of RME data, the Oregon Plan Core Team, Regional Management Team, and other advisory groups will be able to determine if the premise of the Plan – that the management strategies will be able to help the ESU and DPS achieve desired status – is accurate. If not, the adaptive management process will allow for the State of Oregon to consider a different premise.

The adaptive management process for the Plan will utilize the information gathered from the RME Plan to evaluate the effectiveness of the Plan in achieving its goals. This information will be considered at regular intervals to assess the progress in population and ESU/DPS health, along with the success of implementing actions and the effectiveness of those actions. These regular assessments will occur at three levels and within an implementation governance framework described above.

1. Annual status reports. The WRCT will direct production of a brief annual report that reviews the most recent data available for the ESU/DPS. This annual report will serve as an *early warning system, meaning reductions in abundance could* alert us to unexpectedly adverse marine conditions; management conditions; biological characteristics of the UWR fish populations; or the habitat that supports the ESU/DPS. The annual report will also formally document adaptive management decisions and actions, as well as how they relate to actions, desired statuses, and delisting threat reduction scenarios in this Plan.

2. Five-year status report. Oregon will provide RME information to NMFS for their five-year status reports, including a succinct status report regarding implementation of commitments by agencies, restoration work accomplished, and summarizing salmon, steelhead and habitat data available by population.

3. Twelve-year ESU/DPS assessment. Produce a comprehensive assessment of the status of the ESU and DPS, conducted by an appropriate team of scientists from different agencies. The assessment will include viability metrics, trends in habitat, and implementation and effectiveness of restoration and management commitments. This assessment would be similar in scope to the 2005 Oregon Coastal Coho Assessment (ODFW 2005b). Depending on the outcome of this thorough 12-year assessment, the periodicity of future detailed assessments may be adjusted.

The adaptive management process will play out on different levels as the Plan is implemented. Annual RME information collected will be reviewed to determine the effectiveness of large-scale strategies and actions, and in some cases, site-specific actions. Those actions found to be ineffective will be discouraged. New actions based on the results of research may be proposed to more effectively implement a strategy. The State will make these responsive adjustments as more information is collected. Considering changes to strategies will be a more deliberative process.

Assessing the effectiveness of the Plan, including its strategies, will be conducted in 2023, and periodically thereafter. An assessment will also be considered if information suggests there has been a significant decline in the health of any of the ESU/DPS (i.e., the annual report will serve as an early warning system). Assessments of the Plan will be coordinated by the WRCT, with involvement of Oregon Plan teams, and will include public participation.

The adaptive management process can lead to changes in all aspects of the Plan. The review of information may suggest revision of one or more of the RME's measurable criteria, their metrics, or thresholds for passing. Any such revisions would involve NMFS and other co-managers. If the periodic assessment of this Plan's effectiveness shows that progress is not being made toward achieving the desired status of the ESU or DPS, it may be necessary to consider other approaches to obtain the improvements in survival needed. In this situation Oregon will convene the Planning Team and consider alternate approaches. The first alternative to consider would be whether the timeline identified for delisting is appropriate. If it is determined that the timeline is still appropriate, alternative actions should be considered. It is impossible to outline all of the potential alternatives to consider without knowing what the results of RME that may have been conducted have concluded. Some alternatives that may be considered include: implementing additional actions that have immediate benefits, such as those related to harvest and hatcheries; identifying actions that seek to increase the level of protective and restorative practices for tributary habitat, potentially shifting from mostly voluntary to more regulatory approaches; or developing new actions for threats that were not initially identified as limiting. This list of potential alternatives is not complete and these additional actions are not suggested at this time. They are only being provided as examples of what might be considered in the future.

Population Status Assessments

The effectiveness of this Recovery Plan to recover Chinook and steelhead in the Willamette basin will be determined by regularly assessing the status of each population over time. To determine the status of each population, an assessment will be made of each population's current status utilizing the interim measurable criteria identified in Chapter 8. A comparison of that current status to the population's status at the time the Plan was implemented, or the population's status at the time of the prior assessment, will be used to determine whether status has improved, remained the same, or declined. Status cannot be evaluated over a short period of time, but may be discernable prior to the full assessment period called for within each interim criterion (e.g., six straight years of lower than expected abundance and productivity would cause the abundance criterion to be considered unmet before the full 12 years had expired).
A decline in the status of any population would require Oregon to evaluate whether the decline is the result of ineffective actions, or unforeseen limiting factors and threats. If a population decline is indicated, the WRCT will convene appropriate entities and groups to consider the cause for the decline and the strategies and actions necessary to reverse the decline and set a trend towards recovery. The results of this assessment and proposed strategies and actions will be shared with the public and the legislature. Assessments showing no change in population status, or improvement, will be utilized to determine if the strategies and actions implemented are as effective as anticipated. Action effectiveness will be considered during the 12-year review process.

Future NMFS Status Reviews and Plan Modifications

The future implementation of this Plan relies heavily on incorporating knowledge gained from research, monitoring, and evaluation of populations, limiting factors and threats, and the actions designed to achieve the desired statuses. As part of this adaptive management process, the ESA requires a review of all listed species at least once every five years. The NMFS interim recovery guidance (NMFS 2007b) requires that immediately following this five-year review, approved recovery plans will be reviewed, in conjunction with implementation monitoring, to determine whether or not the Plan needs to be brought up to date.

The NMFS Interim Recovery Guidance describes three types of Plan modifications: (1) an update; (2) a revision; or (3) an addendum. An update involves relatively minor changes. An update may identify specific actions that have been initiated since the Plan was completed, as well as changes in species status or background information that do not alter the overall direction of the recovery effort. An update does not suffice if substantive changes are being made in the recovery criteria or if any changes in the recovery strategy, criteria, or actions indicate a shift in the overall direction of recovery; in this case, a revision would be required. Updates can be made by NMFS and would be forwarded to stakeholders and cooperators, and posted on the NMFS website. An update would not require a public review and comment period. NMFS expects that updates will result from implementation of the adaptive management program for this Plan. Minor addenda such as information updates to implementation strategies also can be added to a Plan after it has been approved. A revision is a substantial rewrite and is required if major changes are needed in the recovery strategy, objectives, criteria, or actions. A revision may also be required if new threats to the species are identified, when research identifies new life history traits or threats that have significant recovery ramifications, or when the current Plan is not achieving its objectives. Revisions must include a public review and comment period.

Chapter 10: Broad Sense Recovery

This Chapter describes Oregon's goal of broad sense recovery. The earlier chapters in this Plan defined what NMFS considers will be necessary for the UWR ESU and DPS to be viable and delisted. Along with this definition, the chapters have described the 1) current status of the ESU and DPS and respective populations, 2) criteria and desired population statuses for delisting the ESU and DPS, 3) factors limiting the populations, and 4) the threat reduction actions needed to close the population conservation gaps from current statuses to desired statuses. If the actions identified in this Plan are adopted, we think the ESU/DPS delisting recovery goals will be achieved. Achieving the level of recovery defined in the threat reduction scenarios (Chapter 6) will result in a majority of the populations in the ESU and DPS remaining or becoming viable (low or very low risk) and the other populations remaining at current levels of risk or achieving less degree of extinction risk. Within this delisting scenario framework, some UWR Chinook and steelhead populations are not targeted for viable status, and these populations may provide lesser benefits to Oregonians than those with higher recovery goals. Under delisting criteria, these populations will provide insurance against an ESA listing, but they would only retain remnants of what they historically represented. Even for populations that are targeted to achieve viability, it is expected they will be able to withstand some level of incidental impact from fisheries targeting hatchery fish, but may not be healthy enough to accept additional risks such as direct harvest. Although returns of wild spawners will number in the several thousands in some populations in the ESU and DPS, they may not be numerous enough to seed the full capacity of a population area. As such, many stream reaches may remain unoccupied by wild Chinook salmon and steelhead, and many people will not be aware that they are living in ecosystems that are natural nurseries for anadromous salmonids, and that could support greater natural production and healthier linkages between salmonid life stages.

10.1 Goal for Broad Sense Recovery

For many Oregonians, maintaining salmon and steelhead populations as something close to museum pieces is not enough. The public advisory group that helped develop Oregon's Native Fish Conservation Policy (NFCP) recognized this and supported the objective of conserving Oregon's native fish at levels that can "provide recreational, commercial, cultural and aesthetic benefits … to present and future citizens" (ODFW 2003). The NFCP uses this statement as the basis for a desired status within each native fish conservation Plan. This objective also fulfills the mission of the *Oregon Plan for Salmon and Watersheds*, which is to restore "Oregon's native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits". The *Oregon Plan for Salmon and Watersheds* is founded on the principle that citizens throughout the region value and enjoy the substantial ecological, cultural and economic benefits that derive from having healthy, diverse populations of salmon and steelhead. Such a desired status is also considered in ESA recovery plans and has been called "broad sense recovery." Since this Plan serves as a State of Oregon Conservation Plan and has two desired statuses, we use the term "broad sense recovery" to represent the long-term goal of this Plan. The UWR Stakeholder Team that helped develop this Conservation and Recovery Plan discussed the idea of broad sense recovery early in the planning process. Based on those discussions a general goal for wild populations of salmon and steelhead in the UWR ESU and DPSs was developed.

<u>Broad Sense Recovery Goal</u>

Oregon populations of naturally produced salmon and steelhead are sufficiently abundant, productive, and diverse (in terms of life histories and geographic distribution) that the ESU and DPS as a whole (a) will be self-sustaining, and (b) will provide significant ecological, cultural, and economic benefits.

10.1.1 Broad Sense Recovery Criteria

The following criteria have been developed to help measure attainment of the broad sense recovery goal.

1. All UWR Chinook and steelhead populations have a "very low" extinction risk and are "highly viable" over 100 years throughout their historic range, and
2. The majority of UWR salmon and steelhead populations are capable of contributing social, cultural, economic and aesthetic benefits on a regular and sustainable basis.

The first criterion can be measured based on the risk of extinction over 100 years being less than 1% – the same metric for a population at very low risk. It is uncertain whether the achievement of this criterion in itself will lead to the achievement of the broad sense recovery goal, or if greater improvement in status is needed to achieve the second criterion of broad sense recovery. It can also be measured based on the abundance monitoring and targets identified in Chapter 8. The second criterion is much more subjective and will be based on value judgments made during the regular 12-year Plan assessments. These judgments will likely include a review of the amount and types of fisheries being supported by each wild population, the public perception of how healthy the populations are, and whether any cultural or aesthetic uses of the populations are being limited.

Broad sense recovery is a long-term goal for the UWR ESU and DPS. There are no rules or laws that require that it be achieved within a stated period of time; rather it will be a goal to measure progress against. Because the broad sense recovery goal requires all of the populations to be highly viable, the UWR ESU and DPS will achieve the delisting recovery goal before they achieve broad sense recovery. It is likely that some populations can achieve the first broad sense recovery criterion (very low risk of extinction) well before other populations. For a few populations, it appears possible to go beyond very low extinction risk, and for those populations (with a VL+ risk class in Table 10-1) the broad sense desired status is to achieve that higher level of viability.

10.2 Broad Sense Scenarios

The effort needed to achieve broad sense recovery for all of the populations is uncertain, but believed to be substantial and well beyond what is necessary to achieve the delisting scenarios. Table 10-1 shows the current and broad sense abundances for each population and the gap between the two under their respective broad sense scenarios. The current impacts can be found in the scenario tables in Chapter 6.

The amount of effort needed to achieve the threat reductions called for in Table 10-1 is difficult to determine. For this reason, a focus of this Conservation and Recovery Plan is defining the details of the threat reduction scenarios to meet population-level desired statuses for ESU and DPS delisting, and what must be done to achieve these desired statuses. Population recovery targets within the ESU and DPS delisting context are the first priority for this Plan, but population broad sense recovery is the long-term goal.

