National Marine Fisheries Service Endangered Species Act (ESA) Section 7 Consultation and Magnuson–Stevens Act Essential Fish Habitat (EFH) Consultation

Consultation on the Evaluation and Determination of Research Programs Submitted for Consideration Under the Endangered Species Act 4(d) Rule's Scientific Research Limit [50 CFR 223.203(b)(7)] and Scientific Research and Monitoring Exemptions [50 CFR 223.210(c)(1)]

NMFS Consultation Number: WCR-2017-8530
Administrative Record Number: 151422WCR2017PR00302

Action Agencies: The National Marine Fisheries Service (NMFS)
The Bonneville Power Administration
The Bureau of Land Management
The U.S. Army Corps of Engineers
The U.S. Bureau of Reclamation
The U.S. Fish and Wildlife Service
The U.S. Forest Service
The U.S. Geological Survey
The U.S. National Park Service

Affected Species and Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No
Puget Sound steelhead (*O. mykiss*)	Threatened	Yes	No	No
Hood Canal summer-run chum salmon (*O. keta*)	Threatened	Yes	No	No
Snake River fall Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
Snake River spring/summer (spr/sum) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
Snake River steelhead (*O. mykiss*)	Threatened	Yes	No	No
Upper Columbia River steelhead (O. mykiss)	Threatened	Yes	No	No
Middle Columbia River steelhead (*O. mykiss*)	Threatened	Yes	No	No
Columbia River chum salmon (*O. keta*)	Threatened	Yes	No	No
Lower Columbia River Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
Lower Columbia River coho salmon (*O. kisutch*)	Threatened	Yes	No	No
Lower Columbia River steelhead (*O. mykiss*)	Threatened	Yes	No	No

Southern Distinct Population Segment of Pacific eulachon (*Thaleichthys pacificus*)	Threatened	Yes	No	No
Upper Willamette River Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
Upper Willamette River steelhead (*O. mykiss*)	Threatened	Yes	No	No
Oregon Coast coho salmon (*O. kisutch*)	Threatened	Yes	No	No
Southern Oregon/Northern California Coasts coho salmon (*O. kisutch*)	Threatened	Yes	No	No
California Coastal Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
Northern California steelhead (*O. mykiss*)	Threatened	Yes	No	No
Central California Coast steelhead (*O. mykiss*)	Threatened	Yes	No	No
Central Valley spring-run Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No
California Central Valley steelhead (*O. mykiss*)	Threatened	Yes	No	No
Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*)	Threatened	Yes	No	No
South-Central California Coast steelhead (*O. mykiss*)	Threatened	Yes	No	No
Southern Resident killer whales (*Orcinus orca*)	Endangered	No	No	No

Fishery Management Plan That Describes EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	No	No

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By: Chr E Yat

FOR Barry A. Thom
Regional Administrator

Date: April 12, 2018 (Expires on: December 31, 2018)

List of Acronyms

CDFW – California Department of Fish and Wildlife
CFR – Code of Federal Regulation
CR – Columbia River
DPS – Distinct Population Segment
EFH – Essential Fish Habitat
ESA – Endangered Species Act
ESU – Evolutionarily Significant Unit
FR – Federal Register
FWS – United States Fish and Wildlife Service
HCS – Hood Canal summer-run
IDFG – Idaho Department of Fish and Game
ISAB – Independent Scientific Advisory Board
LCR – Lower Columbia River

LCRFB – Lower Columbia River Fish Recovery Board
MCR – Middle Columbia River
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
NWFSC – Northwest Fisheries Science Center
ODFW – Oregon Department of Fish and Wildlife
OC – Oregon Coast
PS – Puget Sound
SONNC – Southern Oregon/Northern California Coasts
SDPS – Southern DPS
SR – Snake River
UCR – Upper Columbia River
UWR – Upper Willamette River
VSP – Viable Salmonid Population
WDFW – Washington Department of Fish and Wildlife

1. INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

1.1 Background

The National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 USC 1531 et seq.), and implementing regulations at 50 CFR 402.

We also completed an Essential Fish Habitat (EFH) consultation. It was prepared in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801, et seq.) and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System [https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts]. A complete record of this consultation is on file with the Protected Resources Division in Portland, Oregon.

1.2 Consultation History

This document constitutes NMFS' Opinion on the proposed Federal actions that may affect the threatened species listed in Table 1. These Federal actions are funded, conducted, and/or permitted by The National Marine Fisheries Service (NMFS), The Bonneville Power Administration, The Bureau of Land Management, The U.S. Army Corps of Engineers, The U.S. Bureau of Reclamation, The U.S. National Park Service, The U.S. Fish and Wildlife Service, The U.S. Forest Service, and The U.S. Geological Survey.

Table 1. Listed Salmon, Steelhead, Sturgeon, and Eulachon Included in State Fishery Agency Scientific Research and Monitoring Programs in 2018.

Listed Species/State Fishery Agencies	WDFW	IDFG	ODFW	CDFW
Puget Sound Chinook salmon (*Oncorhynchus tshawytscha*)	X			
Hood Canal summer-run chum salmon (*O. keta*)	X			
Puget Sound steelhead (*O. mykiss*)	X			
Upper Columbia River steelhead (O. mykiss)	X			
Snake River fall Chinook salmon (*O. tshawytscha*)	X	X	X	
Snake River spring/summer Chinook salmon (*O. tshawytscha*)	X	X	X	
Snake River steelhead (*O. mykiss*)	X	X	X	
Middle Columbia River steelhead (*O. mykiss*)	X		X	
Lower Columbia River Chinook salmon (*O. tshawytscha*)	X		X	
Columbia River chum salmon (*O. keta*)	X		X	
Lower Columbia River coho salmon (*O. kisutch*)	X		X	
Lower Columbia River steelhead (*O. mykiss*)	X		X	
Upper Willamette River Chinook salmon (*O. tshawytscha*)			X	
Upper Willamette River steelhead (*O. mykiss*)			X	
Oregon Coast coho salmon (*O. kisutch*)			X	
Southern Oregon/Northern California Coasts coho salmon (*O. kisutch*)			X	X
California Coastal Chinook salmon (*O. tshawytscha*)				X
Northern California steelhead (*O. mykiss*)				X
Central California Coast steelhead (*O. mykiss*)				X
Central Valley spring-run Chinook salmon (*O. tshawytscha*)				X
California Central Valley steelhead (*O. mykiss*)				X
South-Central California Coast steelhead (*O. mykiss*)				X

Southern Distinct Population Segment of eulachon (*Thaleichthys pacificus*)	X	X	X
Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*)	X	X	X
Southern Resident killer whales (*Orcinus orca*)	X	X	X

The four state fishery agencies on the West Coast— Washington Department of Fish and Wildlife (WDFW), Idaho Department of Fish and Game (IDFG), Oregon Department of Fish and Wildlife (ODFW), and California Department of Fish and Wildlife (CDFW)—have submitted scientific research and monitoring programs (Programs) for review under the 4(d) rule's limit 7 for scientific research. This biological opinion is based on the information contained in those programs, the individual research project proposals, and the document: Evaluation and Determination of Research Programs Submitted by the WDFW, IDFG, ODFW, and CDFW. NMFS evaluates the Programs with respect to the factors identified in the 4(d) rules and additional considerations germane to those factors. One of this evaluation's primary purposes is to highlight areas of both general and specific concern (e.g., issues, projects, or techniques that bear close monitoring). NMFS worked with the state fishery agencies to develop conditions and requirements that address these concerns.

The Programs contain a total of 204 projects that would affect 24 threatened fish species in California, Idaho, Oregon, and Washington. We did not receive any projects that might affect Ozette Lake sockeye salmon.

The proposed actions also have the potential to affect Southern Resident killer whales and their critical habitat by diminishing the whales' prey base. We concluded that the proposed activities are not likely to adversely affect killer whales or their critical habitat and the full analysis is found in the "Not Likely to Adversely Affect" Determination section (2.9).

All projects contained in the Programs would either be conducted by or coordinated with the state fishery agencies. Complete descriptions of the projects, including amounts of take proposed, descriptions of the study designs, justifications for the take, and descriptions of the techniques to be used, can be found on our permits website at https://apps.nmfs.noaa.gov.

On July 10, 2000, NMFS issued a 4(d) rule for 14 threatened salmon and steelhead (65 FR 42422, 50 CFR 223.203) (salmon and steelhead 4(d) rule). The rule applies the prohibitions of section 9(a)(1) of the ESA to the threatened salmonid species listed in the rule, but imposed certain limits on those prohibitions. Limit 7 states that the prohibitions of section 9(a)(1) of the ESA (16 U.S.C. 1538(a)(1)) do not apply to scientific research activities (50 CFR 223.203(b)(7)) that are submitted by a state fishery agency as a "research program," provided that the Program complies with the four factors specified in the rule (see Part IV of the Evaluation and Determination document) and is authorized in writing by NMFS Northwest Regional Administrator. Under the rule, states are required to submit a new Program each year. The Programs NMFS authorizes would be exempt from the prohibitions of section 9(a)(1) for one year—at the end of which NMFS would require annual reports documenting research-related take for the past year.

On June 28, 2005, January 5, 2006, February 11, 2008, and September 25, 2008 NMFS issued final listing determinations and protective regulations for 26 threatened and endangered salmon and steelhead species (70 FR 37160, 71 FR 834, 73 FR 7816, 73 FR 55451). The protective regulations extended the 4(d) rule to all threatened salmonid species considered in this evaluation. The protective regulations apply the prohibitions of section 9(a)(1) of the ESA to threatened natural and listed hatchery salmon and steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

On June 2, 2010 NMFS issued final rules establishing prohibitions for the threatened Southern Distinct Population Segment (DPS) of North American green sturgeon (75 FR 30714, 50 CFR 223.210). The rule applies the prohibitions of section 9(a)(1) of the ESA to green sturgeon, but imposed certain exemptions on those prohibitions. Exemption 1 states that the prohibitions of section 9(a)(1) of the ESA (16 U.S.C. 1538(a)(1)) do not apply to ongoing or future state-sponsored scientific research or monitoring activities that are part of a NMFS-approved, ESA-compliant state 4(d) research program, provided that the program complies with the four factors specified in the rule (see Part IV of the Evaluation and Determination document). Under the rule, states are required to submit a new Program each year. The programs NMFS authorizes would be exempt from the prohibitions of section 9(a)(1) for one year—at the end of which NMFS would require reports documenting each project's take.

The NMFS has not promulgated protective regulations via § 4(d) of the ESA for eulachon. Promulgation of 4(d) take prohibitions for eulachon shall result in a reinitiation of this opinion if the effects of the research program considered in this opinion results in take that is prohibited by the 4(d) rule.

1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). In our analysis of the effects of the action, we also consider the effects of other activities that are interrelated or interdependent with the proposed action. "Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). In this instance, we found no actions that are interrelated to or interdependent with the proposed research actions. In the absence of any such actions, the proposed actions here are research activities proposed by the agencies listed as the Action Agencies above and our approval of the IDFG, ODFW, and WDFW Programs.

Our approval of the Programs is based on a determination that the Programs (1) meet the factors described in the 4(d) rules, (2) fulfill additional considerations germane to research programs, and (3) act to conserve the affected threatened species. Our review of those Programs is set out in the April 6, 2018, Evaluation/Determination Document. The 4(d) research exception would apply to the Programs for one year (through December 31, 2018), at which time NMFS would require annual reports documenting research-related take for the past year.

As noted, some of the projects identified in the Programs will be funded, conducted, or authorized by the Federal agencies listed above (Federal Action Agencies). These Federal agencies must comply with section 7 of the ESA because their actions may affect threatened species or designated critical habitat. The Federal actions are expected to take (or cause to be taken) listed salmon and steelhead. The activities include:

- Determining the abundance, distribution, growth rate, and condition of adult and juvenile fish.
- Conducting disease and genetic studies.
- Determining diet composition.
- Evaluating salmonid production (i.e., smolt-to-adult survival rates).
- Determining stock composition, population trends, and life history patterns.
- Evaluating habitat restoration projects.
- Evaluating the effects artificial production and supplementation have on listed fish.
- Investigating migration timing and migratory patterns.
- Evaluating fish passage facilities, screens and other bypass systems.
- Investigating fish behaviors in reservoirs and off channel areas.
- Evaluating salmon spawning below dams.
- Monitoring effects of dam removal.
- Assessing point-source discharge effects on fish communities.

1.4 Action Area

“Action area” means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). As the Programs describe, the research actions will occur throughout much of Washington, Idaho, Oregon, and California. Because the proposed activities are so wide-ranging, the action area for this opinion potentially includes the majorities of all the listed species’ ranges (including a great many stream reaches to be randomly chosen from year to year) and therefore we cannot describe the action area in more detail. Nonetheless, where it is possible to narrow the area of a given project’s scope, the effects analysis (Section 2.4) takes that limited geographic scope into account when determining the proposed actions’ impacts on the species and their critical habitat.

The specific areas for each project are detailed in the Programs and summarized in the Evaluation/Determination Document. In all cases, individual research activities would take place on very small sites. For example, researchers may anchor a rotary screw trap in the stream channel, deploy seines and nets covering tens of feet of stream, or wade a few hundred feet of stream while backpack electrofishing. The proposed actions have very little potential to affect the water, substrate, and adjacent riparian zones of estuarine and riverine reaches, and no potential to affect nearshore marine habitats. Most of the proposed research activities would take place in designated critical habitat.

2. ENDANGERED SPECIES ACT BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, Federal agencies must ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical habitat. If incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures and terms and conditions to minimize such impacts.

The proposed action is not likely to adversely affect Southern Resident killer whales or its critical habitat. The analysis is found in the "Not Likely to Adversely Affect" Determinations section (2.9).

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of “to jeopardize the continued existence of a listed species,” which is “to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species” (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

The adverse modification analysis considers the impacts on the conservation value of designated critical habitat. Destruction of or adverse modification of critical habitat means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features.

Section 4(d) protective regulations for salmon and steelhead prohibit taking naturally spawned fish and listed hatchery fish with an intact adipose fin but do not prohibit taking listed hatchery fish that have had their adipose fins removed (70 FR 37160, 71 FR 834, 73 FR 7816). Furthermore, we have not promulgated section 4(d) protective regulations for eulachon. As a result, researchers do not need a permit to take eulachon or hatchery salmon and steelhead that have had their adipose fin removed. Nevertheless, this document evaluates impacts on both natural and hatchery fish to determine the effects of the action on each species as a whole.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an “exposure-response-risk” approach. For research actions, exposure equates to capturing and handling the animals (including tagging, etc.); response is the degree to which they are affected by the actions (e.g., injured or killed); and risk relates to what those responses mean at the individual, population, and species levels.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors to assess the risk that the proposed action poses to species and critical habitat.
- Reach jeopardy and adverse modification conclusions.
- If necessary, define a reasonable and prudent alternative to the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

This Opinion examines the status of each species that would be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species’ likelihood of both survival and recovery. The species status section also helps to inform the description of the species’ current “reproduction, numbers, or distribution” as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that conservation value.

The ESA defines species to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." NMFS adopted a policy for identifying salmon DPSs in 1991 (56 FR 58612). It states that a population or group of populations is considered an ESU if it is “substantially reproductively isolated from conspecific populations,” and if it represents “an important component of the evolutionary legacy of the species.” The policy equates an ESU with a DPS. In 1996 NMFS and the U.S. Fish and Wildlife Service adopted a joint DPS policy, and in 2005 NMFS began applying that policy to O. mykiss (steelhead). Hence, the Chinook, chum, and coho salmon listing units in this biological opinion constitute ESUs of the species O. tshawytscha, O. keta, and O. kisutch respectively. The steelhead listing units in this biological opinion constitute DPSs of the species O. mykiss. The ESUs of salmon and DPSs of steelhead include natural-origin populations and hatchery populations, as described below.

2.2.1 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) and U.S. Global Change Research Program recently published updated assessments of anthropogenic influence on climate, as well as projections of climate change over the next century (IPCC 2013; Melillo et al. 2014). Reports from both groups document ever increasing evidence that recent warming bears the signature of rising concentrations of greenhouse gas emissions. There is moderate certainty that the 30-year average temperature in the Northern Hemisphere is now higher than it has been over the past 1,400 years. In addition, there is high certainty that ocean acidity has increased with a drop in pH of 0.1 (NWFSC 2015).

Projected Climate Change

Trends in warming and ocean acidification are highly likely to continue during the next century (IPCC 2013). In winter across the west, the highest elevations (e.g. in the Rocky Mountains) will shift from consistent longer (>5 months) snow-dominated winters to a shorter period (3-4 months) of reliable snowfall (Klos et al. 2014); lower, more coastal or more southerly watersheds will shift from consistent snowfall over winter to alternating periods of snow and rain ("transitional"); lower elevations or warmer watersheds will lose snowfall completely, and rain-dominated watersheds will experience more intense precipitation events and possible shifts in the timing of the most intense rainfall (e.g., Salathe et al. 2014). Warmer summer air temperatures will increase both evaporation and direct radiative heating. When combined with reduced winter water storage, warmer summer air temperatures will lead to lower minimum flows in many watersheds. Higher summer air temperatures will depress minimum flows and raise maximum stream temperatures even if annual precipitation levels do not change (e.g., Sawaske and Freyberg 2014) (NWFSC 2015).

Higher sea surface temperatures and increased ocean acidity are predicted for marine environments in general (IPCC 2013). However, regional marine impacts will vary, especially in relation to productivity. The California Current is strongly influenced by seasonal upwelling of cool, deep, water that is high in nutrients and low in dissolved oxygen and pH. An analysis of 21 global climate models found that most predicted a slight decrease in upwelling in the California Current, although there is a latitudinal cline in the strength of this effect, with less impact toward the north (Rykaczewski et al. 2015; NWFSC 2015).

Freshwater environments

Sea surface temperatures across the Northeast Pacific Ocean are anomalously warm which has contributed to above average terrestrial temperatures in the PNW (Bond et al. 2015). Mean air temperatures for Washington, Oregon, and Idaho were the warmest on record for the 24-month period ending in August 2015 (from a 120-year record starting in 1895). In contrast, precipitation in the PNW was slightly above average during 2014. Since January 2015, however, precipitation has been below average and the 8-month period from January to August was the 11th driest on record. The exceptionally warm air during the winter of 2014/2015 and below average precipitation from January-April resulted in anomalously low snow pack conditions in the Olympic and Cascade Mountains, with most areas having less than 25 percent of average snow pack in April 2015 (compared to the 1981-2010 record). The combined effects of low flows and high air temperatures resulted in higher than normal stream temperatures and reports of fish kills of salmon and sturgeon in the Willamette and mainstem Columbia Rivers in late June and July 2015 (NWFSC 2015).

Impacts on Salmon

Studies examining the effects of long term climate change to salmon populations have identified a number of common mechanisms by which climate variation is likely to influence salmon sustainability. These include direct effects of temperature such as mortality from heat stress, changes in growth and development rates, and disease resistance. Changes in the flow regime (especially flooding and low flow events) also affect survival and behavior. Expected behavioral responses include shifts in seasonal timing of important life-history events, such as the adult migration, spawn timing, fry emergence timing, and juvenile migration (NWFSC 2015).

Climate impacts in one life stage generally affect body size or timing in the next life stage and can be negative across multiple life stages (Healey 2011; Wade et al. 2013; Wainwright and Weitkamp 2013). Changes in winter precipitation will likely affect incubation and/or rearing stages of most populations. Changes in the intensity of cool season precipitation could influence migration cues for fall and spring adult migrants, such as coho salmon and steelhead. Egg survival rates may suffer from more intense flooding that scours or buries redds. Changes in hydrological regime, such as a shift from mostly snow to more rain, could drive changes in life history, potentially threatening diversity within an ESU (Beechie et al. 2006). Changes in summer temperature and flow will affect both juvenile and adult stages in some populations, especially those with yearling life histories and summer migration patterns (Quinn 2005; Crozier and Zabel 2006; Crozier et al. 2010). Adults that migrate or hold during peak summer temperatures can experience very high mortality in unusually warm years. For example, in 2015 only 4 percent of adult Redfish Lake sockeye survived the migration from Bonneville to Lower Granite Dam after confronting temperatures over 22°C in the lower Columbia River. Marine migration patterns could also be affected by climate induced contraction of thermally suitable habitat. Abdul-Aziz et al. (2011) modeled changes in summer thermal ranges in the open ocean for Pacific salmon under multiple IPCC warming scenarios. For chum salmon, pink salmon, coho salmon, sockeye salmon, and steelhead, they predicted contractions in suitable marine habitat of 30-50 percent by the 2080s, with an even larger contraction (86-88 percent) for Chinook salmon under the medium and high emissions scenarios (A1B and A2) (NWFSC 2015).

2.2.2 Status of Listed Species

For Pacific salmon and steelhead—and eulachon and green sturgeon—NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (McElhany et al. 2000). These “viable salmonid population” (VSP) criteria therefore encompass the species’ “reproduction, numbers, or distribution” as described in 50 CFR 402.02. When these parameters are collectively at appropriate levels, they maintain a population’s capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species’ entire life cycle, and these characteristics, in turn, are influenced by habitat and other environmental conditions.

“Spatial structure” refers both to the spatial distributions of individuals in the population and the processes that generate that distribution. A population’s spatial structure depends fundamentally on habitat quality and spatial configuration and the dynamics and dispersal characteristics of individuals in the population.

“Diversity” refers to the distribution of traits within and among populations. These range in scale from DNA sequence variation at single genes to complex life history traits (McElhany et al. 2000).

“Abundance” generally refers to the number of naturally-produced adults (i.e., the progeny of naturally-spawning parents) in the natural environment (e.g., on spawning grounds).

“Productivity,” as applied to viability factors, refers to the entire life cycle; i.e., the number of naturally-spawning adults produced per parent. When progeny replace or exceed the number of parents, a population is stable or increasing. When progeny fail to replace the number of parents, the population is declining. McElhany et al. (2000) use the terms “population growth rate” and “productivity” interchangeably when referring to production over the entire life cycle. They also refer to “trend in abundance,” which is the manifestation of long-term population growth rate.

For species with multiple populations, once the biological status of a species’ populations has been determined, NMFS assesses the status of the entire species using criteria for groups of populations, as described in recovery plans and guidance documents from technical recovery teams. Considerations for species viability include having multiple populations that are viable, ensuring that populations with unique life histories and phenotypes are viable, and that some viable populations are both widespread to avoid concurrent extinctions from mass catastrophes and spatially close to allow functioning as metapopulations (McElhany et al. 2000).

A species’ status thus is a function of how well its biological requirements are being met: the greater the degree to which the requirements are fulfilled, the better the species’ status. For the purposes of our later analysis, all the species considered here require functioning habitat and adequate spatial structure, abundance, productivity, and diversity to ensure their survival and recovery in the wild.

2.2.2.1 Puget Sound Chinook Salmon

Description and Geographic Range

On June 28, 2005, NMFS listed PS Chinook salmon—both natural and some artificially-propagated fish—as a threatened species (70 FR 37160). The species includes all naturally spawned Chinook salmon populations from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward. This includes rivers and streams flowing into Hood Canal, South Sound, North Sound, and the Strait of Georgia in Washington. The following 26 artificial propagation programs are part of the species and are also listed (79 FR 20802; Table 2): Kendall Creek Hatchery Program; Marblemount Hatchery Program (spring subyearlings and summer-run), Harvey Creek Hatchery Program (summer-run and fall-run), Whitehorse Springs Pond Program, Wallace River Hatchery Program (yearlings and subyearlings), Tulalip Bay Program, Issaquah Hatchery Program, Soos Creek Hatchery Program, Icy Creek Hatchery Program, Keta Creek Hatchery Program, White River Hatchery

Program, White Acclimation Pond Program, Hupp Springs Hatchery Program, Voights Creek Hatchery Program, Diru Creek Program, Clear Creek Program, Kalama Creek Program, George Adams Hatchery Program, Rick's Pond Hatchery Program, Hamma Hamma Hatchery Program, Dungeness/Hurd Creek Hatchery Program, Elwha Channel Hatchery Program, and the Skookum Creek Hatchery Spring-run Program. Under the final listing in 2005, the section 4(d) protections (and limits on them) apply to natural-origin and hatchery PS Chinook salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

Table 2. Expected Puget Sound Chinook salmon hatchery releases (WDFW 2017).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Deschutes	Tumwater Falls	2017	Fall	3,800,000	-
Dungeness-Elwha	Dungeness	2017	Spring	-	50,000
	Elwha	2016	Fall	-	200,000
		2017	Fall	250,000	2,250,000
	Gray Wolf River	2017	Spring	-	50,000
	Hurd Creek	2016	Spring	-	50,000
	Upper Dungeness Pond	2017	Spring	-	50,000
Duwamish	Icy Creek	2016	Fall	300,000	-
	Palmer	2017	Fall	-	1,000,000
	Soos Creek	2017	Fall	3,000,000	200,000
Hood Canal	Hood Canal Schools	2017	Fall	-	500
	Hoodsport	2016	Fall	120,000	-
		2017	Fall	2,300,000	-
Kitsap	Bernie Gobin	2016	Spring	40,000	-
		2017	Fall	-	200,000
			Summer	2,300,000	100,000
	Chambers Creek	2017	Fall	400,000	-
	Garrison	2017	Fall	450,000	-
	George Adams	2017	Fall	3,575,000	225,000
	Gorst Creek	2017	Fall	1,530,000	-
	Grovers Creek	2017	Fall	450,000	-
	Hupp Springs	2017	Spring	-	400,000
	Lummi Sea Ponds	2017	Fall	500,000	-
	Minter Creek	2017	Fall	1,250,000	-
Lake Washington	Friends of ISH	2017	Fall	-	1,425
	Issaquah	2017	Fall	2,000,000	-
Nisqually	Clear Creek	2017	Fall	3,300,000	200,000
	Kalama Creek	2017	Fall	600,000	-
	Nisqually MS	2017	Fall	-	90
Nooksack	Kendall Creek	2017	Spring	800,000	-
	Skookum Creek	2017	Spring	-	1,000,000
Puyallup	Clarks Creek	2017	Fall	400,000	-
	Voights Creek	2017	Fall	1,600,000	-
	White River	2016	Spring	-	55,000
		2017	Spring	-	340,000
San Juan Islands	Glenwood Springs	2017	Fall	725,000	-
	Orcas Island SD	2017	Fall	-	225
Skykomish	Wallace River	2016	Summer	500,000	-

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
		2017	Summer	800,000	200,000
Stillaguamish	Brenner	2017	Fall	-	200,000
	Whitehorse Pond	2017	Summer	220,000	-
Strait of Georgia	Samish	2017	Fall	3,800,000	200,000
Upper Skagit	Marblemount	2017	Spring	387,500	200,000
			Summer	200,000	-
Total Annual Release Number				**36,097,500**	**7,172,240**

Adult PS Chinook salmon typically return to freshwater from March through August and spawn from July through December. Early-timed Chinook salmon tend to enter freshwater as immature fish in the spring, migrate far upriver, and finally spawn in the late summer and early autumn. Late-timed Chinook salmon enter freshwater in the fall at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry. Most PS Chinook salmon tend to mature at ages three and four, but the range is from two to six years.

Spawning females deposit between 2,000 and 5,500 eggs in a shallow nest, or redd, that they dig with their tail. Depending on water temperatures, the eggs hatch between 32 and 159 days after deposition. Alevins, newly hatched salmon with attached yolk sacs, remain in the gravel for another 14 to 21 days before emerging as fry. Juvenile Chinook salmon may migrate downstream to saltwater within 1 to 10 days and spend many months rearing in the estuary, or they may reside in freshwater for a full year, spending relatively little time in the estuary area, before migrating to sea. Most PS Chinook salmon leave the freshwater environment during their first year. Chinook salmon make extensive use of the protected estuary and nearshore habitats before migrating to the ocean.

Although some PS Chinook salmon spend their entire life in the Puget Sound, most migrate to the ocean and north along the Canadian coast. Return migration routes vary from year to year, with some fish migrating along the west coast of Vancouver Island and others through Johnstone Strait and the Strait of Georgia.

Spatial Structure and Diversity

The PS Chinook salmon ESU contains 31 "historically independent populations," of which nine are believed to be extinct (Ruckelshaus et al. 2006). The extinct populations were mostly composed of early-returning fish from the mid- and southern parts of the Puget Sound and in the Hood Canal/Strait of Juan de Fuca (Table 3).

Table 3. Historical populations of Chinook salmon in the Puget Sound (Ruckelshaus et al. 2006).

Population	Region	Status	Run Timing
N. Fork Nooksack	Strait of Georgia	Extant	Early
S. Fork Nooksack	Strait of Georgia	Extant	Early
Nooksack late	Strait of Georgia	*Extinct*	Late

Population	Region	Status	Run Timing
Lower Skagit	North Puget Sound	Extant	Late
Upper Skagit	North Puget Sound	Extant	Late
Cascade	North Puget Sound	Extant	Early
Lower Sauk	North Puget Sound	Extant	Late
Upper Sauk	North Puget Sound	Extant	Early
Suiattle	North Puget Sound	Extant	Early
N. Fork Stillaguamish	North Puget Sound	Extant	Late
S. Fork Stillaguamish	North Puget Sound	Extant	Late
Stillaguamish early	North Puget Sound	*Extinct*	Early
Skykomish	North Puget Sound	Extant	Late
Snoqualmie	North Puget Sound	Extant	Late
Snohomish early	North Puget Sound	*Extinct*	Early
Sammamish	Central and South Puget Sound	Extant	Late
Cedar	Central and South Puget Sound	Extant	Late
Duwamish-Green	Central and South Puget Sound	Extant	Late
Duwamish-Green early	Central and South Puget Sound	*Extinct*	Early
White	Central and South Puget Sound	Extant	Early
Puyallup	Central and South Puget Sound	Extant	Late
Puyallup early	Central and South Puget Sound	*Extinct*	Early
Nisqually	Central and South Puget Sound	Extant	Late
Nisqually early	Central and South Puget Sound	*Extinct*	Early
Skokomish	Hood Canal	Extant	Late
Skokomish early	Hood Canal	*Extinct*	Early
Mid-Hood Canal	Hood Canal	Extant	Late
Mid-Hood Canal early	Hood Canal	*Extinct*	Early
Dungeness	Strait of Juan de Fuca	Extant	Late
Elwha	Strait of Juan de Fuca	Extant	Late
Elwha early	Strait of Juan de Fuca	*Extinct*	Early

Losing these nine historical populations reduced the species’ spatial structure. In all cases, the extinct populations overlapped with extant populations, leaving the impression that the spatial structure had not changed. However, the two Chinook salmon run-types tend to spawn in different parts of the watershed (Myers et al. 1998). Early-timed Chinook salmon tend to migrate farther upriver and farther up into tributary streams, whereas, late-timed fish spawn in the mainstem or lower tributaries of the river. Therefore, losing one run timing could cause an underuse of available spawning habitat and reduce population distribution and spatial structure.

Chinook salmon population diversity can range in scale from genetic differences within and among populations to complex life-history traits. The loss of early-run populations is a leading factor affecting ESU diversity. As stated above, eight of the nine extinct populations were composed of early-returning fish (Table 3). Run-timing is a life-history trait considered to be an adaptation to variable environmental conditions. The early-run populations were an evolutionary legacy of the ESU, and the loss of these populations reduces the overall ESU's diversity.

Another major factor affecting PS Chinook salmon diversity is artificial propagation. In 1993, WDF et al. classified nearly half of the ESU populations as sustained, at least in part, by artificial propagation. Since the 1950s, hatcheries have released nearly two billion fish into Puget Sound tributaries. Most of these fish came from fall-run (late returning) adults from the Green River stock or stocks derived from Green River stock resulting in some PS Chinook salmon populations containing substantial hatchery-origin spawner numbers (first generation hatchery fish). By releasing so many hatchery-origin spawners, the use of a single stock could reduce the naturally spawning populations' genetic diversity and fitness. In 1991, a stock transfer policy (WDF 1991) was developed and implemented to foster local brood stocks by significantly reducing egg and juvenile transfers between watersheds. This policy mandates hatchery programs to use local brood stocks in rivers with extant indigenous stocks.

According to recent production estimates, Puget Sound hatcheries release over 40 million juvenile Chinook salmon each year (Table 2). Most hatchery fish production is for commercial harvest and sport fishing. However, tens of thousands of these fish escape harvest each year and return to spawn in Puget Sound tributaries. From 1990 through 2014, there has been a declining trend in the proportion of natural-origin spawners across the whole ESU (NWFSC 2015). For 2010-2014, more than 70% of the spawners are hatchery fish in eight of the 22 populations (Table 4). For the five MPGs, only the Whidbey Basin MPG had over half of their spawners be of natural origin in the majority of the populations (NWFSC 2015).

Table 4. Five-year means of fraction wild for PS Chinook salmon by population (NWFSC 2015).

Population	Five-year means for fraction wild				
	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Strait of Georgia MPG					
NF Nooksack River	0.53	0.29	0.07	0.18	0.16
SF Nooksack River	0.76	0.63	0.62	0.63	0.28
Strait of Juan de Fuca MPG					
Elwha River	0.65	0.41	0.54	0.34	0.15
Dungeness River	0.17	0.17	0.16	0.33	0.26
Hood Canal MPG					
Skokomish River	0.52	0.40	0.46	0.45	0.17
Mid-Hood Canal	0.79	0.82	0.79	0.61	0.29
Whidbey Basin MPG					
Skykomish River	0.73	0.46	0.55	0.72	0.73
Snoqualmie River	0.85	0.67	0.87	0.68	0.78
NF Stillaguamish River	0.75	0.65	0.80	0.57	0.59
SF Stillaguamish River	1.00	1.00	1.00	0.99	0.83
Upper Skagit River	0.96	0.98	0.96	0.94	0.96
Lower Skagit River	0.96	0.96	0.97	0.96	0.96
Upper Sauk River	0.96	0.96	0.96	0.96	0.96
Lower Sauk River	0.96	0.96	0.95	0.95	0.96
Suiattle River	0.98	0.98	0.98	0.97	0.98
Cascade River	0.98	0.98	0.98	0.98	0.98

Central / South Sound MPG					
Sammamish River	0.24	0.20	0.40	0.23	0.11
Cedar River	0.74	0.70	0.63	0.82	0.82
Green River	0.44	0.32	0.63	0.44	0.43
Puyallup River	0.84	0.70	0.70	0.40	0.57
White River	0.88	0.93	0.95	0.79	0.56
Nisqually River	0.78	0.80	0.68	0.31	0.30

Abundance and Productivity

Bledsoe et al. (1989) proposed an historical abundance of 690,000 PS Chinook salmon. However, this estimate is based upon the 1908 Puget Sound cannery pack, so it should be viewed cautiously since it probably included fish that originated in adjacent areas. Additionally, exploitation rate estimates used in run-size expansions are not based on precise data.

NMFS concluded in 1998 (Myers et al. 1998), 2005 (Good et al. 2005), 2011 (Ford 2011), and 2015 (NWFSC 2015) that the Puget Sound ESU was likely to become endangered in the foreseeable future. In the first status review, we estimated the total PS Chinook salmon run size[1] in the early 1990s to be approximately 240,000 Chinook salmon, with the vast majority as hatchery-origin. Based on current estimates, 67,000 of those fish were naturally produced Chinook salmon (Unpublished data, Norma Sands, NWFSC, March 5, 2010). ESU escapement (total spawners) increased to 47,686 (2000-2004), but has since declined to 40,411(2005-2009) and to 32,451 (2010-2014; Tables 5 and 6).

Table 5. Abundance–five-year geometric means for adult (age 3+) natural origin and total spawners (natural and hatchery origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NWFSC 2015).