10.3 Strategies and Actions to Achieve Broad Sense Recovery

As mentioned above, it is likely that populations will reach their desired status for the ESU and DPS delisting scenario before they achieve broad sense recovery. As progress is made in implementing the actions identified in Chapter 7, the effectiveness and status monitoring identified in Chapter 8 will help define how much effort will be needed to achieve not only desired delisting status recovery, but broad sense recovery as well. The factors outlined in Chapter 5 that currently limit UWR salmon and steelhead from achieving the desired statuses defined in Chapter 6 threat reduction scenarios are also the same factors limiting the achievement of the broad sense scenarios. It will require reducing the impacts of those factors to the levels indicated in Table 10-1, a greater extent than required for the delisting threat reduction scenarios, to achieve the broad sense scenarios. Just as the same limiting factors must be addressed for broad sense as for desired delisting status, the same strategies and actions identified to achieve those statuses (Chapter 7) will need to be implemented for broad sense – only to a greater level or on a broader scale. As a result, no additional actions are identified in this Plan to achieve broad sense recovery. The quantity of work identified that must get done to achieve the threat reductions outlined in the delisting scenarios can be used to gauge how much additional work will be needed to achieve the threat reductions needed to achieve very low risk throughout the ESU/DPS.

The threat reduction scenarios identified for each population to achieve broad sense recovery (Table 10-1) outline the amount each threat category must be reduced. For those populations that there is confidence that they can achieve the broad sense scenario, the threat impacts for all but the freshwater habitat impacts show the same threat impact rate as was defined for desired status. This results in the required reduction in threat impact coming only from additional improvements in freshwater habitat. For the North Santiam, South Santiam, and Middle Fork Willamette Chinook salmon populations, it is unlikely to achieve the broad sense status of very low risk of extinction or beyond very low risk, and they are not included in Table 10-1. These scenarios are considered unlikely to be achieved because they call for reductions beyond what the Planning Team believed to be possible. For these populations, it will be necessary to monitor their status improvement as actions are implemented to achieve their delisting desired status.

Additional actions may be needed in some population areas to obtain the hatchery threat reductions associated with achieving very low risk (hatchery spawners comprising 10% or less of the natural spawners). Some, or most, of these reductions may be achieved through actions already proposed to address this threat in other populations' delisting scenarios (addressing stray hatchery fish from out-of-ESU/DPS areas). The same actions identified to remove hatchery fish in some populations under the desired status scenario would need to be implemented for those populations needing still further reductions in spawning hatchery fish under the broad sense scenario.

Additional threat reductions in estuary habitat will need to be reevaluated as the effectiveness of actions taken in the estuary become known. The threat reduction used in all of the population scenarios came from the proposed NMFS Estuary Module (NMFS 2008b) and was a hypothetical value the scientists suggested could be achieved if all actions identified in the Module were implemented to their fullest. Effectiveness monitoring may determine that greater benefit is being achieved from implemented actions than NMFS scientists thought. Until such evidence is found, no additional estuary habitat actions are proposed to achieve the broad sense scenarios. While the same tributary actions identified for achieving delisting scenarios in Chapter 7 will be needed for broad sense recovery, additional site-specific locations beyond those identified and treated for delisting recovery will need to be identified and the actions implemented. The locations for additional actions will come from data gathered from implementing actions in Chapter 7 that call for documenting habitat conditions and prioritizing locations. The level of additional habitat actions needed to achieve the broad sense scenarios will become apparent as results of RME associated with determining which actions should be implemented and the effectiveness of actions become available.

10.4 Implementation and Adaptive Management for Broad Sense Recovery

The RME identified in Chapter 8 and adaptive management process outlined in Chapter 9 will inform the WRCT on progress towards achieving the broad sense recovery goal. The benchmarks under development in Chapter 8 to measure progress related to biological recovery and to address the five ESA listing factors can also be used to determine progress towards broad sense recovery. The results of effectiveness monitoring will help determine how long it may take to achieve broad sense recovery, or if it appears to even be possible. The results of RM&E will inform the quantity, types and locations of actions that need to be implemented to achieve broad sense recovery, or results may identify that additional strategies may be needed to address a newly discovered limiting factor.

The adaptive management process identified in Chapter 9 has already been identified as being a crucial part of this Recovery Plan being effective and successful at achieving the desired delisting status. It will be even more important to the achievement of broad sense recovery. The uncertainties around what broad sense recovery looks like, what effort it will take to achieve it, and how long it will take to achieve it, are greater than those surrounding desired delisting status. The annual and periodic review of information related to implementation of the actions identified in this Plan, the changing status of populations and the resolution of critical uncertainties will be necessary to begin to lessen the uncertainties surrounding broad sense recovery. Through the adaptive management process the Implementation and Recovery Teams will learn not only what is working and what is not, but also how responsive each population is to improvements made and how that influences the need for additional actions and progress towards delisting and broad sense recovery.

10.5 Conclusion

The development of an effective implementation framework coupled with a responsive adaptive management Plan provides the best assurance that the *UWR Conservation and Recovery Plan for Chinook Salmon and Steelhead* will be fully implemented and effective. The identification in this Plan of the gaps that must be closed to achieve both delisting and broad sense recovery, along with the highlighting of the key and secondary factors that have caused those gaps and the actions necessary to address those factors and reverse their impacts, will ensure that the goals for recovery will be achieved if fully implemented. Implementation and the success of this Plan, however, relies on more than just what is described and identified in this Plan. This Plan will only be successful if the citizens of Oregon living within the Willamette basin embrace this Plan and voluntarily take the actions that are described here. It is only through the involvement of all of those who live and work in this area that recovery will be achieved.

Table 10-1. Summary of Broad Sense recovery targets, and reductions in current mortality impacts to meet Broad Sense recovery goals for UWR Chinook and steelhead populations.

		Broad Threat Management Categories & Sub-Categories / Mortality Rates of Threats										Total Reduced Life Cycle Impact			VSP Extinction Risk Class			
		ood Control / Hydropower (subbasin)				FW Land Use Management	Estuary LFT's	Other Species	Harvest Management	Hatchery Management								
		Spawner Access	Juvenile Passage	Spawner Habitat Conditions	Juvenile Habitat Conditions	Adult and Juvenile Conditions	Land Use & Flood Control/Hydro	Competition / Predation	Adults	Juv Competition / Predation	Adults							
Population	Status	SAM	JPM	SHM	JHM	FWHM	EHM	OSM	HM	JCM	HFM	Cumulative Mortality	% Mortality Reduction	Abundance	A&P	DV	SS	Overall Risk
Clackamas CHS	Current	0.27				0.83	0.10	0.12	0.25	---	0.33	95%	---	1,369	M	M	L	M
	Broad Sense	0.24				0.54	0.08	0.07	0.25	---	0.10	80%	16.2%	5,618	VL+	L	L	VL+
Molalla CHS	Current	0.00	0.00	0.00	0.00	1.00	0.10	0.16	0.25	5.0%	0.95	100%	---	0	VH	H	H	VH
	Broad Sense	0.00	0.00	0.00	0.00	0.65	0.08	0.08	0.25	5.0%	0.10	81%	19.1%	2,627	VL	L	L	VL
Calapooia CHS	Current	0.00	0.00	0.00	0.00	1.00	0.10	0.16	0.25	5.0%	0.95	100%	---	0	VH	H	VH	VH

	Broad Sense	0.00	0.00	0.00	0.00	0.65	0.08	0.08	0.25	5.0%	0.10	81%	19.1%	1,815	VL+	L	L	VL+
McKenzie CHS	Current	0.25	0.00	0.10	0.56	0.56	0.10	0.18	0.25	5.0%	0.35	96%	---	4,889	VL	M	M	L
	Broad Sense	0.15	---	0.10	0.53	0.36	0.08	0.09	0.25	5.0%	0.10	88%	8.3%	13,613	VL+	L	L	VL+
Molalla STW	Current	0.00	---	0.00	0.00	0.94	0.10	0.16	0.16	5.0%	0.19	97%	---	2,456	L	M	L	L
	Broad Sense	0.00	---	0.00	0.00	0.61	0.08	0.08	0.16	5.0%	0.05	75%	22.8%	19,470	VL+	L	L	VL+
N. Santiam STW	Current	0.48	---	0.00	0.57	0.57	0.10	0.17	0.16	5.0%	0.14	95%	---	3,668	L	M	H	L
	Broad Sense	0.37	---	0.00	0.48	0.37	0.08	0.08	0.16	5.0%	0.05	87%	8.9%	10,013	VL+	L	L	VL+
S. Santiam STW	Current	0.18	---	0.00	0.66	0.66	0.10	0.17	0.16	5.0%	0.04	95%	---	2,715	VL	M	M	L
	Broad Sense	0.14	---	0.00	0.66	0.43	0.08	0.08	0.16	5.0%	0.04	89%	5.6%	5,371	VL+	L	L	VL+
Calapooia STW	Current	0.00	---	0.00	0.00	0.96	0.10	0.16	0.16	5.0%	0.00	98%	---	416	M	M	H	M
	Broad Sense	0.00	---	0.00	0.00	0.62	0.08	0.08	0.16	5.0%	0.00	75%	23.6%	4,471	VL+	L	L	VL+

Chapter 11: References

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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
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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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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.

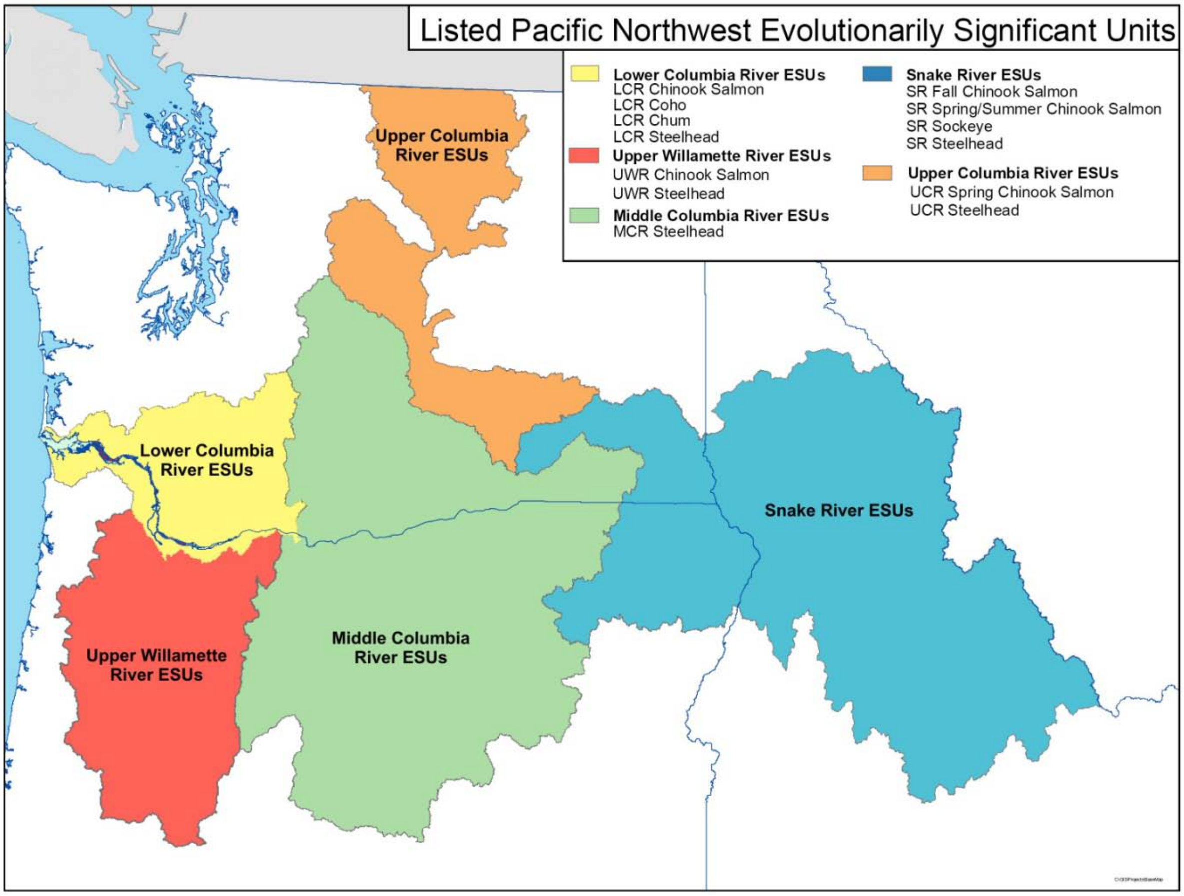

FIGURE ES-1
Listed Pacific Northwest ESUs

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).