Population	**Geometric means**					
	1990-1994	**1995-1999**	**2000-2004**	**2005-2009**	**2010-2014**	**% Change**
Strait of Georgia MPG						
NF Nooksack River	52 (102)	97 (476)	229 (3,476)	277 (1,675)	154 (1,167)	-44 (-30)
SF Nooksack River	126 (171)	133 (217)	235 (398)	244 (388)	88 (418)	-64 (8)
Strait of Juan de Fuca MPG						
Elwha River	420 (658)	274 (735)	357 (716)	193 (597)	164 (1,152)	-15 (93)
Dungeness River	20 (117)	18 (104)	71 (527)	162 (508)	119 (447)	-27 (-6)
Hood Canal MPG						
Skokomish River	506 (994)	478 (1,232)	479 (1,556)	500 (1,216)	256 (1,627)	-49 (34)
Mid-Hood Canal	93 (119)	152 (186)	169 (217)	47 (88)	75 (314)	60 (257)
Whidbey Basin MPG						
Skykomish River	1,658 (2,325)	1,494 (3,327)	2,606 (4,842)	2,388 (3,350)	1,693 (2,320)	-29 (-31)
Snoqualmie River	873 (1,035)	739 (1,187)	2,161 (2,480)	1,311 (1,965)	885 (1,143)	-32 (-42)
NF Stillaguamish River	553 (742)	603 (946)	967 (1,225)	550 (984)	574 (976)	4 (-1)
SF Stillaguamish River	150 (150)	241 (241)	219 (219)	101 (102)	71 (87)	-30 (-15)
Upper Skagit River	5,389 (5,599)	6,159 (6,267)	12,039 (12,484)	9,975 (10,611)	6,924 (7,194)	-31 (-32)
Lower Skagit River	1,417 (1,473)	1,001 (1,041)	2,765 (2,857)	2,118 (2,216)	1,391 (1,446)	-34 (-35)
Upper Sauk River	394 (409)	258 (268)	413 (428)	498 (518)	836 (867)	68 (67)
Lower Sauk River	399 (414)	414 (433)	812 (853)	546 (572)	413 (432)	-24 (-24)

---

[1] Run size is calculated by combining harvest estimates and spawner estimates.

	Geometric means					
Population	**1990-1994**	**1995-1999**	**2000-2004**	**2005-2009**	**2010-2014**	**% Change**
Suiattle River	295 (302)	373 (382)	405 (415)	254 (261)	351 (360)	38 (38)
Cascade River	185 (189)	208 (213)	364 (371)	334 (341)	338 (345)	1 (1)
Central / South Sound MPG						
Sammamish River	52 (227)	32 (160)	385 (1,040)	289 (1,281)	160 (1,679)	-45 (31)
Cedar River	367 (509)	369 (541)	405 (643)	1,043 (1,275)	881 (1,075)	-16 (-16)
Green River	2,253 (5,331)	2,149 (7,272)	4,099 (6,624)	1,334 (3,187)	897 (2,168)	-33 (-32)
Puyallup River	2,143 (2,543)	1.611 (2,340)	1,171 (1,687)	795 (2,012)	598 (1,186)	-25 (-41)
White River	565 (645)	1,307 (1,415)	3,128 (3,309)	4,170 (5,301)	1,689 (3,471)	-59 (-35)
Nisqually River	630 (806)	596 (748)	891 (1,319)	587 (1,963)	701 (2,577)	19 (31)

In their population viability criteria assessment, the Puget Sound Technical Recovery Team (PSTRT) presented viable spawning abundances for 16 of the 22 populations (PSTRT 2002). For the 2010 status review (Ford 2011), viable spawning abundances for the remaining six populations were extrapolated based on a recovered productivity equal to the average for the 16 populations (recruits per spawner = 3.2). It is important to note that these are viability abundances assuming replacement only productivity – higher productivity would result in lower viable spawning abundances. For this reason, we use the low productivity planning range to evaluate the current abundance trends of PS Chinook salmon (Table 6).

Table 6. Average abundance estimates for PS Chinook salmon natural- and hatchery-origin spawners 2011-2015 (unpublished data, Mindy Rowse, NWFSC, November 17, 2017).

Population Name	**Natural-origin Spawners[a]**	**Hatchery-origin Spawners[a]**	**% Hatchery Origin**	**Minimum Viability Abundance[b]**	**Expected Number of Outmigrants[c]**
Strait of Georgia MPG					
NF Nooksack River	159	953	85.70%	16,000	89,003
SF Nooksack River	15	10	38.94%	9,100	1,983
Strait of Juan de Fuca MPG					
Elwha River	202	1,985	90.75%	15,100	174,974
Dungeness River	96	290	75.08%	4,700	30,949
Hood Canal MPG					
Skokomish River	205	951	82.27%	12,800	92,453
Mid-Hood Canal	102	204	66.55%	11,000	24,507
Whidbey Basin MPG					
Skykomish River	1,617	839	34.16%	17,000	196,483
Snoqualmie River	710	195	21.54%	17,000	72,427
NF Stillaguamish River	331	374	53.10%	17,000	56,418
SF Stillaguamish River	63	14	18.09%	15,000	6,111
Upper Skagit River	7,755	381	4.68%	17,000	650,852
Lower Skagit River	1,673	90	5.09%	16,000	141,009
Upper Sauk River	849	24	2.75%	3,000	69,829
Lower Sauk River	383	6	1.57%	5,600	31,104
Suiattle River	417	3	0.80%	600	33,651
Cascade River	232	20	7.86%	1,200	20,148

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Minimum Viability Abundance[b]	Expected Number of Outmigrants[c]
Central / South Sound MPG					
Sammamish River	88	1,083	92.48%	10,500	93,699
Cedar River	825	260	23.97%	11,500	86,834
Duwamish/Green River	796	1,562	66.24%	17,000	188,698
Puyallup River	529	643	54.86%	17,000	93,766
White River	685	2,018	74.65%	14,200	216,295
Nisqually River	679	1,321	66.04%	13,000	159,971
ESU Average	**18,413**	**13,227**	**41.80%**		**2,531,163**

[a] Five-year geometric mean of post-fishery spawners.

[b] Ford 2011

[c] Expected number of outmigrants=Total spawners*40% proportion of females*2,000 eggs per female*10% survival rate from egg to outmigrant

The average[2] abundance (2011-2015) for PS Chinook salmon populations is 31,640 adult spawners (18,413 natural-origin and 13,227 hatchery-origin spawners). Natural-origin spawners range from 15 (in the South Fork Nooksack River population) to 7,755 fish (in the Upper Skagit population). No populations are meeting minimum viability abundance targets, and only three of 22 populations average greater than 20% of the minimum viability abundance target for natural-origin spawner abundance (all of which are in the Skagit River watershed). The populations closest to planning targets (Upper Skagit, Upper Sauk, and Suiattle) need to increase substantially just to meet the minimum viability abundance target. The Lower Skagit population is the second most abundant population, but its natural-origin spawner abundance is only 10% of the minimum viability abundance target.

Juvenile PS Chinook salmon abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Fecundity estimates for the ESU range from 2,000 to 5,500 eggs per female, and the proportion of female spawners in most populations is approximately 40% of escapement. By applying a conservative fecundity estimate (2,000 eggs/female) to the expected female escapement (both natural-origin and hatchery-origin spawners – 12,656 females), the ESU is estimated to produce approximately 25.3 million eggs annually. Smolt trap studies have researched egg to migrant juvenile Chinook salmon survival rates in the following Puget Sound tributaries: Skagit River, North Fork Stillaguamish River, South Fork Stillaguamish River, Bear Creek, Cedar River, and Green River (Beamer et al. 2000; Seiler et al. 2002, 2004, 2005; Volkhardt et al. 2005; Griffith et al. 2004). The average survival rate in these studies was 10%, which corresponds with those reported by Healey (1991). With an estimated survival rate of 10%, the ESU should produce roughly 2.53 million natural-origin outmigrants annually.

---

[2] Average abundance calculations are the geometric mean. The geometric mean of a collection of positive data is defined as the nth root of the product of all the members of the data set, where n is the number of members. Salmonid abundance data tend to be skewed by the presence of outliers (observations considerably higher or lower than most of the data). For skewed data, the geometric mean is a more stable statistic than the arithmetic mean.

Juvenile listed hatchery PS Chinook salmon abundance estimates come from the annual hatchery production goals. Hatchery production varies annually due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggest that production averages from previous years is not a reliable indication of future production. For these reasons, abundance is assumed to equal production goals. The combined hatchery production goal for listed PS Chinook salmon from Table 2 is 43,269,740 adipose-fin-clipped and non-clipped juvenile Chinook salmon.

Fifteen-year trends in wild spawner abundance were calculated for each PS Chinook salmon population for two time series – 1990-2005 and 1999-2014 (Table 7). Trends were calculated from a linear regression applied to the smoothed wild spawner log abundance estimate (NWFSC 2015). For the 1990-2005 time series, trends were negative for only two of 22 populations. Recent trends (1999-2014), however, were negative for 17 of the 22 populations (NWFSC 2015).

Table 7. Fifteen year trends for PS Chinook salmon for two time series – 1990-2005 and 1999-2014 (NWFSC 2015).

	1990-2005		1999-2014	
Population	**Trend**	**95% CI**	**Trend**	**95% CI**
Strait of Georgia MPG				
NF Nooksack River	0.07	(0.04, 0.09)	0.04	(0, 0.07)
SF Nooksack River	0.03	(0, 0.06)	-0.06	(-0.10, -0.02)
Strait of Juan de Fuca MPG				
Elwha River	-0.02	(-0.06, 0.02)	-0.06	(-0.10, -0.03)
Dungeness River	0.14	(0.08, 0.19)	0.09	(0.03, 0.14)
Hood Canal MPG				
Skokomish River	0.02	(-0.01, 0.05)	-0.07	(-0.11, -0.02)
Mid-Hood Canal	0.03	(0, 0.07)	-0.07	(-0.11, -0.02)
Whidbey Basin MPG				
Skykomish River	0.03	(0, 0.06)	-0.02	(-0.04, 0.01)
Snoqualmie River	0.09	(0.05, 0.12)	-0.05	(-0.08, -0.03)
NF Stillaguamish River	0.04	(0.02, 0.06)	-0.04	(-0.06, -0.01)
SF Stillaguamish River	0.01	(-0.01, 0.03)	-0.10	(-0.12, -0.08)
Upper Skagit River	0.07	(0.05, 0.09)	-0.03	(-0.06, 0)
Lower Skagit River	0.05	(0.02, 0.09)	-0.03	(-0.06, -0.01)
Upper Sauk River	0.01	(-0.02, 0.04)	0.06	(0.04, 0.08)
Lower Sauk River	0.05	(0.01, 0.08)	-0.04	(-0.07, -0.01)
Suiattle River	0.01	(-0.01, 0.03)	-0.01	(-0.04, 0.01)
Cascade River	0.06	(0.04, 0.08)	0.01	(-0.01, 0.03)
Central / South Sound MPG				
Sammamish River	0.17	(0.11, 0.23)	-0.02	(-0.06, 0.02)
Cedar River	0.03	(0, 0.06)	0.07	(0.05, 0.10)
Green River	0.02	(-0.02, 0.06)	-0.12	(-0.16, -0.09)
Puyallup River	-0.03	(-0.05, -0.02)	-0.06	(-0.08, -0.03)
White River	0.19	(0.17, 0.21)	-0.03	(-0.08, 0.01)
Nisqually River	0.05	(0.03, 0.06)	-0.01	(-0.05, 0.03)

Currently, for every natural-origin juvenile that migrates to Puget Sound 16 listed hatchery juveniles are released into Puget Sound watersheds. The hatchery fish are then targeted for fisheries and removed when they return to their release sites. However, some will stray and others will be missed. For Puget Sound, an average of 40% (range of 2-90%) of the naturally spawning Chinook salmon are first-generation hatchery fish with more than a third of all populations (9 of 22) having more hatchery-origin than natural-origin spawners (Table 7). Studies have documented that hatchery fish spawning in the wild have a lower success rate than naturally produced fish (McLean et al. 2004, Kostow et al. 2002, Berejikian et al. 2001, Reisenbichler and Rubin 1999).

Limiting Factors

Most of the gains in PS Chinook salmon natural-origin spawner abundance since the 1990s have been lost during the most recent 5-year period (2010-2014) (NWFSC 2015). In fact, 2014 abundance numbers were near the historic lows of the 1990s. In addition, the overall abundance is still only a fraction of historical levels. Several risk factors identified in the 2005 status review (Good et al. 2005) are still present, including high fractions of hatchery fish in many populations and widespread habitat loss and degradation. Additionally, there has been no recent improvement in the species' spatial structure or diversity. None of the extirpated populations has been re-established. However, many habitat and hatchery actions identified in the Puget Sound Chinook salmon recovery plan are expected to take years or decades to be implemented and produce significant improvements (NWFSC 2015). Concerning habitat, the following issues continue to impede PS Chinook salmon recovery throughout the fresh and marine waters of Puget Sound: untreated stormwater, contaminants, shoreline armoring, instream flows, impaired floodplain connectivity, and fish passage (NMFS 2016b).

Status Summary

Across the ESU, most populations have declined in abundance over the past seven to 10 years (NWFSC 2015). Further, all PS Chinook salmon populations are well below the PSTRT planning ranges for recovery escapement levels and below the spawner-recruitment levels identified as consistent with recovery (Ford 2011; NWFSC 2015). Hatchery-origin spawners are present in high fractions in most populations outside of the Skagit River watershed with half of these non-Skagit watersheds seeing a decrease in the fraction of natural-origin spawners (NWFSC 2015). Overall, most populations have declined in abundance since the last two status reviews in 2005 and 2010; but the biological risk was determined to have not changed since the previous status reviews (NWFSC 2015).

2.2.2.2 Puget Sound Steelhead

Description and Geographic Range

On August 9, 1996, NMFS determined that the PS steelhead DPS did not warrant listing (61 FR 41541). In response to a petition received on September 13, 2004, NMFS updated the species' status review. On May 7, 2007, NMFS listed PS steelhead—both natural-origin and some artificially-propagated fish—as a threatened species (72 FR 26722). NMFS concluded that the

PS steelhead DPS was likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Six artificial propagation programs were listed as part of the DPS (79 FR 20802; Table 8), including: Green River Natural Program, White River Winter Steelhead Supplementation Program, Hood Canal Steelhead Supplementation Off-station Projects in the Dewatto, Skokomish, and Duckabush Rivers, and Lower Elwha Fish Hatchery Wild Steelhead Recovery Program. NMFS promulgated 4(d) protective regulations for PS steelhead on September 25, 2008 (73 FR 55451). The section 4(d) protections (and limits on them) apply to natural and hatchery PS steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

Table 8. Expected Puget Sound steelhead listed hatchery releases (WDFW 2017).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Dungeness/Elwha	Dungeness	2017	Winter	10,000	-
	Hurd Creek	2018	Winter	-	34,500
Duwamish/Green	Flaming Geyser	2017	Winter	-	15,000
	Icy Creek	2017	Summer	50,000	-
			Winter	-	23,000
	Soos Creek	2017	Summer	50,000	-
Hood Canal	LLTK – Lilliwaup	2014	Winter	230	-
		2016	Winter	-	6,000
Puyallup	White River	2016	Winter	-	35,000
Total Annual Release Number				**110,230**	**113,500**

Steelhead are found in most of the larger accessible tributaries to Puget Sound, Hood Canal, and the eastern Strait of Juan de Fuca. Surveys of the Puget Sound (not including the Hood Canal) in 1929 and 1930 identified steelhead in every major basin except the Deschutes River (Hard et al. 2007). The DPS includes all naturally spawned anadromous winter-run and summer-run *O. mykiss* populations, in streams in the river basins of Puget Sound, Hood Canal, and the Strait of Juan de Fuca, Washington, bounded to the west by the Elwha River (inclusive) and to the north by the Nooksack River and Dakota Creek (inclusive). Hatchery steelhead are also distributed throughout the range of this DPS.

Of all the Pacific salmonids, *O. mykiss* probably exhibits the greatest life history diversity. Resident *O. mykiss*, commonly called rainbow trout, complete their life cycle entirely in freshwater; whereas steelhead, the anadromous form of *O. mykiss*, reside in freshwater for their first one to three years before migrating to the ocean. Smoltification and seaward migration occur principally from April to mid-May (WDF et al. 1993). Though not well understood, smolts are believed to migrate quickly offshore (Hartt and Dell 1986). Steelhead then remain in the ocean for one to three years before returning to freshwater to spawn. In contrast with other Pacific salmonid species, steelhead are iteroparous, thus capable of repeat spawning. Among all West Coast steelhead populations, eight percent of spawning adults have spawned previously, with coastal populations having a higher repeat spawning incidence than inland populations (Busby et al. 1996).

Steelhead life-history type expression comes through the degree of sexual development when adults enter freshwater. Stream-maturing steelhead, also called summer-run steelhead, enter freshwater at an early maturation stage, usually from May to October. These summer-run steelhead migrate to headwater areas, hold for several months, and spawn in the spring. Ocean-maturing steelhead, also called winter-run steelhead, enter freshwater from December to April at an advanced maturation stage and spawn from March through June (Hard et al. 2007). While some temporal overlap in spawn timing between these forms exist, in basins where both winter- and summer-run steelhead are present, summer-run steelhead spawn farther upstream, often above a partially impassable barrier. In many cases, summer migration timing may have evolved to access areas above falls or cascades during low summer flows that are impassable during high winter flow months. However, relatively few basins in the Puget Sound DPS with the geomorphological and hydrological characteristics necessary to establish this summer-run life history exist. Thus, winter-run steelhead are predominant in Puget Sound.

Spatial Structure and Diversity

Although Puget Sound DPS steelhead populations include both summer- and winter-run life-history types, winter-run populations predominate. For the PS steelhead DPS, Myers et al. (2015) identified three Major Population Groups (MPGs) and 32 Demographically Independent Populations (DIPs) composed of 27 winter-run and nine summer-run steelhead stocks (Table 9). Summer-run stock statuses are mostly unknown; however, most appear to be small, averaging less than 200 spawners annually (Hard et al. 2007). Summer-run stocks are primarily concentrated in the northern Puget Sound and the Dungeness River (Myers et al. 2015).

Table 9. PS steelhead historical Demographically Independent Populations (DIPs), runs, and estimated capacities (Myers et al. 2015).

Demographically Independent Populations	Run(s)	Population Capacity
Central and South Puget Sound MPG		
Cedar River	Winter	5,949 – 11,899
N Lake Washington/Lake Sammamish	Winter	5,268 – 10,536
Green River	Winter	19,768 – 39,537
Puyallup/Carbon River	Winter	14,716 – 29,432
White River	Winter	17,490 – 34,981
Nisqually River	Winter	15,330 – 30,660
South Puget Sound Tributaries	Winter	9,854 – 19,709
East Kitsap Peninsula Tributaries	Winter	1,557 – 3,115
	TOTAL	**89,932 – 179,869**
Hood Canal and Strait of Juan de Fuca MPG		
East Hood Canal Tributaries	Winter	1,270 – 2,540
South Hood Canal Tributaries	Winter	2,985 – 5,970
Skokomish River	Winter	10,030 – 20,060
West Hood Canal Tributaries	Winter	3,608 – 7,217
Sequim/Discovery Bays Independent Tributaries	Winter	512 – 1,024
Dungeness River	Summer; Winter	2,465 – 4,930
Strait of Juan de Fuca Independent Tributaries	Winter	728 – 1,456
Elwha River	Winter	7,116 – 14,231
	TOTAL	**28,714 – 57,428**
North Cascades MPG		

Demographically Independent Populations	Run(s)	Population Capacity
Drayton Harbor Tributaries	Winter	2,426 – 4,852
Nooksack River	Winter	22,045 – 44,091
SF Nooksack River	Summer	1,137 – 2,273
Samish River and Bellingham Bay Tributaries	Winter	3,193 – 6,386
Skagit River	Summer; Winter	64,775 – 129,551
Nookachamps Creek	Winter	1,231 – 2,462
Baker River	Summer; Winter	5,028 – 10,056
Sauk River	Summer; Winter	23,230 – 46,460
Stillaguamish River	Winter	19,118 – 38,236
Deer Creek	Summer	1,572 – 3,144
Canyon Creek	Summer	121 - 243
Snohomish/Skykomish River	Winter	21,389 – 42,779
Pilchuck River	Winter	5,193 – 10,386
NF Skykomish River	Summer	663 – 1,325
Snoqualmie River	Winter	16,740 – 33,479
Tolt River	Summer	321 - 641
	TOTAL	**188,182 – 376,364**
	GRAND TOTAL	**306,828 – 613,661**

Probable steelhead extirpations include three summer-run stocks and one winter-run stock. For the Baker River summer-run DIP, Baker River dam construction blocked access to spawning areas. The current Elwha and Green summer-run steelhead stocks are descended from Skamania Hatchery stock, while historical summer-runs in these systems are thought to have been extirpated early in the 1900s. For the Chambers Creek winter-run steelhead stock, broodstock collection and selective breeding at the South Tacoma Hatchery may have been the cause (Hard et al. 2007).

As described above, the DPS is composed of both summer- and winter-run steelhead. The status of the summer-run DIPs was identified as a risk to DPS viability (NMFS 2005a). Summer-run steelhead DIPs, historically occurring throughout the Puget Sound but now concentrated in the northern region, are generally small and characterized as isolated populations adapted to streams with distinct attributes. The one summer-run DIP with abundance data (Tolt River) exhibits a negative trend in natural-origin run size. Most other DIPs are very small, with annual escapements below 50 fish.

Artificial propagation is a major factor affecting the genetic diversity of both summer- and winter-run steelhead in the Puget Sound DPS. Although offsite releases and releases of steelhead fry and parr have largely ceased in the DPS, annual hatchery steelhead smolt releases derived from non-local steelhead (Skamania summer-run steelhead) or domesticated steelhead originally found within the DPS (Chambers Creek winter-run steelhead) persist in most systems. And several of these releases are still composed of tens or hundreds of thousands of fish. This sustained hatchery management practice has increased the likelihood of interbreeding and ecological interaction between wild and hatchery fish—in spite of the apparent differences in average spawning time and its associated adverse fitness consequences for both summer- and winter-run steelhead. As NMFS (2005a) noted, even low levels (e.g., <5%) of gene flow per year from a non-DPS hatchery stock to a naturally spawning population can have a significant genetic impact after several generations. For 2018, 223,730 hatchery steelhead are expected to be released throughout the range of the PS steelhead DPS (WDFW 2017).

Abundance and Productivity

Historical Puget Sound steelhead abundance is largely based on catch records. Catch records from 1889 to 1920 indicate that catch peaked at 163,796 steelhead in 1895. Using harvest rates of 30-50%, the estimated peak run size for Puget Sound would range from 327,592 to 545,987 fish. Myers et al. (2015) estimated historic PS steelhead abundance at 306,828 to 613,661 based upon geographic, hydrologic, and ecological characteristics (Table 9). In the 1980s, Light (1987) estimated the steelhead run size at approximately 100,000 winter-run and 20,000 summer-run steelhead. However, as many as 70% of the run were first generation hatchery fish (Hard et al. 2007). By the mid-1990s, Busby et al. (1996) estimated a total run of 45,000 (winter- and summer-run combined). Since then, DPS escapement (total spawners) has decreased to 17,363 (2000-2004), 15,926 (2005-2009), and 13,422 (2010-2014; Tables 10 and 11).

Table 10. Abundance–five-year geometric means for adult (age 3+) natural origin and total spawners (natural and hatchery origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NWFSC 2015).

Demographically Independent Populations	**Geometric means**					
	1990-1994	**1995-1999**	**2000-2004**	**2005-2009**	**2010-2014**	**% Change**
Central and South Puget Sound MPG						
Cedar River	(321)	(298)	(37)	(12)	(4)	(-67)
Green River	1,566 (1,730)	2,379 (2,505)	1,618 (1,693)	(716)	(552)	(-23)
Nisqually River	1,201 (1,208)	759 (759)	394 (413)	278 (375)	(442)	(18)
N. Lake WA/Lake Sammamish	321 (321)	298 (298)	37 (37)	12 (12)	-	-
Puyallup/Carbon River	1,156 (1,249)	1,003 (1,134)	428 (527)	315 (322)	(277)	(-14)
White River	696 (696)	519 (519)	466 (466)	225 (225)	531 (531)	136 (136)
Hood Canal and Strait of Juan de Fuca MPG						
Dungeness River	356 (356)	-	38 (38)	24 (25)	-	-
East Hood Canal Tribs.	110 (110)	176 (176)	202 (202)	62 (62)	60 (60)	-3 (-3)
Elwha River	206 (358)	127 (508)	(303)	-	(237)	-
Sequim/Discovery Bay Tribs	(30)	(69)	(63)	(17)	(19)	(12)
Skokomish River	385 (503)	359 (359)	205 (259)	351 (351)	(580)	(65)
South Hood Canl Tribs	89 (89)	111 (111)	103 (103)	113 (113)	64 (64)	-43 (-43)
Strait of Juan de Fuca Tribs	89 (89)	191 (191)	212 (212)	101 (101)	147 (147)	46 (46)
West Hood Canal Tribs	-	97 (97)	210 (210)	149 (174)	(74)	(-50)
North Cascades MPG						
Nooksack River	-	-	-	-	1,693 (1,745)	-
Pilchuck River	1,225 (1,225)	1,465 (1,465)	604 (604)	597 (597)	614 (614)	3 (3)
Samish River/ Bellingham Bay Tribs	316 (316)	717 (717)	852 (852)	534 (534)	846 (846)	58 (58)
Skagit River	7,189 (7,650)	7,656 (8,059)	5,424 (5,675)	4,767 (5,547)	(5,123)	(7)
Snohomish/Skykomish Rivers	6,654 (7,394)	6,382 (7,200)	3,230 (3,980)	4,589 (5,399)	(930)	(-83)
Snoqualmie River	1,831 (1,831)	2,056 (2,056)	1,020 (1,020)	944 (944)	680 (680)	-28 (-28)

Demographically Independent Populations	**Geometric means**					
	1990-1994	**1995-1999**	**2000-2004**	**2005-2009**	**2010-2014**	**% Change**
Stillaguamish River	1,078 (1,078)	1,024 (1,166)	401 (550)	259 (327)	(392)	(20)
Tolt River	112 (112)	212 (212)	119 (119)	73 (73)	105 (105)	44 (44)

Steelhead are most abundant in the North Cascades MPG, with the Skagit and Nooksack rivers supporting the two largest winter-run steelhead DIPs (Table 11). The Snohomish/Snoqualmie DIP used to support the second largest DIP for the DPS, but this DIP has declined by 83% during the last five years (NWFSC 2015). Currently, neither the Central and South Puget Sound MPG nor the Hood Canal and Strait of Juan de Fuca MPG DIPs have averaged greater than 600 spawners annually.

Table 11. Abundance of PS steelhead spawner escapements (natural-origin and hatchery-production combined) from 2012-2016 (pers. comm., A. Marshall, WDFW, July 13, 2017).

Demographically Independent Populations	**Spawners**	**Expected Number of Outmigrants**[b]
Central and South Puget Sound MPG		
Cedar River	1	114
Green River	977	111,134
Nisqually River	759	86,336
N. Lake WA/Lake Sammamish	-	-
Puyallup/Carbon River	590	67,113
White River	124	14,105
Hood Canal and Strait of Juan de Fuca MPG		
Dungeness River	-	-
East Hood Canal Tribs.	87	9,896
Elwha River[c]	273	31,054
Sequim/Discovery Bay Tribs.	19	2,161
Skokomish River	862	98,053
South Hood Canal Tribs.	72	8,190
Strait of Juan de Fuca Tribs.	238	27,073
West Hood Canal Tribs.	159	18,086
North Cascades MPG		
Nooksack River	1,790	203,613
Pilchuck River	868	98,735
Samish River/ Bellingham Bay Tribs.	977	111,134
Skagit River	8,038	914,323
Snohomish/Skykomish Rivers	1,053	119,779
Snoqualmie River	824	93,730
Stillaguamish River	476	54,145
Tolt River	70	7,963
TOTAL	**18,257**	**2,076,734**

[a] Geometric mean of post fishery spawners.

[b] Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant.

[c] Hatchery-origin steelhead not included in abundance estimate

The average abundance (2012-2016) for the PS steelhead DPS is 18,257 adult spawners (natural-origin and hatchery-production combined). Juvenile PS steelhead abundance estimates are calculated from the escapement data (Table 11). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (9,129 females), 31.95 million eggs are expected to be produced annually. With an estimated survival rate of 6.5% (Ward and Slaney 1993), the DPS should produce roughly 2.08 million natural-origin outmigrants annually.

Linear regressions of smoothed log natural spawner abundance were applied to PS steelhead DIPs for two 15-year time series trend analyses (1990-2005 and 1999-2014) (NWFSC 2015). For the 1990-2005 time series, trends were negative for 12 of 17 DIPs; and for the 1999-2014 time series, seven of eight DIPs had negative trends (Table 12). Only the Samish River/Bellingham Bay tributaries DIP had a positive trend for both time series (NWFSC 2015).

Table 12. Fifteen year trends for PS steelhead for two time series – 1990-2005 and 1999-2014 (NWFSC 2015).

Demographically Independent Populations	**1990-2005**		**1999-2014**	
	Trend	**95% CI**	**Trend**	**95% CI**
Central and South Puget Sound MPG				
Cedar River	-	-	-	-
Green River	-0.02	(-0.04, 0.01)	-	-
Nisqually River	-0.09	(-0.11, -0.07)	-	-
N. Lake WA/Lake Sammamish	-0.21	(-0.24, -0.18)	-	-
Puyallup/Carbon River	-0.09	(-0.11, -0.07)	-	-
White River	-0.04	(-0.06, -0.03)	-0.01	(-0.05, 0.02)
Hood Canal and Strait of Juan de Fuca MPG				
Dungeness River	-0.20	(-0.23, -0.17)	-	-
East Hood Canal Tribs.	0.00	(-0.02, 0.03)	-0.08	(-0.12, -0.04)
Elwha River	-	-	-	-
Sequim/Discovery Bay Tribs	-	-	-	-
Skokomish River	-0.03	(-0.05, -0.02)	-	-
South Hood Canal Tribs	0.01	(-0.01, 0.03)	-0.02	(-0.05, 0)
Strait of Juan de Fuca Tribs	0.04	(0.01, 0.07)	-0.02	(-0.06, 0.01)
West Hood Canal Tribs	-	-	-	-
North Cascades MPG				
Nooksack River	-	-	-	-
Pilchuck River	-0.04	(-0.06, -0.02)	-0.02	(-0.05, 0.01)
Samish River/Bellingham Bay Tribs	0.04	(0.02, 0.07)	0.02	(-0.01, 0.05)
Skagit River	-0.02	(-0.04, 0)	-	-
Snohomish/Skykomish Rivers	-0.05	(-0.08, -0.03)	-	-
Snoqualmie River	-0.03	(-0.06, -0.01)	-0.05	(-0.08, -0.02)
Stillaguamish River	-0.09	(-0.11, -0.06)	-	-
Tolt River	0.01	(-0.02, 0.04)	-0.02	(-0.06, 0.01)

Juvenile listed hatchery PS steelhead estimates come from the annual hatchery production goals. Hatchery production varies from year to year due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggests that average production from previous years is not a reliable estimate for future production. For these reasons, we will use production goals to estimate abundance. The combined production goal for listed PS steelhead hatchery stocks is 244,897 adipose-fin-clipped and non-clipped juveniles (Table 8).

Limiting Factors

Throughout the DPS, natural-origin steelhead production has shown, at best, a weak response to reduced harvest since the mid-1990s (Hard et al. 2007). Natural-origin production and productivity declines are most pervasive in the southern Puget Sound but occur throughout much of the DPS (NWFSC 2015). These trends primarily reflect patterns in winter-run steelhead—populations for which data are most plentiful. Patterns for most summer-run populations are unknown. Further, the Puget Sound Steelhead TRT identified freshwater habitat degradation and fragmentation with consequent effects on connectivity, as a primary limiting factor and threat facing the PS steelhead (Hard et al. 2007). Beyond that, the causes for the continued declines are somewhat unknown, but prominent causes include hatchery production, harvest management, and dam effects on habitat quality and quantity. Concerning habitat, the following issues continue to impede PS steelhead recovery throughout the fresh and marine waters of Puget Sound: untreated stormwater, contaminants, shoreline armoring, instream flows, impaired floodplain connectivity, and fish passage (NMFS 2016b).

Status Summary

The Puget Sound Steelhead TRT recently concluded that the DPS was at very low viability, as were all three of its constituent MPGs, and many of its 32 DIPs (Hard et al. 2015). Over the past two to three years, there have been some minor increases in spawner abundance; but most of these improvements are small and abundance and productivity remain at levels of concern (NWFSC 2015). Furthermore, abundance trends remain predominantly negative. In addition, some aspects of diversity and spatial structure (i.e. natural spawning of hatchery fish, limited use of suitable habitat) are still likely to be limiting viability of most PS steelhead DIPs. Overall, the biological risk was determined to have not changed between the 2007 ESA listing, 2010 status review, and 2015 status review (NWFSC 2015).

2.2.2.3 Hood Canal Summer-run Chum Salmon

Description and Geographic Range

On June 28, 2005, NMFS listed HCS chum salmon—both natural and some artificially-propagated fish—as a threatened species (70 FR 37160). The species comprises all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington. Under the final listing in 2005, the section 4(d) protections (and limits on them) apply to natural-origin and hatchery HCS chum salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. Four artificial propagation programs were listed as part of the ESU (79 FR 20802): Hamma Hamma Fish Hatchery Program, Lilliwaup Creek Fish Hatchery Program, Tahuya River Program; and Jimmycomelately Creek Fish Hatchery Program. Three of the four programs have been discontinued. The production goals of the remaining program are listed in the Table 13.

Table 13. Expected Hood Canal summer-run juvenile chum salmon hatchery releases (WDFW 2015).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Hood Canal	LLTK - Lilliwaup	2015	Summer	-	150,000
Total Annual Release Number				**-**	**150,000**

Chum salmon in this ESU are summer-run fish. Juveniles, typically as fry, emerge from the gravel and outmigrate almost immediately to seawater. For their first few weeks, they reside in the top two to three centimeters of estuarine surface waters while staying extremely close to the shoreline (WDFW/PNPTT 2000). Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams. HCS chum salmon spawn from mid-September to mid-October (whereas fall-run chum salmon in the same geographic area spawn from November to December or January). Spawning typically occurs in the mainstems and lower river basins. Adults typically mature between the ages of three and five.

Spatial Structure and Diversity

The HCS chum salmon ESU has two populations, each containing multiple stocks or spawning aggregations (Table 14). In the Strait of Juan de Fuca population, state and tribal biologists assessing the species' status in the early 1990s identified small but persistent natural spawning aggregations in three streams (Salmon, Snow, and Jimmycomelately creeks). In the Dungeness River, spawning of unknown aggregations occurred. In Chimacum Creek, HCS chum salmon extirpation occurred in the mid-1980's.

Table 14. Historical populations, spawning aggregations, and the status of summer-run chum salmon in the Hood Canal ESU (Good et al. 2005, PSTRT 2009; Ford 2011).