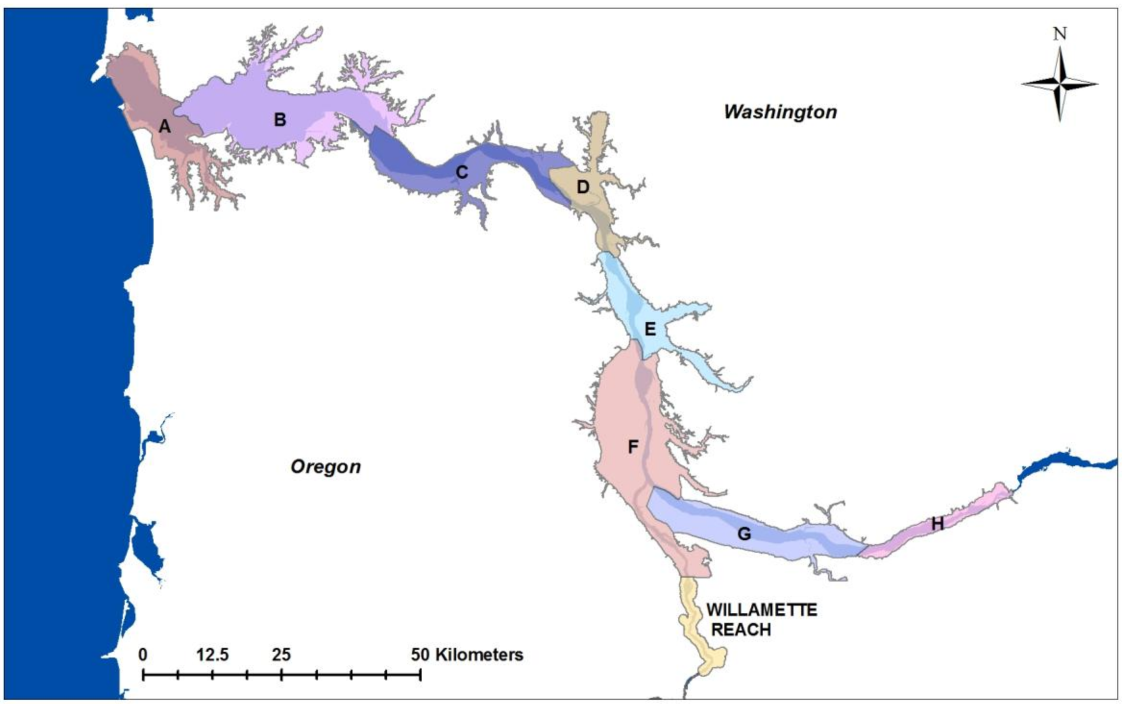

FIGURE 1-2
Lower Columbia River Estuary Reaches
(Adapted from Northwest Power and Conservation Council 2004.)

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.

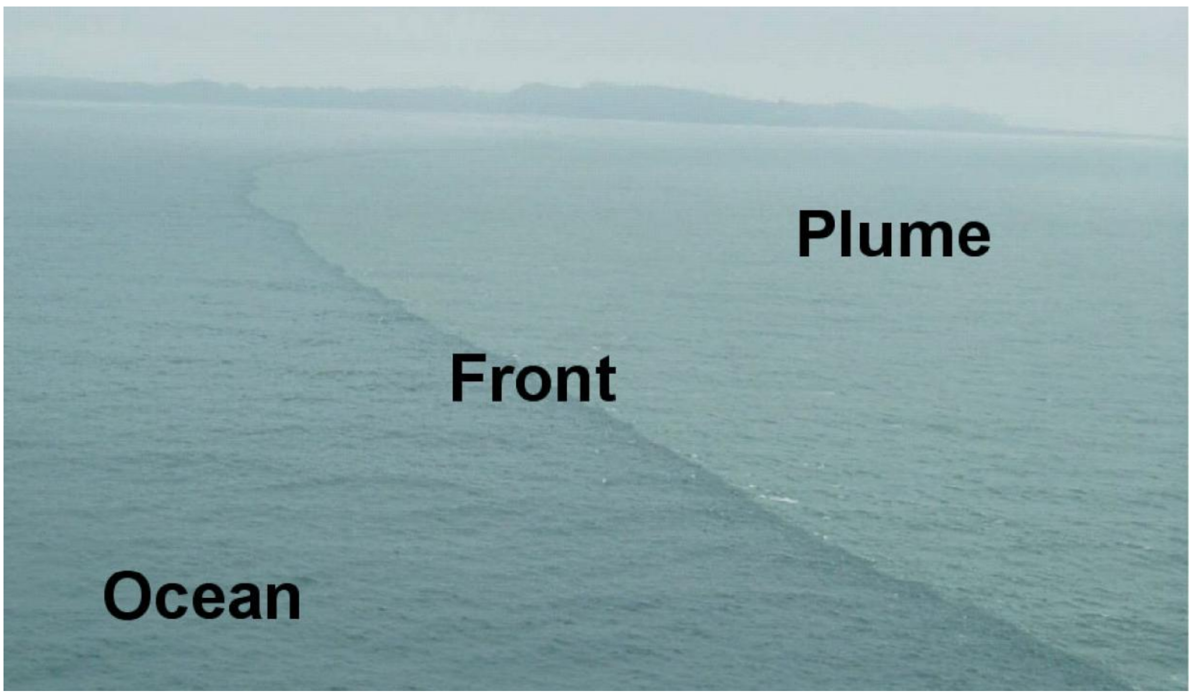

FIGURE 1-3
Plume Front
(Photo courtesy of NMFS.)

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.

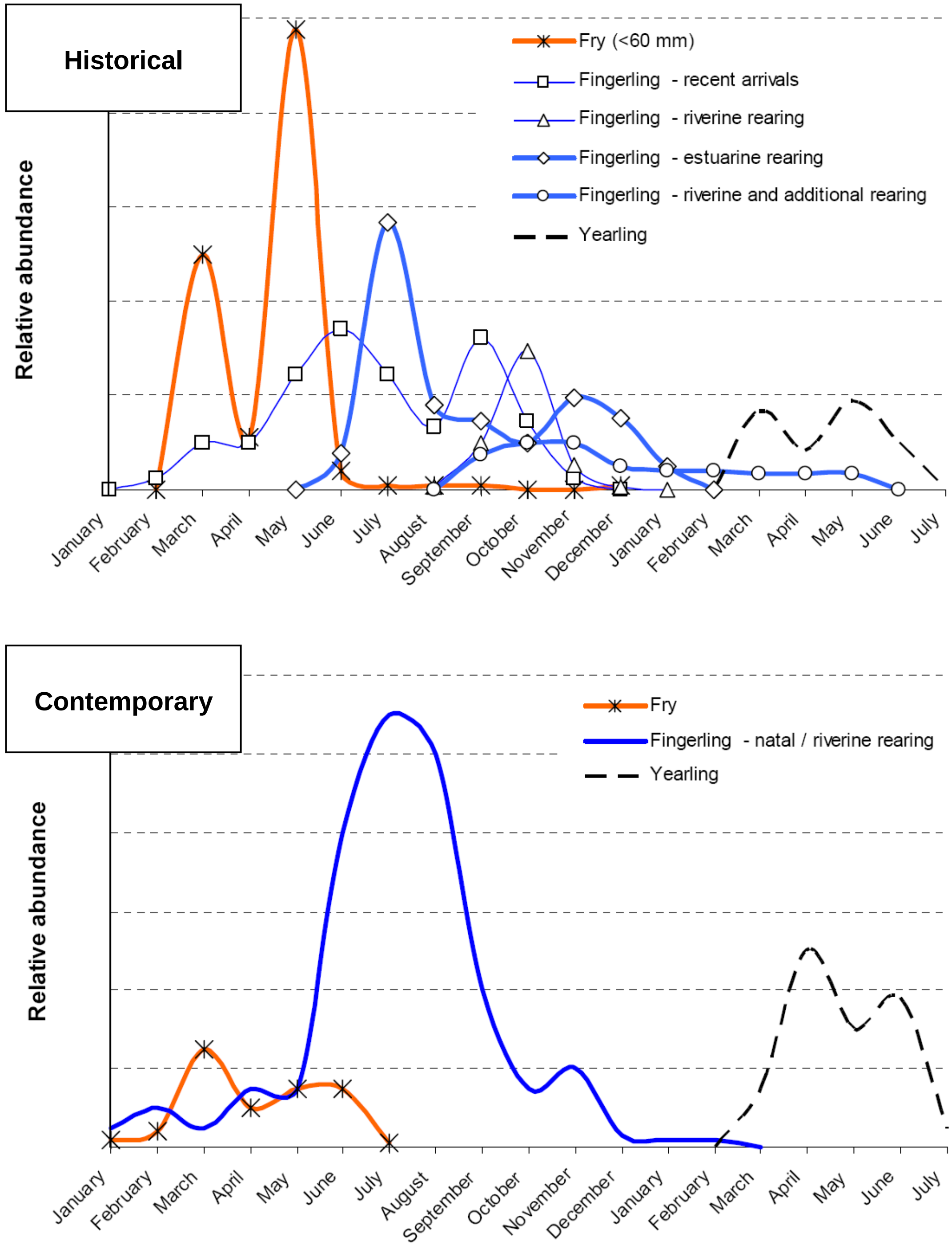

FIGURE 2-1
Historical and Contemporary Early Life History Types of Chinook Salmon in the Columbia River Estuary
(Reprinted from Fresh et al. 2005.)

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.

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[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.