Population	Spawning Aggregations	Status	Supplementation/Reintroduction Program
Strait of Juan de Fuca	Dungeness River	Unknown	Less than 5 annually recently
	Jimmycomelately Creek	Extant	Supplementation program began in 1999.
	Salmon Creek	Extant	Supplementation program began in 1992.
	Snow Creek	Extant	---
	Chimacum Creek	*Extinct*	Reintroduction program began in 1996; natural spawning reported starting in 1999.
Hood Canal	Big Quilcene River	Extant	Supplementation program began in 1992.
	Little Quilcene River	Extant	---
	Dosewallips River	Extant	---

	Duckabush River	Extant	---
	Hamma Hamma River	Extant	Supplementation program began in 1997.
	Lilliwaup Creek	Extant	---
	Big Beef Creek	*Extinct*	Reintroduction program began in 1996; returns reported starting in 2001
	Anderson Creek	*Extinct*	---
	Dewatto River	*Extinct*	Natural re-colonization occurring, but numbers remain low (<70).
	Tahuya River	*Extinct*	Reintroduction program began in 2000 with increased returns starting in 2006.
	Union River	Extant	---
	Skokomish River	*Extinct*	Spawning documented in recent years.
	Finch Creek	*Extinct*	---

In the Hood Canal population, spawning aggregations persisted in most of the major rivers draining from the Olympic Mountains into the western edge of the Canal, including Big and Little Quilcene Rivers, Dosewallips River, Duckabush River, Hamma Hamma River, and Lilliwaup Creek. On the eastern side of Hood Canal, persistent spawning was restricted to the Union River (PSTRT 2009). Historical information and habitat characteristics of other streams indicate that summer chum salmon distribution was once more region-wide, especially in the eastern shore streams draining into Hood Canal. Based on river size and historical tribal fishing records, a major spawning aggregation once occurred in the Skokomish River before the construction of Cushman Dam in the 1920's. State and tribal biologists also identified recent extinctions in Big Beef Creek, Anderson Creek, Dewatto River, Tahuya River, and Finch Creek. Historically, additional streams such as Seabeck, Stavis, Big and Little Mission Creeks, and others probably supported summer chum salmon.

In 1992, state and tribal co-managers initiated an extensive rebuilding program for the HCS chum salmon (WDFW/PNPTT 2000 and 2001). Their recovery plan called for five supplementation and three reintroduction projects (Table 14). After individual projects' production level goals specified in the Summer Chum Salmon Conservation Initiative were met, supplementation or reintroduction programs were terminated on several streams (WDFW/PNPTT 2000 and 2001).

Spatial structure changes are the greatest concern for the ESU's diversity with HCS chum salmon aggregations being more isolated than they were historically (NMFS 2005b). In the past, most HCS chum salmon aggregations were 20-40 km apart with none greater than 80 km. Most extant summer chum salmon aggregations still occur within 20-40 km of each other, but some extinctions have led to a significant increase in spawning aggregations isolated by 80 km or more. Geographically, the extinctions occurred primarily in the northeastern Olympic Peninsula and northwestern Kitsap Peninsula (at the center of the ESU's geographic range), including all spawning aggregations within the Admiralty Inlet catchment, as well as the Skokomish and Tahuya Rivers. As geographic distances increase between spawning aggregations, they exchange fewer migrants. Such isolations impede the natural exchange of genetic information between spawning aggregations and populations.

Supplementation programs have been very successful in both increasing natural spawning abundance in six of eight extant streams (Salmon, Big Quilcene, Lilliwaup, Hamma Hamma, Jimmycomelately, and Union) and increasing spatial structure due to reintroducing spawning aggregations to three streams (Big Beef, Tahuya, and Chimacum creeks) (NWFSC 2015). The reintroductions have had mixed success, with Chimacum Creek being very successful, but natural-origin production has not yet been sustained in Big Beef Creek and Tahuya River (PNPTT and WDFW 2014). In general, habitat degradation is considered limiting to natural origin production. Habitat preservation and restoration projects in individual watersheds have been implemented concurrently with supplementation programs and have aided in the ability to sustain natural-origin production (NWFSC 2015).

Abundance and Productivity

Historical HCS chum salmon abundance is mostly unknown. Harvest records indicate that chum salmon in the Puget Sound (including the HCS chum salmon ESU) were historically more numerous than Chinook salmon. During the years 1914-1919, four times as many chum salmon were harvested as Chinook salmon in the Puget Sound (WDF 1974). In 1968, spawning escapement records indicate that 45,000 adult HCS chum salmon returned to tributaries (WDF et al. 1993). During the early 1970s, adult chum salmon spawners dropped to about 20,000 annually (Ford 2011). By the 1980s, HCS chum salmon abundance began to decline ever more precipitously with several spawning aggregations extirpated during this period with seven spawning aggregations going extinct (Sands et al. 2009). Spawner abundances in both Hood Canal and Strait of Juan de Fuca populations were lowest throughout the 1990's but increased in the early 2000's (NWFSC 2015). Since the late 2000's, abundances have increased by 25% for the Hood Canal population and 53% for the Strait of Juan de Fuca population (Table 15).

Table 15. Abundance–five-year geometric means for adult natural origin and total spawners (natural and hatchery origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NWFSC 2015).

	Geometric means					
Population	**1990-1994**	**1995-1999**	**2000-2004**	**2005-2009**	**2010-2014**	**% Change**
Hood Canal MPG						
Strait of Juan de Fuca	386 (386)	629 (822)	2,190 (4,178)	4,020 (5,353)	6,169 (8,339)	53 (56)
Hood Canal	979 (979)	5,169 (7,223)	13,145 (18,928)	11,307 (13,605)	14,152 (15,553)	25 (14)

The current average run size of 27,452 adult spawners (25,542 natural-origin and 1,910 hatchery-origin spawners; Table 16) is largely the result of aggressive reintroduction and supplementation programs throughout the ESU. In the Strait of Juan de Fuca population, the annual natural-origin spawners returns for Jimmycomelately Creek dipped to a single fish in 1999 and again in 2002 (unpublished data, Mindy Rowse, NWFSC, Feb 2, 2017). From 2011 to 2015, Jimmycomelately Creek averaged 2,299 natural-origin spawners. Salmon and Snow Creeks have improved substantially. Natural-origin spawner abundance was 130 fish in 1999, whereas the average for Salmon and Snow creeks were 2,990 and 539, respectively, for the 2011-2015 period.

Table 16. Abundance of natural-origin and hatchery-origin HCS chum salmon spawners in escapements 2011-2015 (unpublished data, Mindy Rowse, NWFSC, Nov 1, 2017).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[c]
Strait of Juan de Fuca Population				
Jimmycomelately Creek	2,299	964	29.55%	477,215
Salmon Creek	2,990	2	0.05%	437,468
Snow Creek	539	2	0.36%	79,071
Chimacum Creek	1,273	0	0.00%	186,186
Population Average[d]	7,100	968	12.00%	1,179,941
Hood Canal Population				
Big Quilcene River	7,509	0	0.00%	1,098,212
Little Quilcene River	726	0	0.00%	106,243
Big Beef Creek	68	0	0.00%	9,891
Dosewallips River	2,387	4	0.17%	349,672
Duckabush River	4,136	11	0.25%	606,502
Hamma Hamma River	1,810	7	0.37%	265,673
Anderson Creek	1,810	0	0.00%	264,700
Dewatto River	100	0	0.00%	14,560
Lilliwaup Creek	544	488	47.32%	150,934
Tahuya River	176	419	70.42%	87,029
Union River	980	39	3.79%	148,984
Population Average[d]	18,438	967	4.98%	2,837,988
ESU Average	**25,538**	**1,935**	**7.04%**	**4,017,929**

[a] Five-year geometric mean of post fishery natural-origin spawners (2010-2014).

[b] Five-year geometric mean of post fishery hatchery-origin spawners (2010-2014).

[c] Expected number of outmigrants=Total spawners*45% proportion of females*2,500 eggs per female*13% survival rate from egg to outmigrant.

[d] Averages are calculated as the geometric mean of the annual totals (2010-2014).

The Hood Canal populations have a similar success story. In 1989, only two summer chum salmon were found in spawning surveys conducted on the Big and Little Quilcene Rivers. Now, they have a combined average of 5,395 natural-origin spawners annually from 2010-2014. Hamma Hamma River returns averaged in the thousands between 1968 and 1979. But by 1989, there were an estimated 16 natural-origin spawners in the Hamma Hamma River. Recent estimates show an average of 1,733 natural-origin HCS chum salmon returning to the Hamma Hamma River annually.

The PSTRT defined interim planning ranges for population level abundance for both high productivity and low productivity (NMFS 2006). As the next section illustrates, productivity is low in both populations. Abundance in both populations is currently below the PSTRT planning targets for average natural-origin spawner abundance of 13,000 to 36,000 for the Strait of Juan de Fuca population and 25,000 to 85,000 for the Hood Canal population.

Escapement data, the percentage of females in the population, and fecundity can estimate juvenile HCS chum salmon abundance. ESU fecundity estimates average 2,500 eggs per female, and the proportion of female spawners is approximately 45% of escapement in most populations (WDFW/PNPTT 2000). By applying fecundity estimates to the expected escapement of females (both natural-origin and hatchery-origin spawners – 12,363 females), the ESU is estimated to produce approximately 30.9 million eggs annually. For HCS chum salmon, freshwater mortality rates are high with no more than 13% of the eggs expected to survive to the juvenile migrant stage (Quinn 2005). With an estimated survival rate of 13%, the ESU should produce roughly 4.02 million natural-origin outmigrants annually.

Linear regressions of smoothed log natural spawner abundance were applied to both HCS chum salmon populations for two 15-year time series trend analyses (1990-2005 and 1999-2014) (Table 17) (NWFSC 2015). For both time series, trends were positive for both populations (NWFSC 2015).

Table 17. Fifteen year trends for HCS chum salmon for two time series – 1990-2005 and 1999-2014 (NWFSC 2015).

	1990-2005		**1999-2014**	
Population	**Trend**	**95% CI**	**Trend**	**95% CI**
Hood Canal MPG				
Strait of Juan de Fuca	0.17	(0.11, 0.23)	0.15	(0.08, 0.21)
Hood Canal	0.22	(0.17, 0.27)	0.07	(0.01, 0.13)

Annual hatchery production goals can estimate juvenile listed hatchery HCS chum salmon abundance. Hatchery production varies from year to year due to several factors including funding, equipment failures, human error, disease, and availability of adult spawners. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggests that average production from past years is not a reliable indication of production in the coming years. For these reasons, production goals should equal abundance. The hatchery production goal for listed HCS chum salmon from Table 10 is 150,000 unmarked juvenile chum salmon.

Limiting Factors

While there is cause for optimism about this ESU’s prospects, there is also cause for continued concern. Supplementation and reintroduction programs have increased natural-origin spawner numbers and distribution in both populations, but these hatchery supplementation programs have mostly ended with only one program continuing. The Hood Canal population has shown improvements since the early 1990’s with abundance and productivity gains. With spatial structure, however, there is concern in east Hood Canal where spawning aggregations in Big Beef Creek and Tahuya River are about 60 km apart; thus an additional spawning aggregation would be needed in either Dewatto River or Anderson Creek (PNPTT and WDFW 2014; NWFSC 2015). Despite gains in habitat protection and restoration, concerns remain that given the pressures of population growth and existing land use management measures through local governments (i.e., shoreline management plans, critical area ordinances, and comprehensive plans) may be compromised or not enforced (NWFSC 2015). Overall, limiting factors include degraded estuarine and nearshore habitat, water quality, degraded floodplain connectivity and function, degraded channel structure and complexity, degraded riparian areas and large woody debris recruitment, degraded stream substrate, and degraded stream flow (NMFS 2016b). Lastly, although abundances have increased for both populations, they are still well below what is targeted by the PSTRT for recovery.

Status Summary

The spawning abundance within this ESU has increased since the time of its initial listing (1999; 64 FR 14508); however, the 2005-2009 abundance was lower than the previous five years (2000-2004) (Ford 2011). From 2005 through 2009, productivity decreased and was lower than any other previous 5-year average since 1971 (Ford 2011). However, diversity increased from the low values observed in the 1990s, due to the reintroduction of spawning aggregates and the more uniform abundance among populations (Ford 2011). Overall, the biological risk was determined to have not changed between the 2005 and 2010 status reviews (Ford 2011). Since the 2010 status review, HCS chum spawning abundance has increased while most of the hatchery releases have terminated.

2.2.2.4 Snake River Fall Chinook Salmon

Description and Geographic Range

Snake River fall Chinook salmon were first listed as threatened on April 22, 1992 (NOAA 1992). The ESU included all natural-origin populations of fall Chinook in the mainstem Snake River and several tributaries including the Tucannon, Grande Ronde, Salmon, and Clearwater Rivers. Fall Chinook salmon from the Lyons Ferry Hatchery were included in the ESU but were not listed. When NMFS re-examined the status of this species in 2005, we determined that it still warranted listing as threatened, but in this instance fish from four hatchery programs were considered part of the listed unit (70 FR 37160). Under the final listing in 2005, the section 4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. This document evaluates impacts on both listed natural and listed hatchery fish. We are developing a recovery plan for this species.

Table 18. Listed Hatchery Stocks for the SR Fall Chinook ESU.

Artificial Propagation Program	Run	Location (State)
Lyons Ferry Hatchery	Fall	Snake River (Idaho)
Fall Chinook Acclimation Ponds Program – Pittsburg, Captain John, and Big Canyon ponds	Fall	Snake River (Idaho)
Nez Perce Tribal Hatchery – including North Lapwai Valley, Lakes Gulch, and Cedar Flat Satellite facilities	Fall	Snake and Clearwater Rivers (Idaho)
Oxbow Hatchery	Fall	Snake River (Oregon, Idaho)

Spatial Structure and Diversity

Adult SR fall chinook salmon enter the Columbia River in July and migrate into the Snake River from August through October. Fall chinook salmon generally spawn from October through November, and fry emerge from March through April. Downstream migration generally begins within several weeks of emergence (Becker 1970, Allen and Meekin 1973), and juveniles rear in backwaters and shallow water areas through mid-summer before smolting and migrating to the ocean—thus they exhibit an ocean-type juvenile history. Once in the ocean, they spend one to four years (usually three years) before beginning their spawning migration. Fall returns in the Snake River system are typically dominated by 4-year-old fish.

Fall Chinook salmon returns to the Snake River generally declined through the first half of the 20th century (Irving and Bjornn 1981). In spite of the declines, the Snake River basin remained the largest single natural production area for fall Chinook salmon in the Columbia River drainage into the early 1960s (Fulton 1968). The construction of a series of Snake River mainstem dams considerably reduced spawning and rearing habitat for SR fall Chinook salmon. Historically, the primary fall Chinook salmon spawning areas were located on the upper mainstem Snake River. Currently, natural spawning is limited to the area from the upper end of Lower Granite Reservoir to Hells Canyon Dam, the lower reaches of the Imnaha, Grande Ronde, Clearwater, and Tucannon Rivers, and small mainstem sections in the tailraces of the lower Snake River hydroelectric dams.

The Lyons Ferry Hatchery SR fall Chinook salmon broodstock has been used to supply a major natural spawning supplementation effort in recent years (Bugert et al. 1995). Facilities adjacent to major natural spawning areas have been used to acclimate release groups of yearling smolts. Additional releases of subyearlings have been made in the vicinity of the acclimation sites.

Sampling marked returns determines the composition of the fall Chinook salmon run at Lower Granite Dam. Since the early 1980s, the run has consisted of three major components: unmarked returns of natural origin, marked returns from the Lyons Ferry Hatchery program, and strays from hatchery programs outside the mainstem Snake River. Although all three components of the fall run have increased in recent years, returns of Snake River–origin Chinook salmon have increased at a faster rate than hatchery strays. From the 1990s through the early 2000sm however, hatchery spawners resumed an increasing trend while the natural spawner trend seems to be flattening out (Ford 2011). The apparent leveling off of natural returns in spite of the increases in total brood year spawners was thought to indicate that density dependent habitat effects are influencing production or that high hatchery proportions may be influencing natural production rates. While that may well still be the case, in the last five years, the fraction of natural spawners has continued a slow downward trend on average (see table below).

Table 19 --5-year mean of fraction natural origin fish in the population (sum of all estimates divided by the number of estimates).

Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Snake R. Low. Mainstem FR	0.62	0.58	0.38	0.37	0.31

Abundance and Productivity

No reliable estimates of historical abundance are available for this ESU. Because of their dependence on mainstem habitat for spawning, however, fall Chinook salmon probably have been affected by the development of irrigation and hydroelectric projects to a greater extent than any other species of salmon. It has been estimated that the mean number of adult SR fall Chinook salmon declined from 72,000 in the 1930s and 1940s to 29,000 during the 1950s. Despite this decline, the Snake River remained the most important natural production area for fall Chinook salmon in the entire Columbia River basin through the 1950s.

Counts of natural-origin adult fish continued to decline through the 1980s, reaching a low of 78 individuals in 1990. Since then, the return of natural-origin fish to Lower Granite Dam has varied, but has generally increased. The largest increase in fall Chinook returns to the Snake River spawning area was from the Lyons Ferry Snake River stock component. Moreover, from the year 2003 through the year 2008, the five-year average return to the ESU was 11,321 adult fish (Ford 2011); of these, approximately 22% were of natural origin. In the flowing years, those totals continued to increase; from 2009 through 2012, the four-year rolling mean was 34,524 fall Chinook returning over Ice harbor Dam (University of Washington, 2013). As the table below illustrates, those numbers have continued to increase over the last three years.

Table 20 - 5-year geometric mean of raw natural spawner counts. This is the raw total spawner count times the fraction natural estimate, if available. In parentheses, 5-year geometric mean of raw total spawner counts is shown. The geometric mean was computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of 2 values were used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right.

Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Snake R. Low. Maintem	333 (581)	548 (980)	3049 (8496)	3662 (10581)	11254 (37812)

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2013-2017 is shown in Table 21 (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017).

Table 21. Average Outmigration for SR Fall Chinook Salmon (2013-2017).

Origin	Outmigration*
Natural	585,720
Listed Hatchery Intact Adipose	2,878,985
Listed Hatchery Adipose Clipped	2,707,553

*Listed hatchery outmigration estimates include both yearlings and sub-yearlings; there are no natural-origin yearling fish.