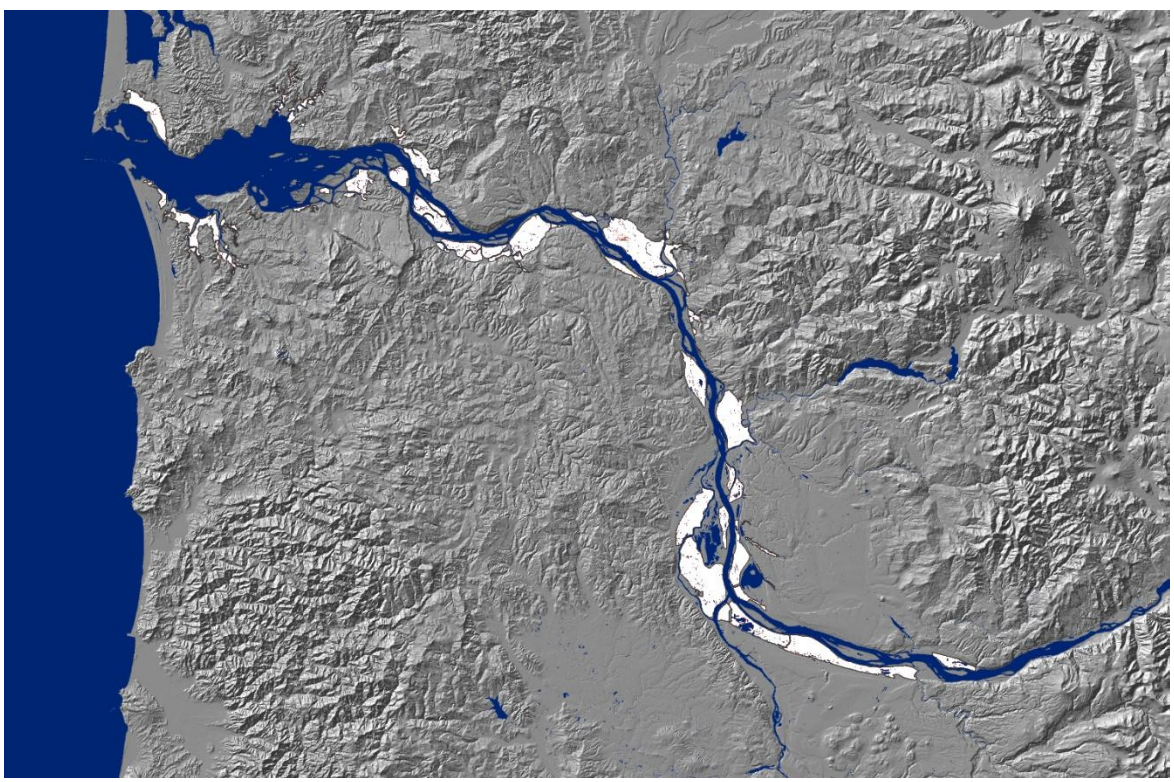

FIGURE 3-1
Diked Areas in the Columbia River Estuary
(Source: Lower Columbia River Estuary Partnership 2005.)

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).

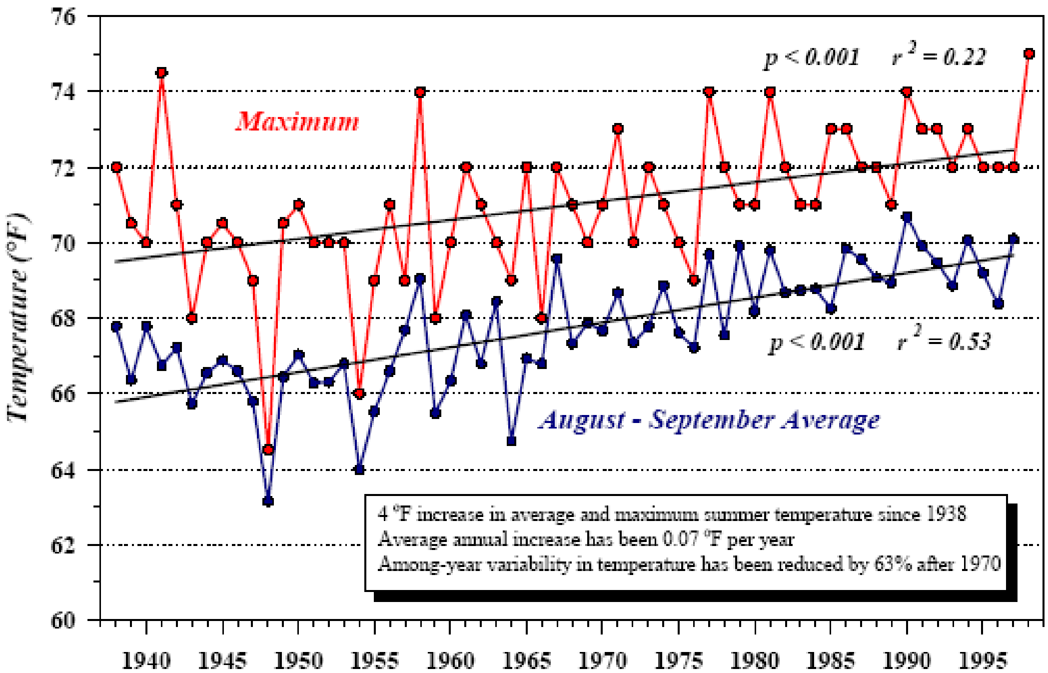

FIGURE 3-2
Temperatures of Water Entering the Estuary
(Reprinted from Lower Columbia Fish Recovery Board 2004.)

(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.

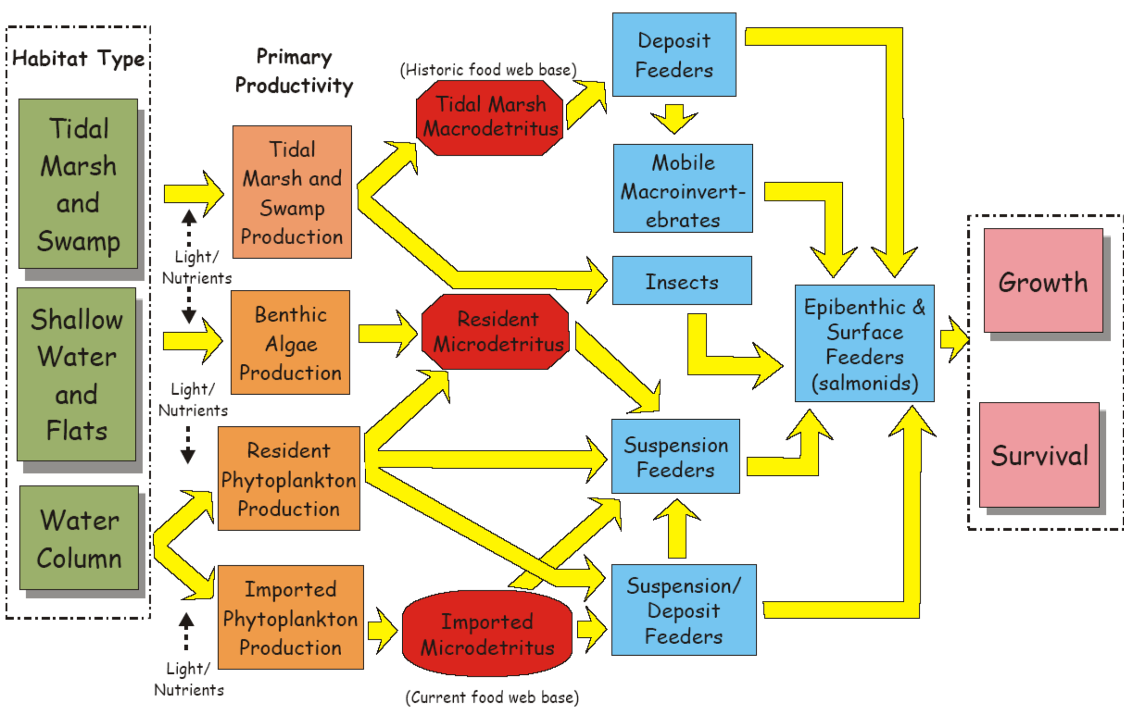

FIGURE 3-3
Conceptual Model of the Columbia River Estuary Food Web

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.

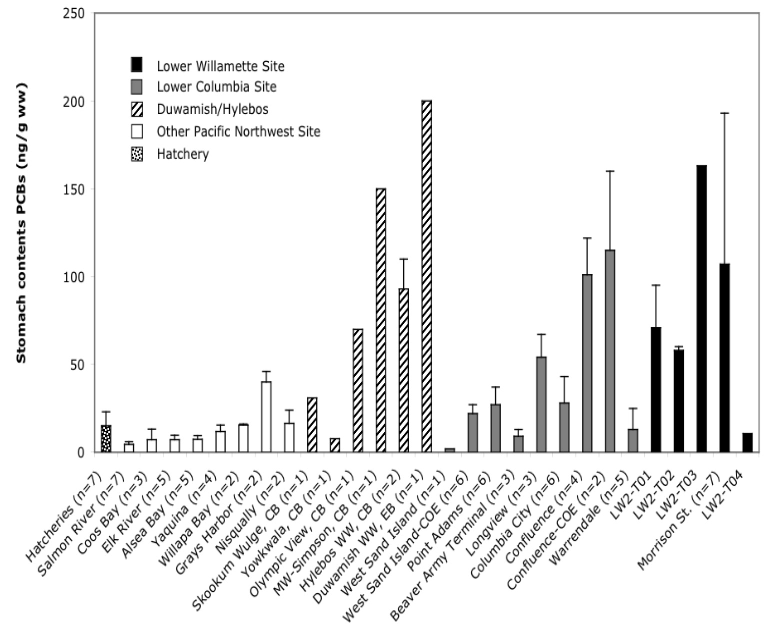

FIGURE 3-4

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)

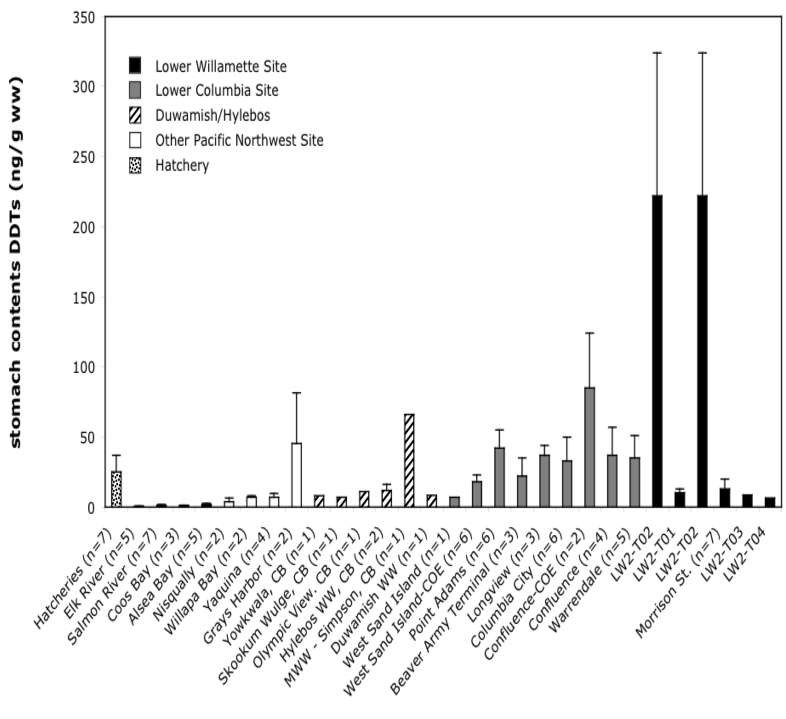

FIGURE 3-5

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)

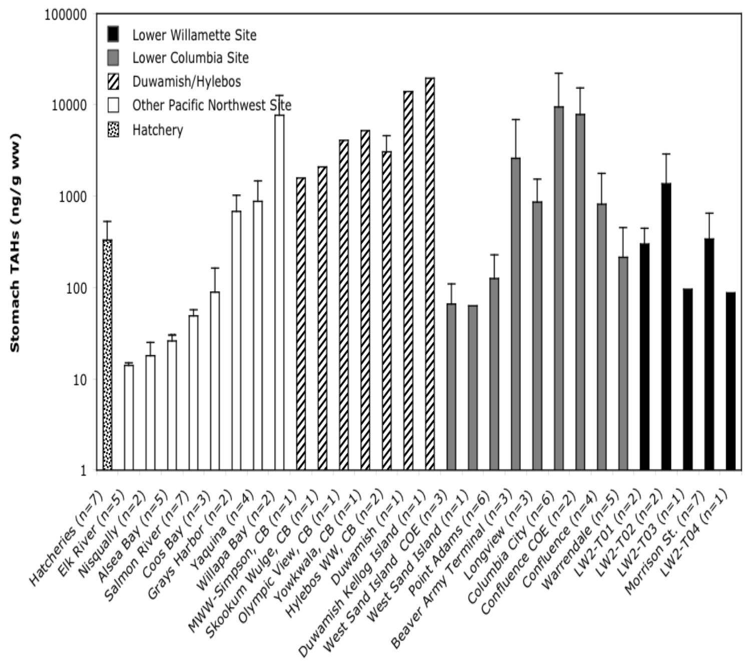

FIGURE 3-6

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.