The number of natural fish should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) spawner counts and associated sex ratios and fecundity estimates can vary considerably between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (3) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.). Listed hatchery fish outmigration numbers are also affected by some of these factors, however releases from hatcheries are generally easier to quantify than is natural production.

Productivity for this species has varied greatly over the years and is highly dependent upon hatchery effectiveness. The 1990–2001 estimates of the median population growth rate (λ) were 0.98, assuming a hatchery-spawning effectiveness of 1.0 (equivalent to that of wild spawners), and 1.137 with an assumed hatchery-spawning effectiveness of 0.0. The estimated long-term growth rate for SR fall Chinook salmon population (1975 – 2008) is generally a positive one. The various rates are 1.06 for total spawners, 1.04 if hatchery effectiveness is zero, and 0.90 if hatchery effectiveness is one (Ford 2011). That slightly positive trend has continued in recent years (NWFSC 2015). However, though the overall trend is positive, concerns remain regarding the increasing hatchery component.

Limiting Factors

SR fall Chinook salmon occupy the mainstem Snake River (and the lower reaches of some tributaries) from its confluence with the Columbia River up to the Hells Canyon complex of dams. Almost all historical spawning habitat in the Snake River was blocked by the Hells Canyon Dam complex. Much of the remaining habitat has been reduced by inundation from lower Snake River reservoirs. Spawning and rearing, habitats are affected largely by agriculture including water withdrawals, grazing, and riparian vegetation management disruption of migration corridors and affected flow regimes and estuarine habitat. Mainstem Columbia and Snake River hydroelectric development has disrupted migration corridors and affected flow regimes and estuarine habitat. All of these factors, along with harvest, have negatively affected the ESU to the extent that it was necessary to list them under the ESA, therefore we have identified these limiting factors:

- Degradation of floodplain connectivity and function and channel structure and complexity
- Harvest-related effects
- Loss of access to historical habitat above Hells Canyon and other Snake River dams
- Impacts from mainstem Columbia River and Snake River hydropower systems
- Hatchery-related effects
- Degraded estuarine and nearshore habitat.

Status Summary

Several factors—both population- and habitat-related have caused this ESU to decline to the point that it is likely to become endangered in the foreseeable future. While there have been some improvement in terms of both abundance and productivity in recent years, it is not enough to prevent them from being threatened and they are currently considered to be at moderate risk with regard to the VSP parameters (NWFSC 2015).

2.2.2.5 Snake River Spring/summer Chinook Salmon

Description and Geographic Range

Snake River spring/summer Chinook salmon were first listed as threatened on April 22, 1992 (NOAA 1992). At the time, it included all natural-origin populations in the Tucannon, Grande Ronde, Imnaha, and Salmon Rivers. Some or all of the fish returning to several of the hatchery programs were also listed, including those returning to the Tucannon River, Imnaha River, and Grande Ronde River hatcheries, and to the Sawtooth, Pahsimeroi, and McCall hatcheries on the Salmon River. When NMFS re-examined the status of these fish, we determined that they still warranted listing as threatened, but we expanded to 15 the list of hatchery programs contributing fish considered to constitute part of the species. Subsequently that list was reduced to the programs displayed in the table below (79 FR 20802). Under the final listing in 2005, the section 4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. This document evaluates impacts on both listed natural and listed hatchery fish. A recovery plan is being developed for this species.

Table 22. List of Hatchery Stocks Included in the SR Spr/sum Chinook Salmon ESU.

Artificial Propagation Program	Run	Location (State)
Tucannon River Program*	Spring	Tucannon River (Washington)
Lostine River (captive*/conventional)	Summer	Grande Ronde (Oregon)
Catherine Creek (captive/conventional)	Summer	Grande Ronde (Oregon)
Lookingglass Hatchery (reintroduction)	Summer	Grande Ronde (Oregon)
Upper Grande Ronde (captive/conventional)	Summer	Grande Ronde (Oregon)
Imnaha River	Spring/ Summer	Imnaha River (Oregon)
Big Sheep Creek	Spring/ Summer	Imnaha River (Oregon)
McCall Hatchery	Summer	South Fork Salmon River (Idaho)
Johnson Creek Artificial Propagation Enhancement*	Summer	East Fork South Fork Salmon River (Idaho)
Pahsimeroi Hatchery	Summer	Salmon River (Idaho)
Sawtooth Hatchery	Spring	Upper Mainstem Salmon River (Idaho)
Dollar Creek**	Spring	SF Salmon River (Idaho)
Panther Creek**	Summer	Salmon River (Idaho)
Yankee Fork**	Spring	Yankee Fork (Idaho)

* Denotes programs that were listed as part of the 1999 listing of the ESU
**Denotes program proposed for inclusion in 2016

Spatial Structure and Diversity

The present range of spawning and rearing habitat for naturally spawned SR spring/summer Chinook salmon is primarily limited to the Salmon, Grande Ronde, Imnaha, and Tucannon River subbasins. Historically, the Salmon River system may have supported more than 40% of the total return of spring/summer-run Chinook salmon to the Columbia River system (e.g., Fulton 1968). Most SR spring/summer Chinook salmon enter individual subbasins from May through September. Juvenile SR spring/summer Chinook salmon emerge from spawning gravels from February through June (Peery and Bjornn 1991). Typically, after rearing in their nursery streams for about one year, smolts begin migrating seaward in April and May (Bugert et al. 1990, Cannamela 1992). After reaching the mouth of the Columbia River, spring/summer Chinook salmon probably inhabit nearshore areas before beginning their northeast Pacific Ocean migration, which lasts two to three years.

The South Fork and Middle Fork Salmon River currently support the bulk of natural production in the drainage. Two large tributaries entering above the confluence of the Middle Fork Salmon River, the Lemhi and Pahsimeroi Rivers, drain broad alluvial valleys and are believed to have historically supported substantial, relatively productive anadromous fish runs.

SR spring/summer Chinook salmon are produced at a number of artificial production facilities in the Snake River basin. Much of the production was initiated under the Lower Snake River Compensation Plan (LSRCP). Lyons Ferry Hatchery serves as a rearing station for Tucannon River spring-run Chinook salmon broodstock. Rapid River Hatchery and McCall Hatchery provide rearing support for a regionally derived summer-run Chinook salmon broodstock released into lower Salmon River areas. Two major hatchery programs operate in the upper Salmon Basin—the Pahsimeroi and Sawtooth facilities. Since the mid-1990s, small-scale natural stock supplementation studies and captive breeding efforts have been initiated in the Snake River basin.

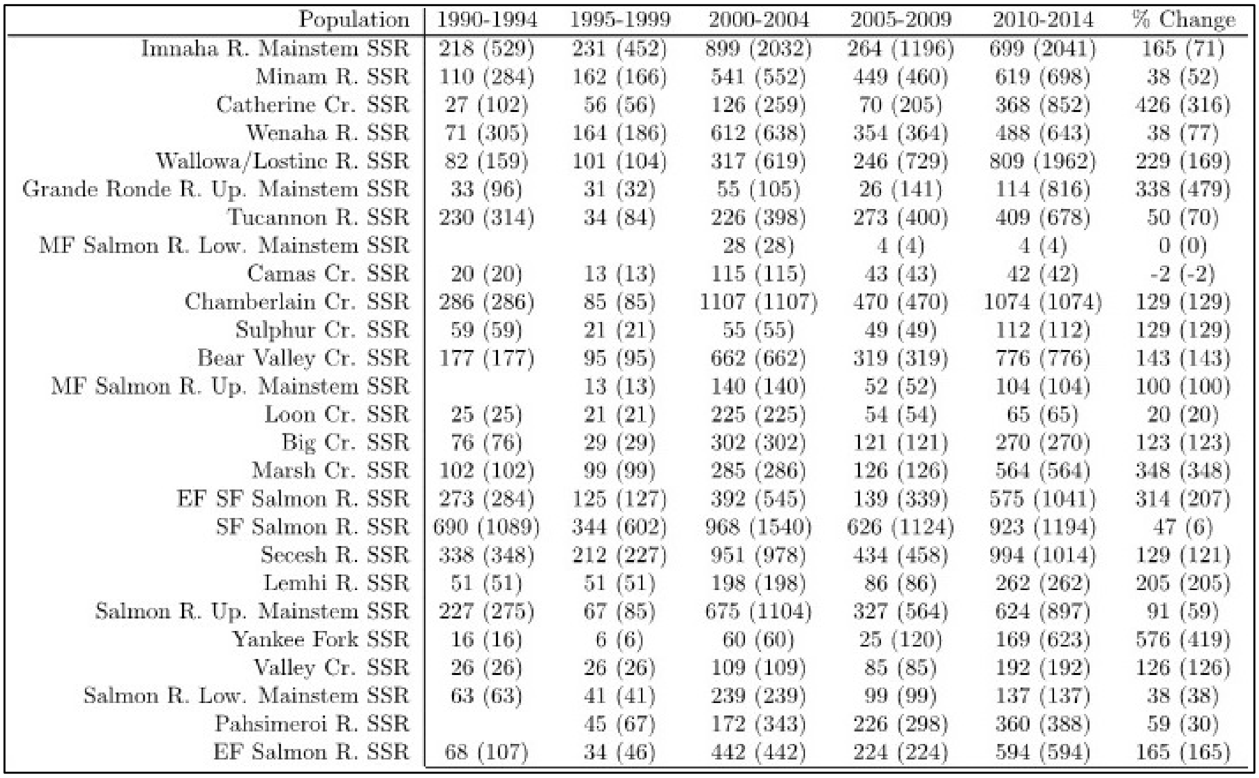
One threat to diversity from hatchery introgression—the use of the Rapid River Hatchery stock in Grande Ronde drainage hatchery programs—has been phased out since the late 1990s. In addition, a substantial proportion of marked returns of Rapid River Hatchery stock released in the Grande Ronde River have been intercepted and removed at the Lower Granite Dam ladder and at some tributary-level weirs. Carcass survey data indicate large declines in hatchery contributions to natural spawning in areas previously subject to Rapid River Hatchery stock strays.

Abundance

No direct estimates of historical SR spr/sum Chinook returns to the Snake River are available. Chapman (1986) estimated that the Columbia River produced 2.5 million to 3.0 million spring and summer Chinook per year in the late 1800s. Total spring and summer Chinook production from the Snake basin contributed a substantial proportion of those returns; the total annual production of SR spr/sum Chinook may have been in excess of 1.5 million adult returns per year (Matthews and Waples 1991). Returns to Snake River tributaries had dropped to roughly 100,000 adults per year by the late 1960s (Fulton 1968). Increasing hatchery production contributed to subsequent years’ returns, masking a continued decline in natural production.

The 1997-2001 geometric mean total return for spring/summer Chinook was slightly more than 6,000 fish. This was a marked improvement over the previous ten years when the geometric mean return was 3,076. That increase continued relatively steadily through 2004, when 97,946 adults returned (including jacks), but dropped off precipitously in 2005 when only 39,126 fish (including jacks) returned above Ice Harbor Dam (FPC 2005). The increases from 2001 through 2004 are generally thought to have been a result of good ocean conditions for rearing and good Columbia River flows for outmigration. But even with generally better trends in recent years, no population of spring/summer is meeting recovery goals. From the year 2008 through the year 2011, the four-year average return to the ESU was 11,819 adult fish (SPS query April 2014); of these, approximately 82% were of natural origin. As the following table demonstrates, those numbers have increased for almost all populations since then.

Table 23 -- 5-year geometric mean of raw natural origin spawner counts. This is the raw total spawner count times the fraction natural origin estimate, if available. In parentheses, 5-year geometric mean of raw total spawner counts is shown. The geometric mean was computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of 2 values were used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right.



Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Imnaha R. Mainstem SSR	218 (529)	231 (452)	899 (2032)	264 (1196)	699 (2041)	165 (71)
Minam R. SSR	110 (284)	162 (166)	541 (552)	449 (460)	619 (698)	38 (52)
Catherine Cr. SSR	27 (102)	56 (56)	126 (259)	70 (205)	368 (852)	426 (316)
Wenaha R. SSR	71 (305)	164 (186)	612 (638)	354 (364)	488 (643)	38 (77)
Wallowa/Lostine R. SSR	82 (159)	101 (104)	317 (619)	246 (729)	809 (1962)	229 (169)
Grande Ronde R. Up. Mainstem SSR	33 (96)	31 (32)	55 (105)	26 (141)	114 (816)	338 (479)
Tucannon R. SSR	230 (314)	34 (84)	226 (398)	273 (400)	409 (678)	50 (70)
MF Salmon R. Low. Mainstem SSR			28 (28)	4 (4)	4 (4)	0 (0)
Camas Cr. SSR	20 (20)	13 (13)	115 (115)	43 (43)	42 (42)	-2 (-2)
Chamberlain Cr. SSR	286 (286)	85 (85)	1107 (1107)	470 (470)	1074 (1074)	129 (129)
Sulphur Cr. SSR	59 (59)	21 (21)	55 (55)	49 (49)	112 (112)	129 (129)
Bear Valley Cr. SSR	177 (177)	95 (95)	662 (662)	319 (319)	776 (776)	143 (143)
MF Salmon R. Up. Mainstem SSR		13 (13)	140 (140)	52 (52)	104 (104)	100 (100)
Loon Cr. SSR	25 (25)	21 (21)	225 (225)	54 (54)	65 (65)	20 (20)
Big Cr. SSR	76 (76)	29 (29)	302 (302)	121 (121)	270 (270)	123 (123)
Marsh Cr. SSR	102 (102)	99 (99)	285 (286)	126 (126)	564 (564)	348 (348)
EF SF Salmon R. SSR	273 (284)	125 (127)	392 (545)	139 (339)	575 (1041)	314 (207)
SF Salmon R. SSR	690 (1089)	344 (602)	968 (1540)	626 (1124)	923 (1194)	47 (6)
Secesh R. SSR	338 (348)	212 (227)	951 (978)	434 (458)	994 (1014)	129 (121)
Lemhi R. SSR	51 (51)	51 (51)	198 (198)	86 (86)	262 (262)	205 (205)
Salmon R. Up. Mainstem SSR	227 (275)	67 (85)	675 (1104)	327 (564)	624 (897)	91 (59)
Yankee Fork SSR	16 (16)	6 (6)	60 (60)	25 (120)	169 (623)	576 (419)
Valley Cr. SSR	26 (26)	26 (26)	109 (109)	85 (85)	192 (192)	126 (126)
Salmon R. Low. Mainstem SSR	63 (63)	41 (41)	239 (239)	99 (99)	137 (137)	38 (38)
Pahsimeroi R. SSR		45 (67)	172 (343)	226 (298)	360 (388)	59 (30)
EF Salmon R. SSR	68 (107)	34 (46)	442 (442)	224 (224)	594 (594)	165 (165)

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2013-2017 is shown in Table 6 (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017).

Table 24. Average Outmigration for Listed SR spr/sum Chinook Salmon (2013-2017).

Origin	Outmigration
Natural	1,383,142
Listed Hatchery Intact Adipose	1,007,592
Listed Hatchery Adipose Clipped	4,453,059

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (3) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (4) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Productivity

Productivity data have been generally lacking since this species was listed. Those data that do exist have been pretty highly variable in terms of methodology, consistency, and coverage. The most recent status review (NWFSC 2015) went to great lengths to compile and codify both the most recent and the historical data for many of the SR spring/summer Chinook populations and they are reflected in the following figure.

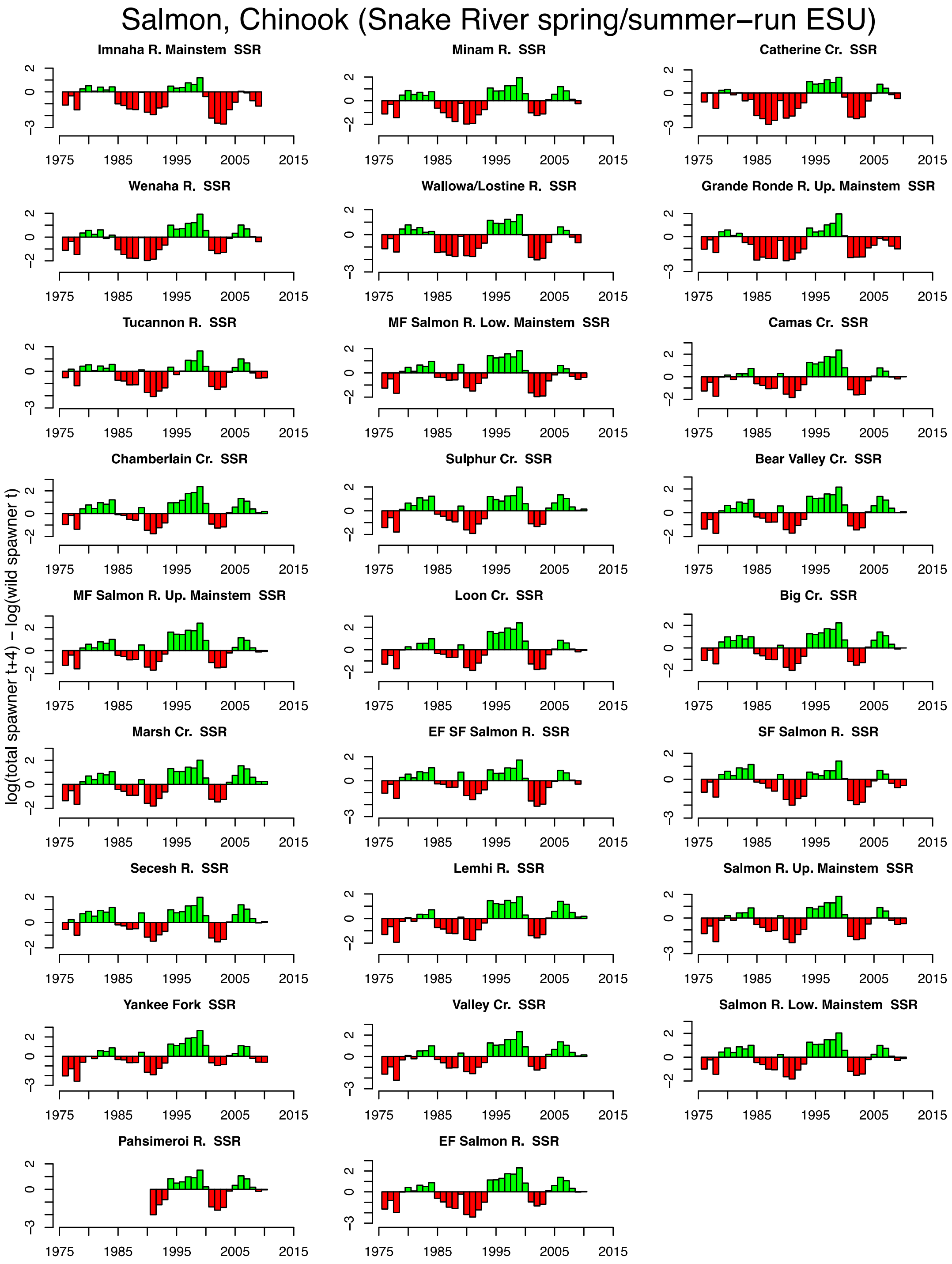


Figure 1 – Trends in population productivity, estimated as the log of the smoothed natural spawning abundance in year *t* - smoothed natural spawning abundance in year (*t* – 4). Spawning years on x axis.