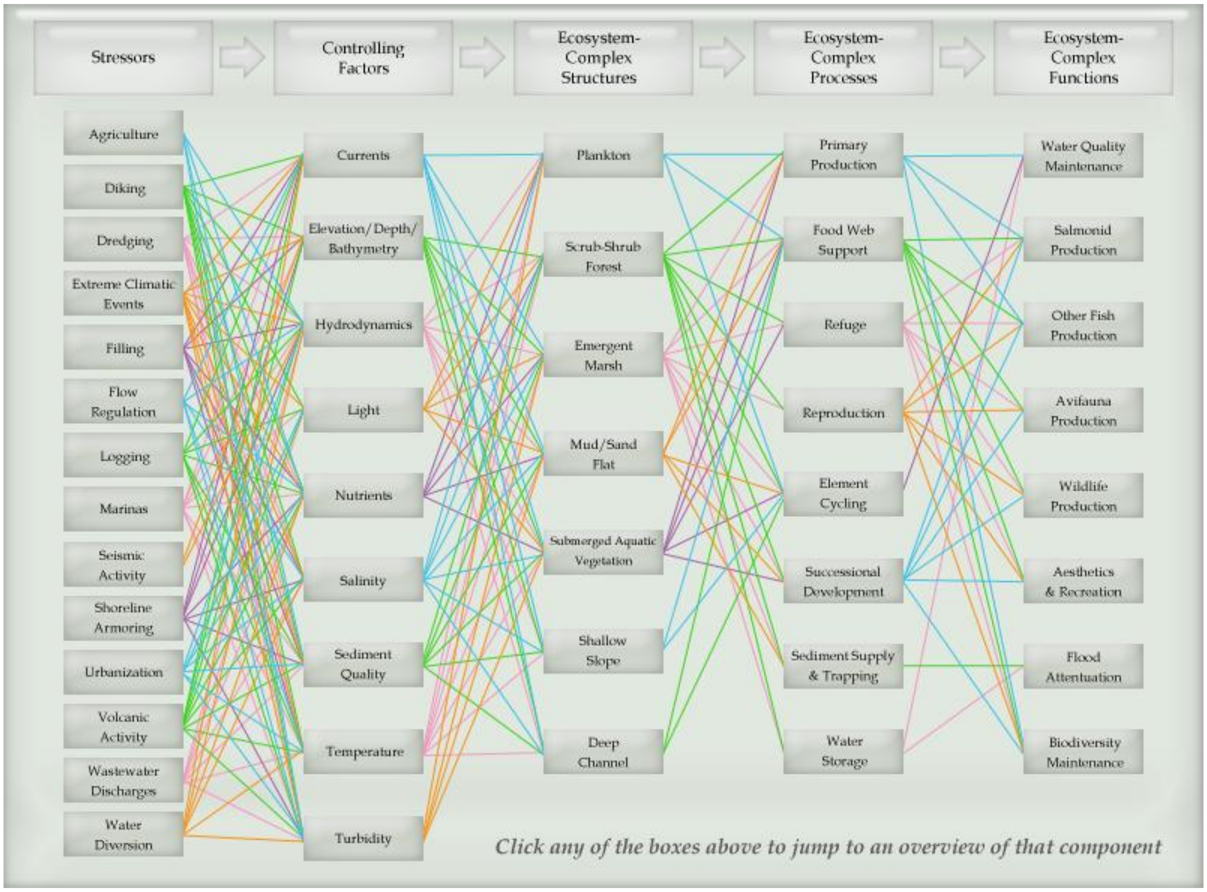

FIGURE 4-1
Conceptual Model of the Columbia River Estuary
(Note: "Stressors" are equivalent to threats as defined in this module.)
(Figure provided courtesy of the U.S. Army Corps of Engineers.)

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.

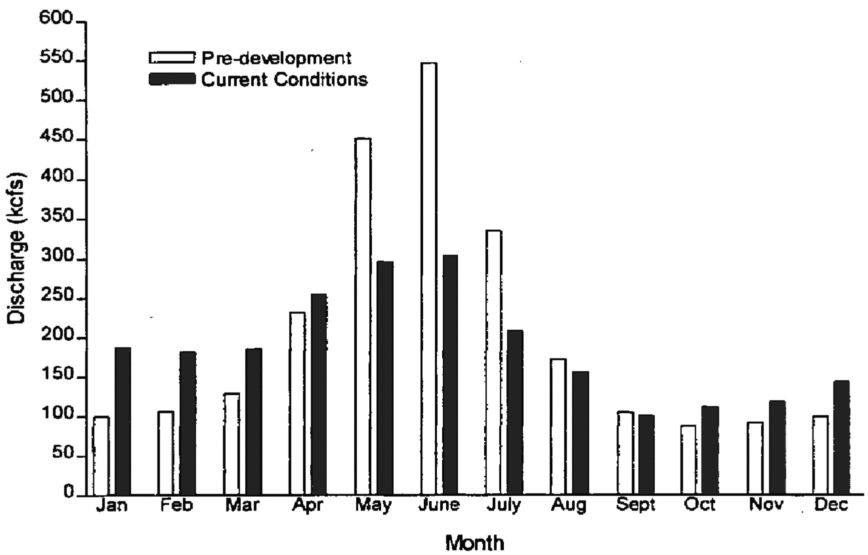

FIGURE 4-2
Changes in the Annual Columbia River Flow
(Adapted from National Marine Fisheries Service 2000.)

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.

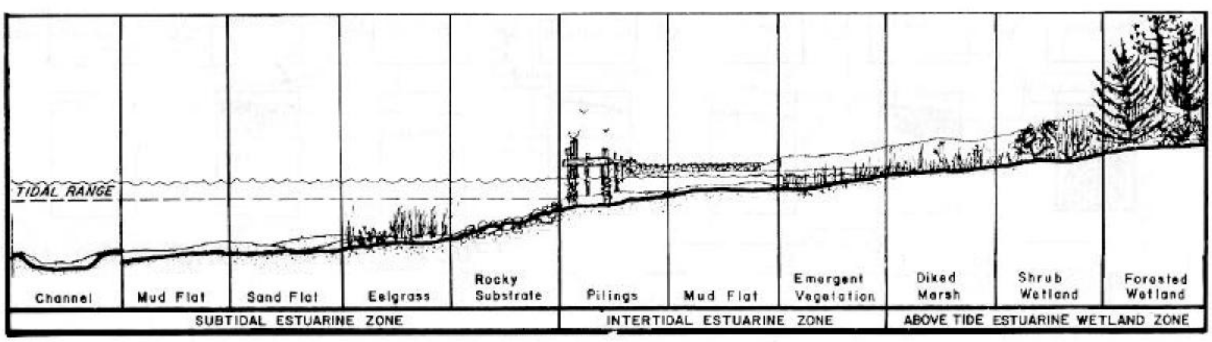

FIGURE 4-3
Subtidal, Intertidal, and Above-Tidal Estuarine Wetland Zones

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	HIGH
Dikes and filling	15	↑
Altered predator/prey relationships	12	
Urban and industrial practices	12	
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	
Over-water structures	4	↓
Ship ballast practices	3	LOW

* 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

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[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*

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[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").

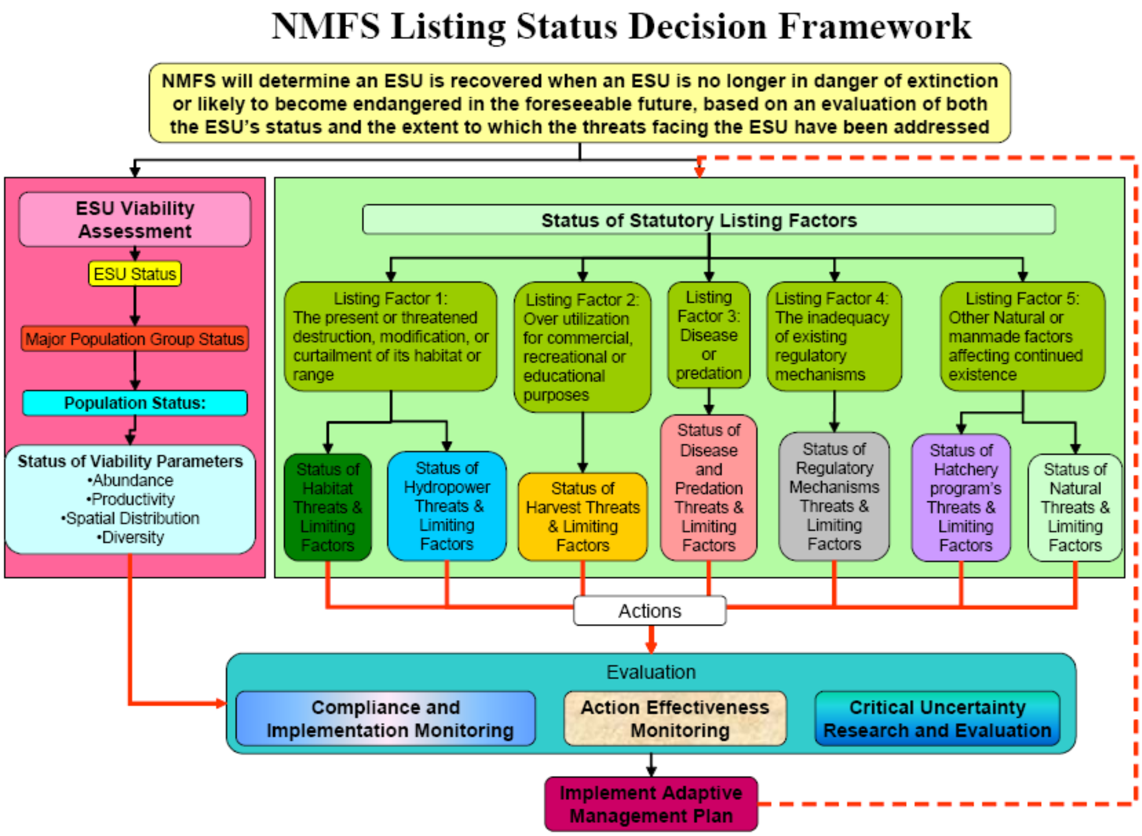
ICM 2. Total the amount of estuary habitat conserved and restored annually by habitat type.