As the figure above illustrates, production has varied greatly over the last several decades. In the most recent ten years, trends were generally up (above replacement) from 2005 through 2010, and either neutral or downward since then.

Limiting Factors

This ESU occupies the Snake River Basin—including the headwaters of many streams—from its confluence with the Columbia River, upstream to the Hells Canyon complex of Dams. The area is generally a mix of dry forest, upland steppe, and semi-arid grassland. Streams tend to lose much of their flow through percolation and evaporation, and only the larger rivers that lie below the water table contain substantial flows year round. Extended dry intervals are very common in the Snake River Plateau. Mainstem Columbia and Snake River hydroelectric development has greatly disrupted migration corridors and affected flow regimes and estuarine habitat. There is habitat degradation in many areas related to forest, grazing, and mining practices, with major factors being lack of pools, high temperatures, low flows, poor overwintering conditions, and high sediment loads. Therefore all of these factors—along with harvest interceptions and hydropower system mortalities—have negatively affected the ESU to the extent that it was necessary to list it under the ESA:

- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality.
- Effects related to the hydropower system in the mainstem Columbia River, including reduced upstream and downstream fish passage, altered ecosystem structure and function, altered flows, and degraded water quality.
- Harvest-related effects.
- Predation.

Status Summary

Several factors—both population- and habitat-related–have caused this ESU to decline to the point that it is likely to become endangered in the foreseeable future. While there has been some improvement in a number of areas, particularly the 10-year average abundance, it is not enough to prevent them from being threatened. The NWFSC (2015) rated all but one population in the ESU (all 28 of them) as being at “high risk” when the four VSP parameters were combined into an overall score for each. In general, those ratings were driven by high risk ratings for the abundance and productivity parameters.

2.2.2.6 Snake River Steelhead

Description and Geographic Range

Snake River (SR) steelhead were listed as a threatened species on January 5, 2006 (71 FR 834); the listing includes all naturally spawning populations of steelhead in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho. Six artificial propagation programs are considered part of the listed species (Table 25). Under the final listing in 2006, the section

4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. This document evaluates impacts on both listed natural and listed hatchery fish. We are developing a recovery plan for this species.

Table 25. Listed Hatchery Populations of SR Steelhead.

Artificial Propagation Program	Run	Location (State)
Tucannon River *	Summer	Tucannon River (Washington)
Dworshak NFH/Clearwater FH	Summer	South Fork Clearwater River (Idaho)
Dworshak NFH	Summer	Clearwater R/North Fk Clearwater R (Idaho)
Dworshak NFH	Summer	Lolo Creek-Clearwater River (Idaho)
East Fork Salmon River	Summer	East Fork Salmon River (Idaho)
Little Sheep Creek/Imnaha River Hatchery (ODFW stock # 29) *	Summer	Imnaha River (Oregon)
EF Salmon River (B-run)**	B Run	Dworshak NFH Program and SF Clearwater Hatchery (Idaho)
Squaw Creek**	B Run	Dworshak NFH Program and SF Clearwater Hatchery (Idaho)
Little Salmon River**	B Run	Dworshak NFH Program and SF Clearwater Hatchery (Idaho)
SF Clearwater**	B Run	Dworshak NFH Program and SF Clearwater Hatchery (Idaho)

* Denotes programs that were listed as part of the 1999 listing of the DPS
**Denotes program recommended for inclusion in 2016.

Spatial Structure and Diversity

SR steelhead are distributed throughout the Snake River drainage system, including tributaries in southwest Washington, eastern Oregon and north/central Idaho (NMFS 1996). Steelhead migrate a substantial distance from the ocean (up to 1,500 km) and use high elevation tributaries (typically 1,000-2,000 meters above sea level) for spawning and juvenile rearing. Steelhead occupy habitat that is considerably warmer and drier (on an annual basis) than other steelhead DPSs. Steelhead are generally classified as summer-run, based on their adult run timing patterns. Summer steelhead enter the Columbia River from late June to October. After holding over the winter, summer steelhead spawn during the following spring (March to May). Managers classify up-river summer steelhead runs into two groups based primarily on ocean age and adult size upon return to the Columbia River. A-run steelhead are predominately age-1 ocean fish while B-run steelhead are larger, predominated by age-2 ocean fish.

With the exception of the Tucannon River and some small tributaries to the mainstem Snake River, the tributary habitat used by SR steelhead is above Lower Granite Dam. Major groupings of populations and subpopulations can be found in the Grande Ronde River system, the Imnaha River drainage, the Clearwater River drainages, the South Fork Salmon River, the smaller mainstem tributaries before the confluence of the mainstem Snake River, the Middle Fork Salmon River, the Lemhi and Pahsimeroi Rivers, and the upper Salmon River tributaries.

Almost all artificial production of steelhead in the Snake River steelhead DPS has been associated with two major mitigation initiatives—the Lower Snake River Compensation Program (LSRCP) and the mitigation program for Dworshak Dam on the North Fork Clearwater River. The LSRCP is administered by the USFWS and was established as compensation for losses incurred as a result of the construction and operation of the four lower Snake River hydroelectric dams. Production under this initiative generally began in the mid-1980s. The Dworshak mitigation program provides artificial production as compensation for the loss of access to the North Fork Clearwater, a major historical production area. Dworshak Hatchery, completed in 1969, is the focus for that production. In all, hatchery releases in some 17 subbasins—covering nearly 60 different stocks of SR steelhead—total an average of over 10 million smolts a year (Good et al. 2005).

Given the range of conditions and the number of populations in these major groups, the status of the species with regard to structure and diversity risk factors is highly variable. Generally though, the structure and diversity risks for all populations is considered low to moderate. The most recent assessments (NWFSC 2015) of this species' risk with regard to these factors is found in Table 26, below.

Abundance and Productivity

Although no direct historical estimates of production from the Snake River basin are available, the basin is believed to have supported more than half the total steelhead production from the Columbia River basin (Mallet 1974). The longest consistent indicator of steelhead abundance in the Snake River basin is derived from counts of natural-origin steelhead at the uppermost dam on the lower Snake River (Lower Granite Dam). According to these estimates, the abundance of natural-origin steelhead at the uppermost dam on the Snake River has declined from a 4-year average of 58,300 in 1964 to a 4-year average of 8,300 ending in 1998. In general, steelhead abundance declined sharply in the early 1970s, rebuilt modestly from the mid-1970s through the 1980s, and declined again during the 1990s. With a few exceptions, annual estimates of steelhead returns to specific production areas within the Snake River are not available. Annual estimates of returns are available for the Tucannon River, sections of the Grande Ronde River system, and the Imnaha River. Overall, from the year 2004 through the year 2009, the five-year average return to the ESU was 162,323 adult fish (Ford 2011); of these, approximately 90% were of hatchery origin (PCSRF 2007). That recent upward trend has generally continued and the most recent year for which these numbers have been calculated and published is 2014. That year, the SR steelhead total return to Lower Granite Dam was 43,803 natural adults (AMIP). And the most recent four-year average for those returns was 33,340. Given that these fish constitute approximately 10% of the total run, it signifies that the total return for 2014 was 438,000 fish and the 2011-2014 average was 333,400.

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the

Columbia River basin. The averages of the five most recent projections for the SR steelhead juvenile outmigration are displayed below.

Table 26. Recent Five-Year Average Projected Outmigrations for SR Steelhead (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017).

Origin	Outmigration
Natural	804,571
Listed Hatchery: Adipose Clipped	749,088
Listed Hatchery: Intact Adipose	3,345,005

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (3) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (4) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

We only have good productivity data for two SR steelhead populations: Joseph Creek and the upper Grand Ronde River. Data for longer term trend analyses for the populations begin with estimates from the early 1970s and extend through 2009. The average trend over the full time period was a negative 1 to 5% per year for the Upper Grande Ronde and a positive 4% per year for Joseph Creek across the range of long term trend metrics (Ford 2011). Estimates of annual spawning escapements into the Upper Grande Ronde River (dam counts) fluctuated around lower levels for a prolonged period except for a peak in the mid-1980s and an increase in the most recent two years for which we have data. Estimated escapements in Joseph Creek were generally lower in the 1970s, and fluctuated around higher levels after also peaking in the mid-1980s. The aggregate Lower Granite Dam abundance estimates are available for years going back to the 1986- 87 cycle. The general trend in returns derived from those counts has been slightly positive across all groups for the last few years: that is, from 1995 through 2008, the trends for all spawners range from 0.98 to 1.11—depending on hatchery efficiency (Ford 2011). This trend has been slowly but steadily increasing since at least 1987. However, the fraction of hatchery spawners has also been increasing that entire time and, as noted, that trend remains an issue of concern.

Limiting factors

SR steelhead occupy the Snake River basin (including many tributary habitats) from its confluence with the Columbia River upstream to the Hells Canyon complex of dams. The area is generally a mix of dry forest, upland steppe, and semi-arid grassland. Streams tend to lose much of their flow through percolation and evaporation, and only the larger rivers that lie below the water table contain substantial flows year-round. Extended dry intervals are very common in the Snake River Plateau. In addition, much of this DPS's habitat has been affected by logging, mining, water withdrawals, and hydropower development. As a result of these activities and tribal and recreation harvest, the main limiting factors for this DPS are (NMFS 2011b; NMFS 2011c):

- Adverse effects related to the mainstem Columbia River hydropower system
- Impaired tributary fish passage
- Degradation of d floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality
- Increased water temperature
- Harvest-related effects, particularly for B-run steelhead
- Predation
- Genetic diversity effects from out-of-population hatchery releases

Status Summary

Abundance and productivity data for this species are very limited, but the most recent status review (NWFSC 2015) has added a good deal to our knowledge. The following table describes what we know about the overall risks facing most of the major populations in the DPS.

Table 27 – Summary of status relative to the ICTRT viability criteria. Ratings with ? are based on limited or provisional data series (NWFSC 2015).

Population	Abundance/Productivity Metrics				Spatial Structure and Diversity Metrics			Overall Viability Rating
	ICTRT Minimum Threshold	Natural Spawning Abundance	ICTRT Productivity	Integrated A/P Risk	Natural Processes Risk	Diversity Risk	Integrated SS/D Risk	
Tucannon River	1,000	NA	NA	High??	Low	Moderate	Moderate	HIGH RISK??
Asotin Creek	500		NA	Moderate?	Low	Moderate	Moderate	MAINTAINED? (HIGH RISK??)
Lower Grande Ronde River	1,000	NA	NA		Low	Moderate	Moderate	MAINTAINED?
Joseph Creek	500	1,839	1.86	Very Low	Very Low	Low	Low	HIGHLY VIABLE
Upper Grande Ronde	1500	1,649 (.21)	3.15 (.40)	Viable (Moderate)	Very Low	Moderate	Moderate	VIABLE
Wallowa River	1,000	NA	NA	High??	Very Low	Low	Low	Moderate?
Imnaha River	1,000	NA	NA	Moderate?	Very Low	Moderate	Moderate	Moderate?
Lower Main. Clearwater R.	1,500	2,099 (.15)	2.36(.16)	Moderate?	Very Low	Low	Low	MAINTAINED?
South Fork Clearwater R.	1,000	NA	NA	High	Low	Moderate	Moderate	MAINTAINED/HIGH RISK?
Lolo Creek	500	NA	NA	High	Low	Moderate	Moderate	
Selway R.	1,000	1,650 (0.17)	2.33 (0.18)	Moderate?	Very Low	Low	Low	MAINTAINED?
Lochsa R.	1,000			Moderate?	Very Low	Low	Low	
		NA	NA					
Little Salmon R.	500	NA	NA	Moderate?	Low	Moderate	Moderate	MAINTAINED?

South Fork Salmon R.	1,000	1,028 (0.17)	1.80 (.148)	Moderate?	Very Low	Low	Low	MAINTAINED?
Secesh R.	500			Moderate?	Low	Low	Low	MAINTAINED?
Chamberlain Creek	500	2,213 (0.16)	2.38 (.104)	Moderate?	Low	Low	Low	MAINTAINED?
Lower Middle Fork Salmon R.	1,000			Moderate?	Very Low	Low	Low	MAINTAINED?
Upper Middle Fork Salmon R.	1,000			Moderate?	Very Low	Low	Low	MAINTAINED?
Panther Creek	500	NA	NA	Moderate	High	Moderate	High	HIGH RISK?
North Fork Salmon R.	500	NA	NA	Moderate	Low	Moderate	Moderate	MAINTAINED?
Lemhi R.	1,000	NA	NA	Moderate	Low	Moderate	Moderate	MAINTAINED?
Pahsimeroi R.	1,000	NA	NA	Moderate	Moderate	Moderate	Moderate	MAINTAINED?
East Fork Salmon R.	1,000	NA	NA	Moderate	Very Low	Moderate	Moderate	MAINTAINED?
Up Main. Salmon R.	1,000	NA	NA	Moderate	Very Low	Moderate	Moderate	MAINTAINED?

2.2.2.7 Upper Columbia River Steelhead

Description and Geographic Range

On August 18, 1997, NMFS first listed UCR steelhead as an endangered species under the ESA (62 FR 43937). In that determination, NMFS concluded that the UCR steelhead were in danger of extinction throughout all or a significant portion of their range. When NMFS re-examined the status of the UCR steelhead, explicitly taking into account the effect of abundant hatchery steelhead on the immediacy of the risk, we determined that the DPS was likely to become endangered in the foreseeable future (threatened), rather than presently endangered (71 FR 834). That listing was set aside on June 13, 2007 (Trout Unlimited et al. v. Lohn; Case Number CV06-0483-JCC), and the status of the species reverted to endangered as a result of the court’s order. The district court’s order was appealed to the Ninth Circuit and the status reverted onc3e again to Threatened. On August 15, 2011, NMFS announced the results of an ESA 5-year review UCR Chinook (76 FR 50448). After reviewing new information on the viability of this species, ESA section 4 listing factors, and efforts being made to protect the species, NMFS concluded that this species should retain its threatened listing classification. Another review was completed in 2015 (NWFSC 2015) and, given the same considerations, the 2015 status review team found that while there had been some improvement in a number of areas, the risk categories for this species remained unchanged from the previous review. However, the team rated the species’ overall risk trend as “improving”. A recovery plan is available for this species (Upper Columbia Salmon Recovery Board 2007).

Table 28. List of Hatchery Stocks Included in the UCR Steelhead DPS.

Artificial Propagation Program	Run	Location (State)
Wenatchee River Steelhead *	Summer	Wenatchee River (Washington)
Wells Hatchery Steelhead *	Summer	Methow River (Washington)
	Summer	Okanogan River (Washington)

Winthrop NFH Steelhead (Wells Steelhead)	Summer	Methow River (Washington)
Omak Creek Steelhead	Summer	Okanogan River (Washington)
Ringold Hatchery (Wells Steelhead)	Summer	Middle Columbia River (Washington)

* Denotes programs that were listed as part of the 1999 listing of the DPS

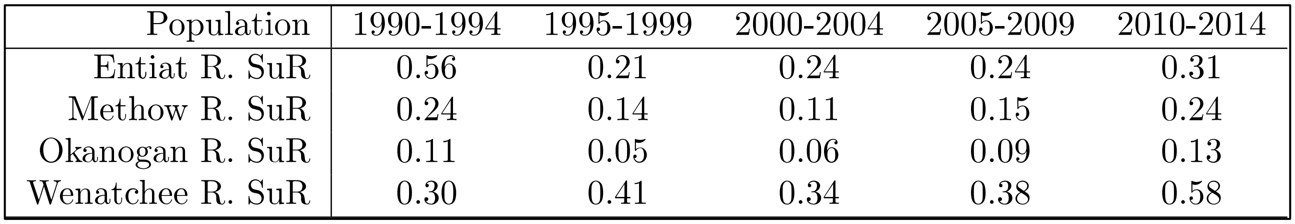
Spatial Structure and Diversity

The UCR steelhead inhabit the Columbia River and its tributaries upstream of the Yakima River. This region includes several rivers that drain the east slopes of the Cascade Mountains and several that originate in Canada (only U.S. populations are included in the listed species). Dry habitat conditions in this area are less conducive to steelhead survival than those in many other parts of the Columbia River basin (Mullen et al. 1992a). Although the life history of these fish is similar to that of other inland steelhead, smolt ages are some of the oldest on the West Coast (up to seven years old), probably due to the ubiquitous cold water temperatures (Mullen et al. 1992b). Adults spawn later than in most downstream populations—remaining in fresh water up to a year before spawning. Most current natural production occurs in the Wenatchee and Methow River systems, with a smaller run returning to the Entiat River (WDF et al. 1993). Very limited spawning also occurs in the Okanagan River basin. Most of the fish spawning in natural production areas are of hatchery origin. The final listing in 2006, the section 4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. This document evaluates impacts on both listed natural and listed hatchery fish.