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

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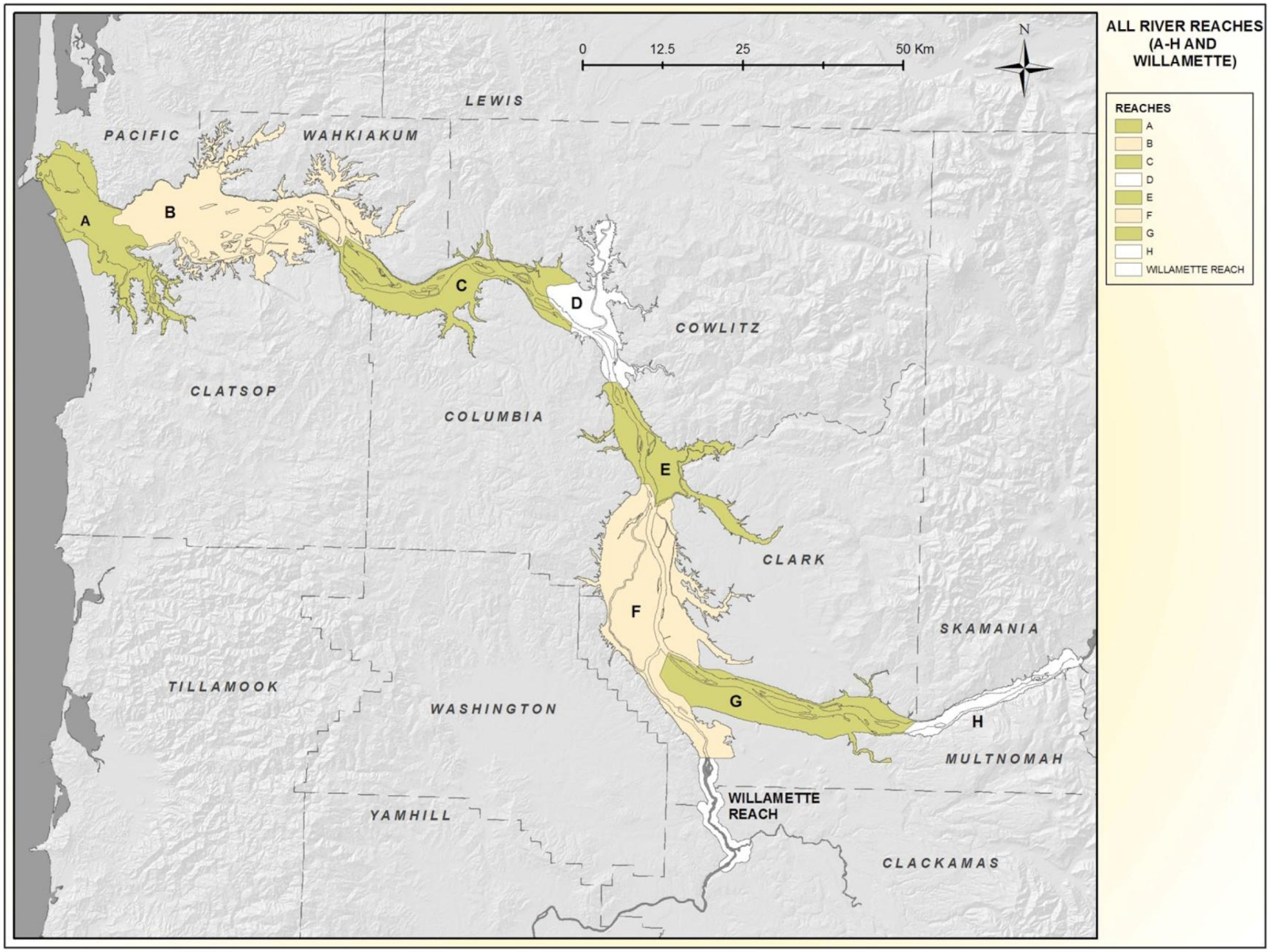
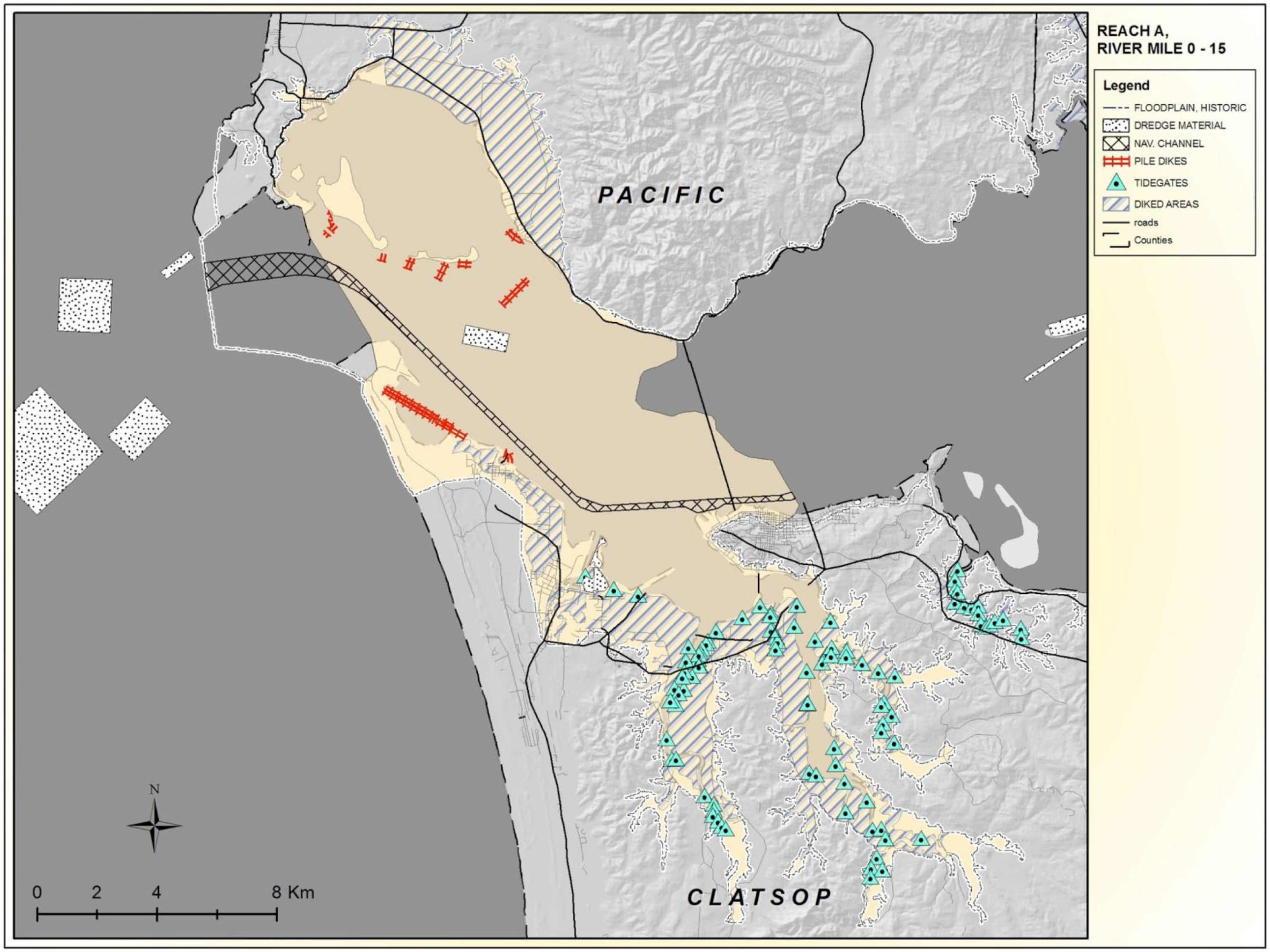
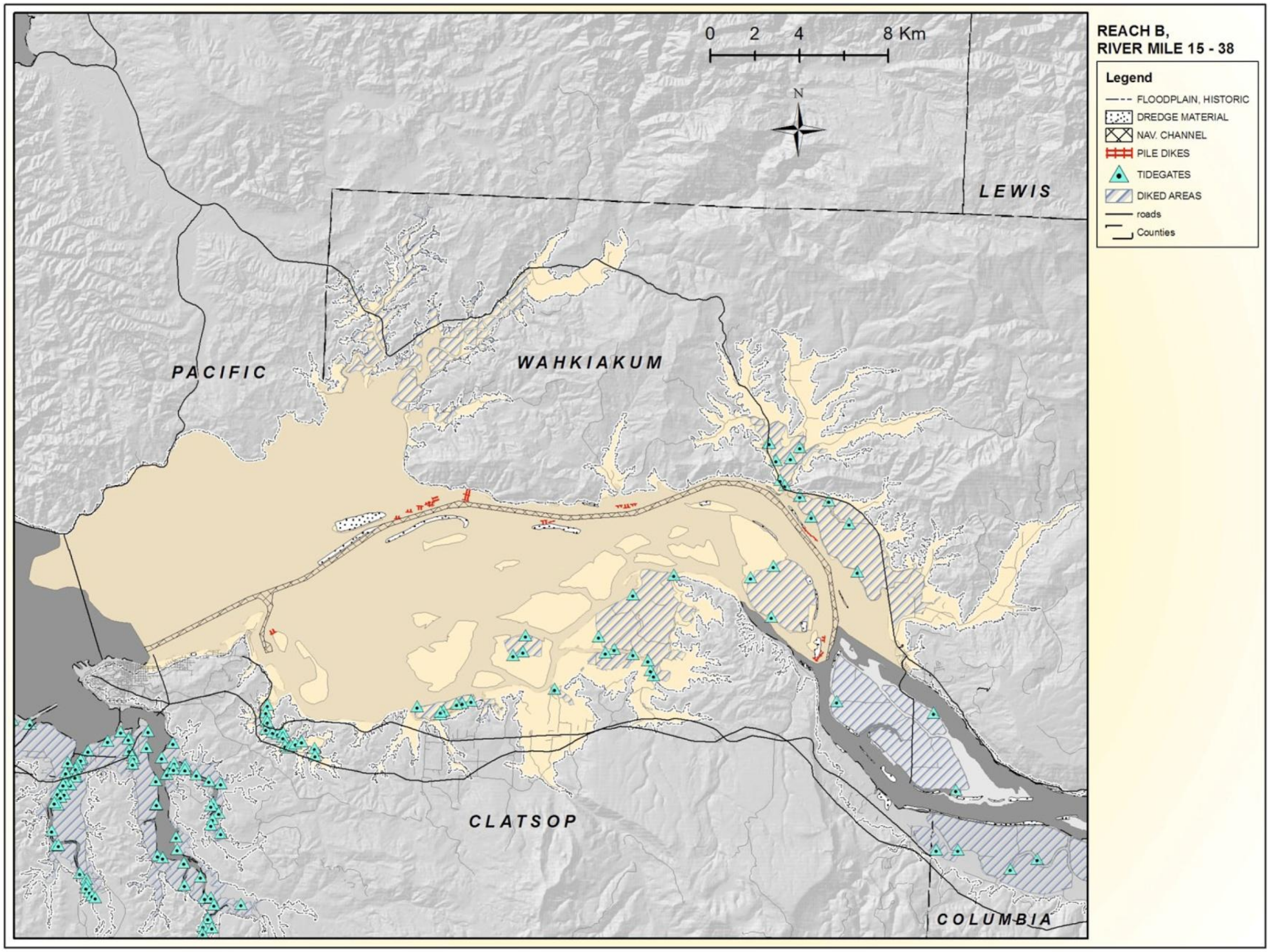
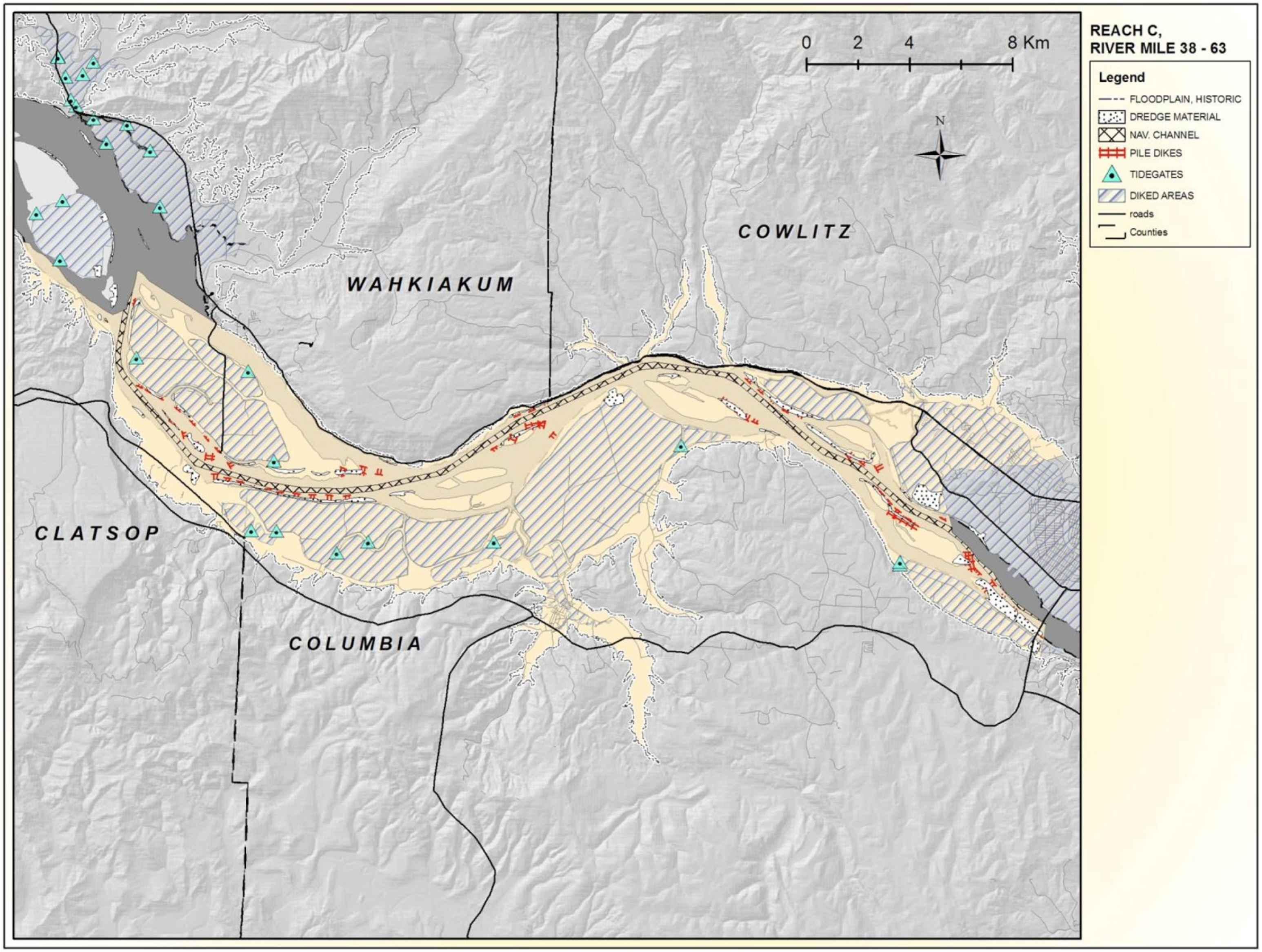
APPENDIX A

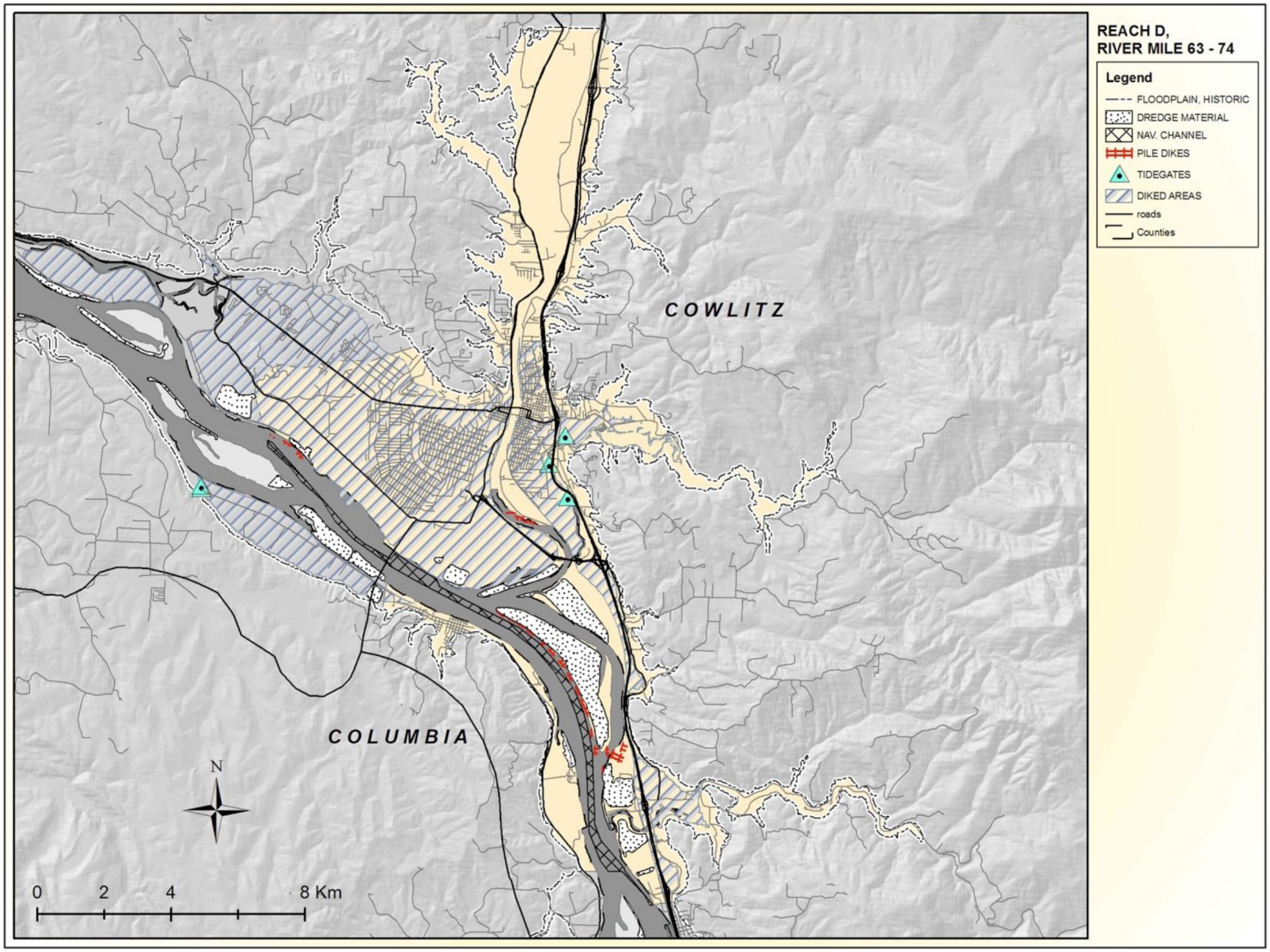
Selected Threats to Salmonids by Reach

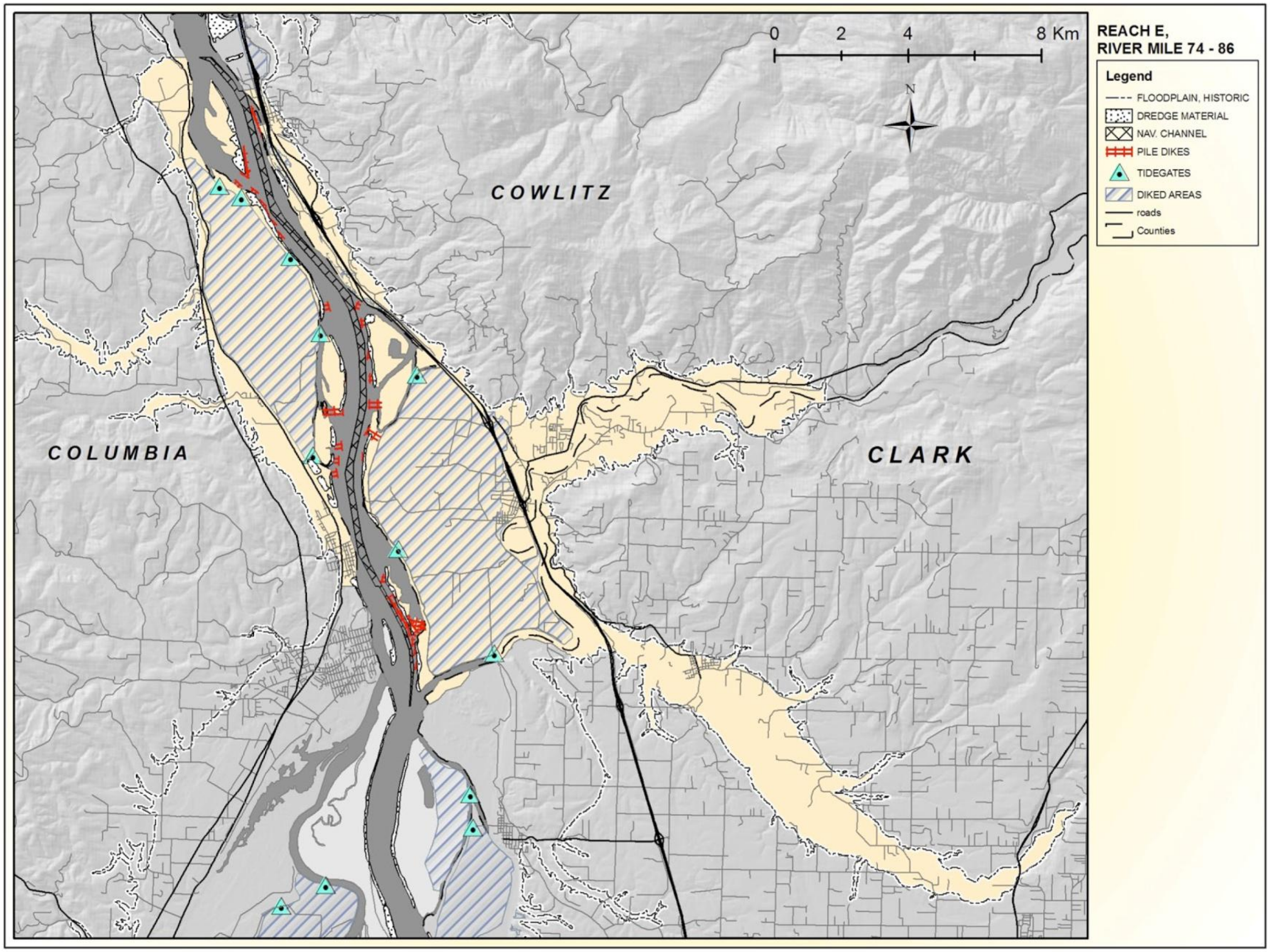

ALL RIVER REACHES (A-H AND WILLAMETTE)
REACHES
A
B
C
D
E
F
G
H
WILLAMETTE REACH
0
12.5
25
50 Km
N
LEWIS
PACIFIC
WAHKIAKUM
COWLITZ
CLATSOP
COLUMBIA
CLARK
SKAMANIA
TILLAMOOK
WASHINGTON
MULTNOMAH
YAMHILL
CLACKAMAS
WILLAMETTE REACH
A
B
C
D
E
F
G
H

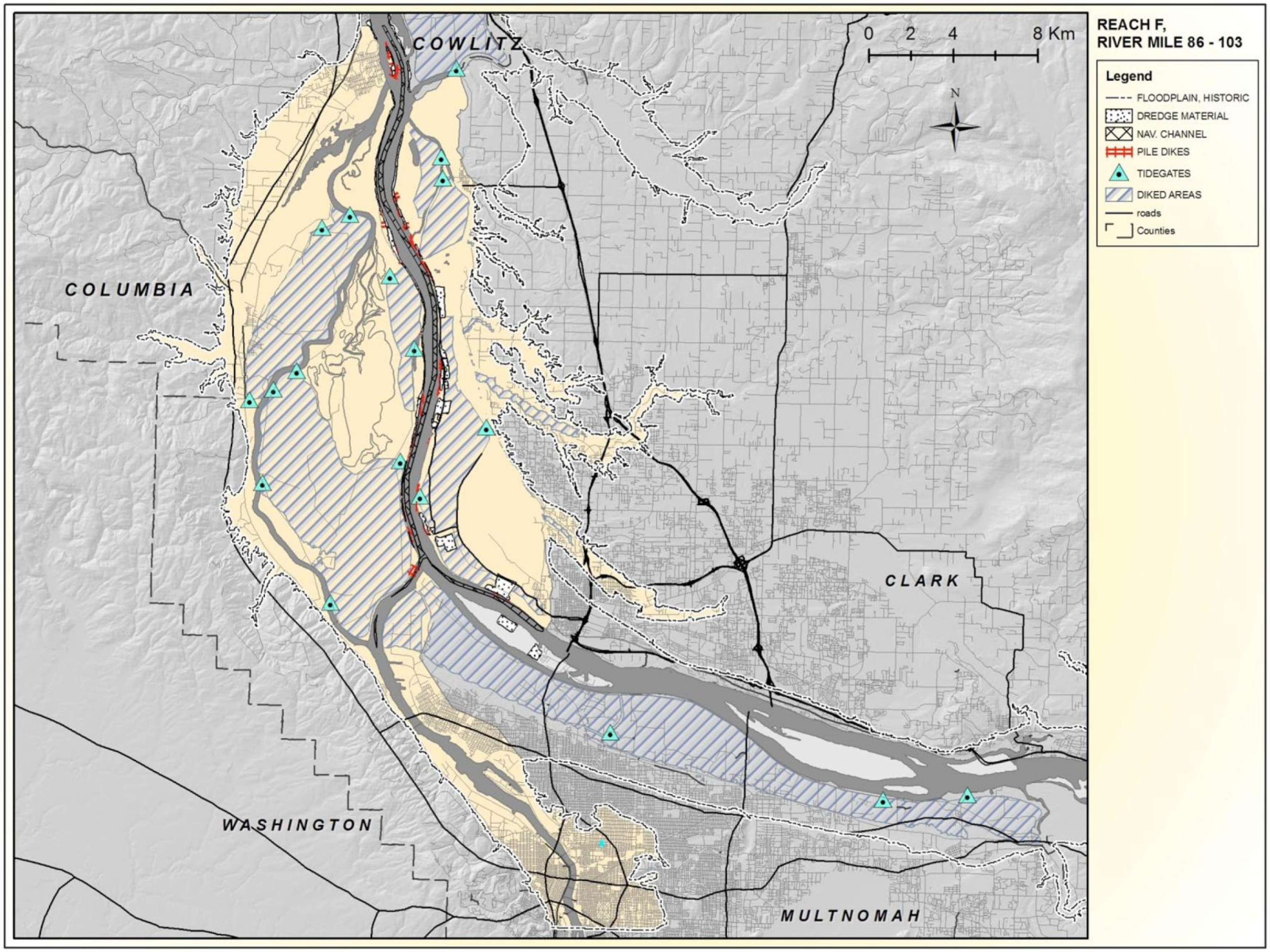

REACH A,
RIVER MILE 0 - 15
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
PACIFIC
CLATSOP
N
0
2
4
8 Km

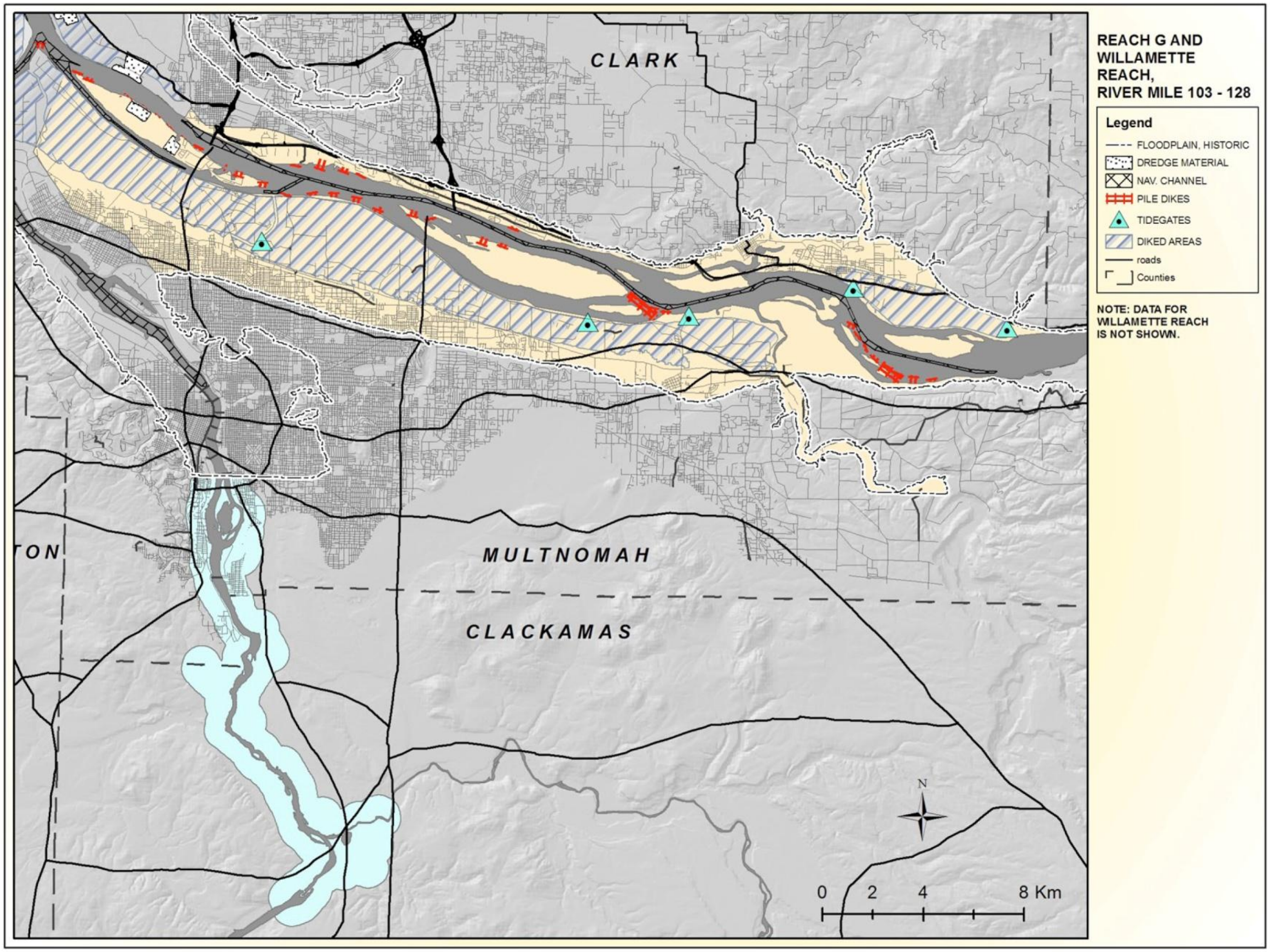

REACH B,
RIVER MILE 15 - 38
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
0 2 4 8 Km
N
LEWIS
PACIFIC
WAHKIAKUM
CLATSOP
COLUMBIA

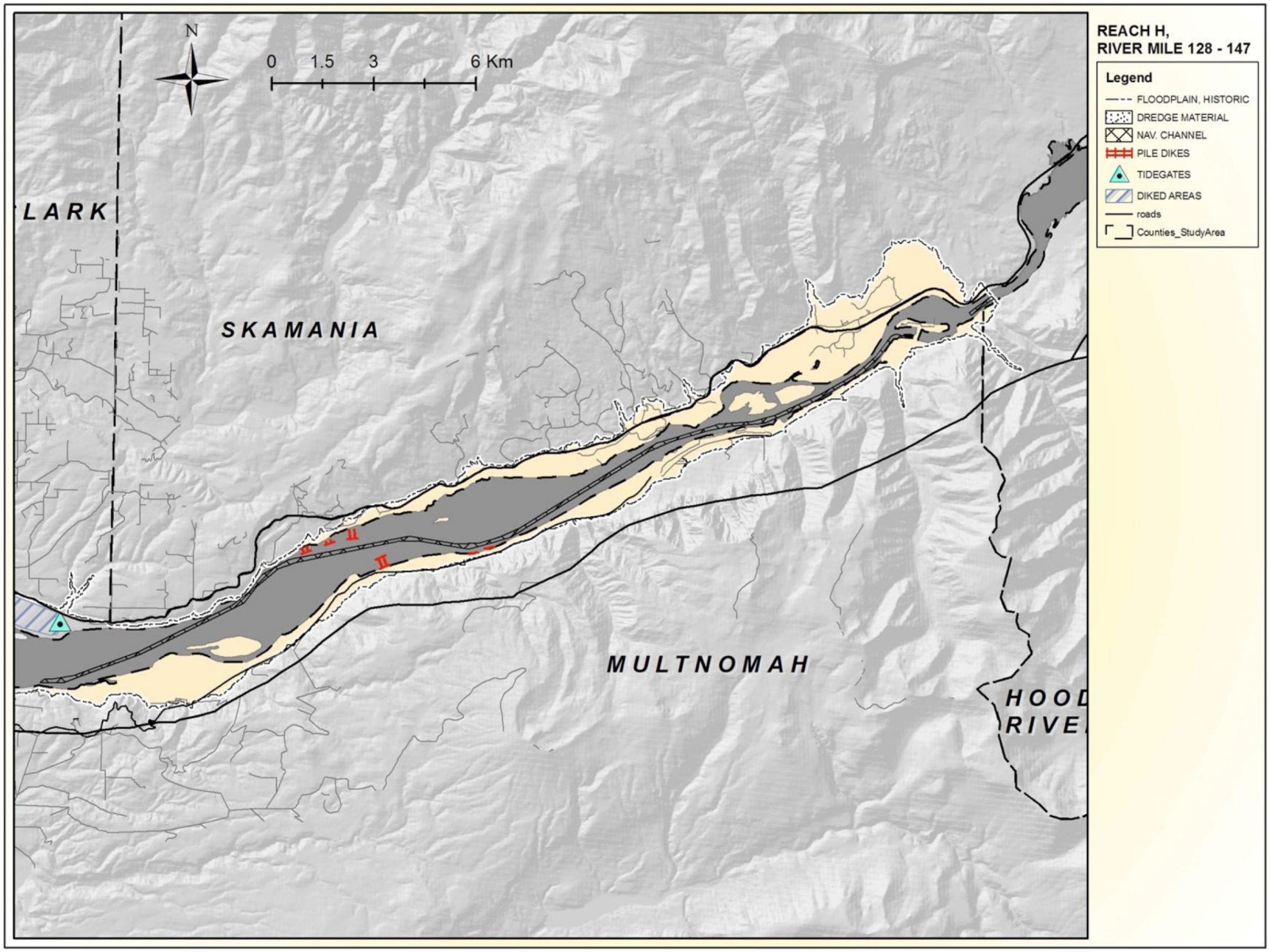

REACH C,
RIVER MILE 38 - 63
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
0 2 4 8 Km
N
WAHKIAKUM
COWLITZ
CLATSOP
COLUMBIA


REACH D,
RIVER MILE 63 - 74
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
COWLITZ
COLUMBIA
N
0
2
4
8 Km


REACH E,
RIVER MILE 74 - 86
0
2
4
8 Km
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
N
COWLITZ
COLUMBIA
CLARK


REACH F,
RIVER MILE 86 - 103
0 2 4 8 Km
N
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
COWLITZ
COLUMBIA
CLARK
WASHINGTON
MULTNOMAH


REACH G AND WILLAMETTE REACH, RIVER MILE 103 - 128
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties
NOTE: DATA FOR WILLAMETTE REACH IS NOT SHOWN.
CLARK
MULTNOMAH
CLACKAMAS
TON
N
0 2 4 8 Km



REACH H,
RIVER MILE 128 - 147
Legend
FLOODPLAIN, HISTORIC
DREDGE MATERIAL
NAV. CHANNEL
PILE DIKES
TIDEGATES
DIKED AREAS
roads
Counties_StudyArea
N
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.