Life histories are relatively uniform throughout all populations in the UCR steelhead DPS. In 2000, NMFS developed an initial set of population definitions for this DPS, along with basic criteria for evaluating the status of each population using guidelines described in McElhany et al. (2000). The Interior Columbia Technical Recovery team (ICTRT 2007) adopted these population definitions and, as noted above, determined the populations to be the Methow, the Entiat, the Wenatchee, and the Okanogan.

Hatchery returns dominate the estimated escapement in the Wenatchee, Methow, and Okanogan river drainages. The effectiveness of hatchery spawners relative to their natural counterparts is a major uncertainty for all populations but the fraction of hatchery spawners has increased consistently for all four populations since the late 1990s (NWFSC 2015). Although the return timing into the Columbia River is similar for both wild and hatchery steelhead returning to the upper Columbia, the spawning timing in the hatchery is accelerated. Natural-origin proportions were the highest in the Wenatchee River (58%). Although increasing, natural origin proportions in the Methow and Okanogan rivers remained at low levels. There are currently direct releases of hatchery origin juveniles in three of the four populations, the exception being the Entiat River.

Table 29 -- 5-year mean of fraction natural origin (sum of all estimates divided by the number of estimates)(NWFSC 2015).



Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Entiat R. SuR	0.56	0.21	0.24	0.24	0.31
Methow R. SuR	0.24	0.14	0.11	0.15	0.24
Okanogan R. SuR	0.11	0.05	0.06	0.09	0.13
Wenatchee R. SuR	0.30	0.41	0.34	0.38	0.58

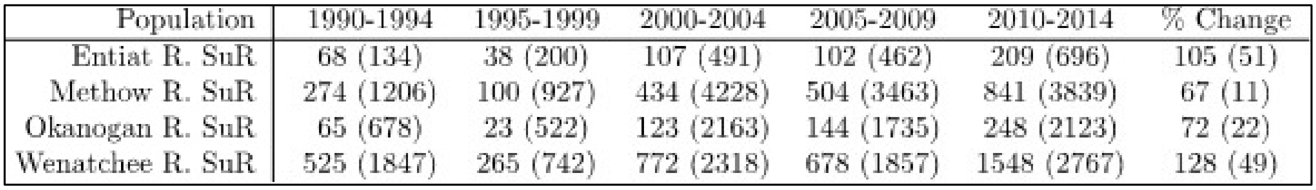
Abundance and Productivity

Estimates of historical (pre-1960s) abundance specific to the UCR steelhead are available from fish counts at dams. Counts at Rock Island Dam from 1933 to 1959 averaged 2,600 to 3,700, suggesting a pre-fishery run size in excess of 5,000 adults for tributaries above Rock Island Dam (Chapman et al. 1994). Runs may have already been depressed by lower Columbia River fisheries at this time. Steelhead in the upper Columbia River continue to exhibit low abundances, both in absolute numbers and in relation to numbers of hatchery fish throughout the region.

A review of data from the past several years indicates that natural steelhead abundance has declined or remained low in the major river basins occupied by this species since the early 1990s. However, returns of both hatchery and naturally produced steelhead to the upper Columbia have increased somewhat in recent years

The most recent estimates (5-year geometric mean) of total and natural-origin spawner abundance have increased relative to the prior review for all four populations (Table 30). The abundance series for the aggregate return monitored at Priest Rapids Dam and for all four populations generally reflect a common pattern in annual returns for both hatchery and natural origin fish. Although the magnitudes vary among the individual populations, each series shows three peaks in annual returns occurring in the mid-1980s, the early 2000s and 2010/2011. That pattern appears to be largely driven by variations in smolt to adult return rates. In spite of the recent increases, natural-origin returns remain well below target levels. As Table 30 illustrates, the recent five-year average escapement of UCR steelhead was 2,846 naturally produced adult fish and 6,579 hatchery propagated adult fish.

Table 30. 5-year Geometric Mean of Escapement of Adult Upper Columbia River Steelhead (NWFSC 2015).



Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Entiat R. SuR	68 (134)	38 (200)	107 (491)	102 (462)	209 (696)	105 (51)
Methow R. SuR	274 (1206)	100 (927)	434 (4228)	504 (3463)	841 (3839)	67 (11)
Okanogan R. SuR	65 (678)	23 (522)	123 (2163)	144 (1735)	248 (2123)	72 (22)
Wenatchee R. SuR	525 (1847)	265 (742)	772 (2318)	678 (1857)	1548 (2767)	128 (49)

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2013-2017 is shown in Table 31 (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017).

Table 31. Average Outmigration for UCR Steelhead (2013-2017).

Origin	Outmigration
Natural	176,213
Listed Hatchery Intact Adipose*	159,702
Listed Hatchery Adipose Clipped*	642,307

*When the above species was listed, NMFS included certain artificially propagated (hatchery-origin) populations in the listing. Some of those listed fish have had their adipose fins clipped at their respective hatcheries and some have not.

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (3) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (4) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Estimates of natural production in this steelhead DPS are well below replacement—indicating that natural steelhead populations in the upper Columbia River basin are not self-sustaining at the present time. The Biological Review Team discussed anecdotal evidence that resident rainbow trout—present in numerous streams throughout the region—contribute to anadromous run abundance. This would reduce estimates of the natural steelhead replacement ratio.

Assumptions regarding the relative effectiveness of hatchery-origin spawners also influence return-per-spawner patterns for the two steelhead production areas (Wenatchee/Entiat and Methow/Okanogan). Under the assumption that hatchery and wild spawners are both contributing to the subsequent generation of natural returns, return-per-spawner levels have been consistently below 1.0 since 1976. Under this scenario, natural production would be expected to decline rapidly in the absence of hatchery spawners. Under the assumption that hatchery fish returning to the upper Columbia River do not contribute to natural production, return-per-spawner levels were above 1 until the late 1980s. Return-per-spawner estimates subsequently dropped below replacement (1.0) and remained low until the mid-1990s (and beyond). Nonetheless, the actual contribution of hatchery returns to natural spawning remains a key uncertainty for UCR steelhead. Still, as the next figure shows, productivity remains generally below replacement for all four populations

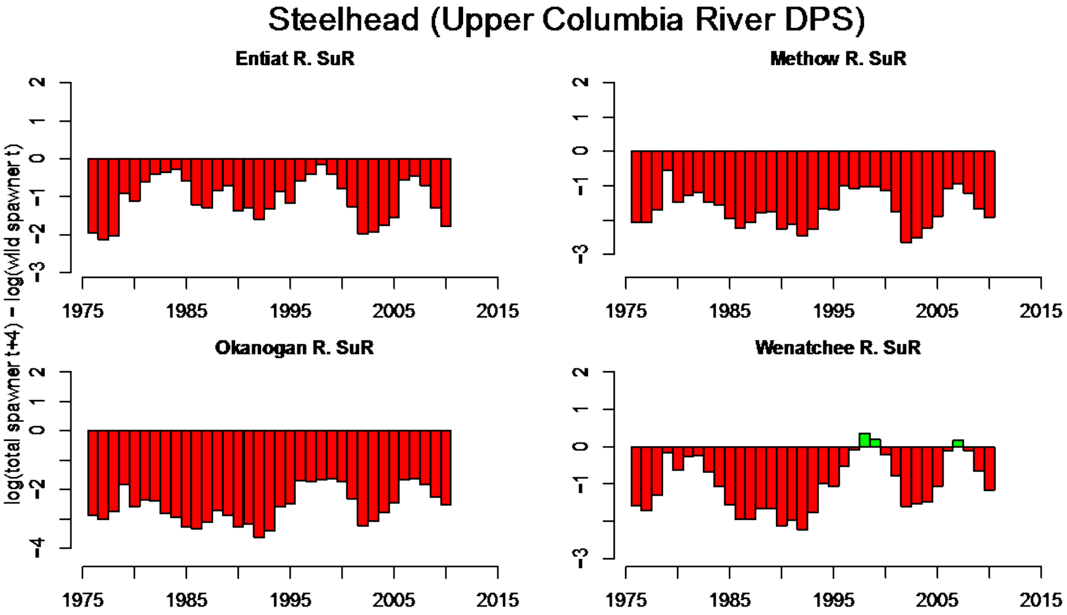


Figure 2 – Trends in population productivity, estimated as the log of the smoothed natural spawning abundance in year *t* – smoothed natural spawning abundance in year (*t* – 4). Spawning years on x-axis.

Limiting Factors

This DPS occupies the Columbia River upstream from the Yakima River. The streams in this region primarily drain the Northern Cascade Mountains of Washington State. The river valleys are deeply dissected and maintain low gradients except for the extreme headwaters. Stream flow in this area is provided by melting snowpack, groundwater, and runoff from alpine glaciers. This leads to exceedingly cold stream temperatures which, in turn, may lead to some of the oldest ages for smolts on record—up to seven years. Habitat in the area has been degraded by a number of factors, primarily high temperatures, excess sediment, habitat loss, degraded channels, impaired floodplains, and reduced stream flow. All of these factors (and others) have negatively affected the DPS' PCEs to the extent that it was necessary to list them under the ESA (Upper Columbia Salmon Recovery Board 2007; NOAA Fisheries 2011):

- Adverse effects related to the mainstem Columbia River hydropower system
- Impaired tributary fish passage
- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas, large woody debris recruitment, stream flow, and water quality
- Hatchery-related effects
- Predation and competition
- Harvest-related effects

Status Summary

Several factors—both population- and habitat-related have caused this DPS to decline to the point that it is likely to become endangered in the foreseeable future. While there has been some improvement in a number of areas, particularly in the realms of recent returns and lessened hatchery effects, it is not enough to prevent them from being threatened. Overall, three populations remain at high risk for nearly all VSP parameters, and one, the Wenatchee River population is at somewhat lower risk and its viability rating is considered to be “maintained” rather than “high risk” (as it is for all three other populations).

Table 32 -Viability assessments for extant Upper Columbia Steelhead DPS populations. Natural spawning abundance: most recent 10 year geometric mean (range). ICTRT productivity: 20 year geometric mean for parent escapements below 75% of population threshold. Current abundance and productivity estimates are geometric means. Range in annual abundance, standard error and number of qualifying estimates for productivities in parentheses. Upward arrows: current estimates increased over prior review. Oval: no change, downward arrow indicate estimate has decreased.

Population	Abundance and productivity metrics				Spatial structure and diversity metrics			Overall viability rating
	ICTRT minimum threshold	Natural spawning abundance	ICTRT productivity	Integrated A/P risk	Natural processes risk	Diversity risk	Integrated SS/D risk	
Wenatchee River 2005–2014	1,000	1,025 (386-2,235)	1.207 (.021, 3/20)	Low	Low	High	High	Maintained
Entiat River 2005–2014	500	146 (59-310)	0.434 (.22, 12/20)	High	Moderate	High	High	High risk
Methow River 2005–2014	1,000	651 (365-1,105)	0.371 (0.37, 3/20)	High	Low	High	High	High risk
Okanogan River 2005–2014	750	189 (107-310)	0.154 (.275, 6/20)	High	High	High	High	High risk

2.2.2.8 Middle Columbia River Steelhead

Description and Geographic Range

MCR steelhead were first listed as a threatened species on March 5, 1999 (64 FR 14517). That status was reaffirmed on January 5, 2006 (71 FR 834); the listing includes all naturally spawned steelhead populations beginning upstream from the Wind River in Washington and the Hood River in Oregon and proceeding to the Yakima River, Washington. It does not include fish from the Snake River basin. Fish from seven artificial propagation programs were also listed—the Touchet River, Satus Creek, Toppenish Creek, Naches River, Upper Yakima River, Umatilla

River, and Deschutes River stocks, that listing was reaffirmed on April 14, 2014 (79 FR 20802). A recovery plan is available for this species (NMFS 2009b).

Spatial Structure and Diversity

MCR steelhead are predominantly summer steelhead, but winter-run fish are found in the Klickitat River and Fifteenmile Creek. Most MCR steelhead smolt at two years and spend one to two years in salt water before re-entering fresh water, where they may remain for up to a year before spawning. Historically, the species was made up of five major population groups (MPGs), one of which—Willow Creek—has been extirpated. The four remaining MPGs comprise 17 extant populations and two that have been extirpated (see Table 33).

Table 33. Recent Abundance, Productivity, Diversity, and Structure Data and Risk Ratings for MCR Steelhead. (Source: ICTRT 2009).

POPULATION	ABUNDANCE THRESHOLD	ABUNDANCE*	10-YEAR HATCHERY FRACTION	PRODUCT-IVITY**	A&P RISK RATING***	S&D RISK RATING***
Eastern Cascades MPG						
Deschutes (West)	1,000	456	0.26	1.05	M	M
Deschutes (East)	1,000	1599	0.39	1.89	L	M
Klickitat R.	1,000	Insuff. Data			M	M
Fifteenmile Cr.	500	703	0.0	1.82	L	L
Rock Cr.	500	Insuff. Data			H	M
White Salmon R.	500	Extirpated			N/A	N/A
Crooked R.	2,250	Extirpated			N/A	N/A
Yakima River MPG						
Upper Yakima	1,500	85	0.02	1.09	H	H
Naches R.	1,500	472	0.06	1.12	M	M
Toppenish Cr.	500	322	0.06	1.60	M	M
Satus Creek	1,000	379	0.06	1.73	M	M
John Day basin MPG						
Lower Mainstem	2,250	1,800	0.1	2.99	M	M
North Fork	1,500	1,740	0.08	2.41	VL	L
Upper Mainstem	1,000	524	0.08	2.14	M	L
Middle Fork	1,000	756	0.08	2.45	M	L
South Fork	500	259	0.08	2.06	M	L
Umatilla/Walla Walla MPG						
Umatilla R.	1,500	1,472	0.36	1.50	M	M
Walla Walla	1,000	650	0.02	1.34	M	M
Touchet R.	1,000	Insuff. Data			H	M
Willow Creek	1,000	Extirpated			N/A	N/A

*Most recent 10-year geometric mean.

**Geometric mean of returns per spawner over the most recent 20 years in data series.

***A&P=Abundance and Productivity; S&D=Structure and Diversity.

Hatchery fish stray to spawn naturally throughout the range of the species. Estimates of the proportion of hatchery-origin natural spawners range from low (Yakima, Walla Walla, and John Day Rivers) to moderate (Umatilla and Deschutes Rivers) (NMFS 2003). Most hatchery production is derived primarily from within-basin stocks. One recent area of concern is the increase in the number of Snake River hatchery steelhead that stray and spawn naturally within the Deschutes River subbasin. In addition, one of the main threats cited in NMFS' listing decision for this species was the fact that hatchery fish constituted a steadily increasing proportion of MCR steelhead natural escapement (62 FR 43937). Straying frequencies into at least the Lower John Day River are high. Out-of-basin hatchery stray proportions, although reduced, remain very high in the Deschutes River basin.

Nonetheless, most populations remain at low to moderate risk with respect to spatial structure and diversity—the one exception being the upper Yakima River population (see Table 33).

Abundance and Productivity

Escapements to all extant MPGs have recently shown overall upward trends, though some tributary counts in the Deschutes River have been moving downward for years and the Yakima River is still recovering from extremely low abundance in the 1980s. The John Day River represents the largest native, naturally-spawning stock in the species. The combined spawner surveys for the John Day River showed spawner declines of about 15% per year from 1985 to 1999, but trends have largely been up since then (NMFS 2003, Ford 2011) and the North Fork John Day population, for instance is a very low risk to abundance and productivity factors. When we proposed to list these fish, we cited low returns to the Yakima River, poor abundance estimates for the Klickitat River and Fifteenmile Creek winter steelhead, and overall declines among naturally-producing stocks. However, recent dam counts show an overall increase in MCR steelhead abundance and a relatively stable naturally-produced component.

The species' populations are generally considered to be at medium to low risk with respect to abundance and productivity, but a few populations remain at high risk (see Table 33), though both the Touchet River and Westside Deschutes do remain at high risk.

Table 34. 5-year geometric mean of natural-origin spawners. In parentheses, 5-year geometric mean of total spawners (hatchery and natural).

Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Deschutes R. Eastside SuR	607 (761)	693 (1439)	3823 (4848)	1872 (2354)	1540 (1803)
Deschutes R. Westside SuR	248 (323)	226 (341)	742 (950)	477 (578)	935 (993)
Fifteenmile Cr. WR	405 (405)	396 (396)	941 (941)	264 (264)	471 (490)
John Day R. Low. Mainstem Tribs. SuR	1235 (1248)	968 (1017)	3487 (4052)	1024 (1382)	1745 (2059)
John Day R. Up. Mainstem SuR	1019 (1029)	350 (368)	695 (777)	471 (512)	1050 (1072)
MF John Day R. SuR	1210 (1225)	545 (572)	1229 (1375)	634 (689)	4776 (4864)
NF John Day R. SuR	785 (793)	1142 (1200)	2247 (2514)	1488 (1618)	3011 (3073)
SF John Day R. SuR	398 (402)	135 (142)	493 (551)	586 (637)	1077 (1099)
Touchet R. SuR	392 (438)	342 (395)	354 (387)	337 (446)	489 (615)
Umatilla R. SuR	1068 (1344)	919 (1660)	2341 (3312)	1931 (2498)	3214 (3921)
Walla Walla R. SuR	995 (995)	516 (522)	957 (997)	717 (739)	1239 (1274)
Naches R. SuR	285 (313)	260 (293)	855 (868)	823 (846)	1775 (1829)
Satus Cr. SuR	343 (377)	266 (300)	640 (652)	807 (829)	1585 (1624)
Toppenish Cr. SuR	103 (113)	135 (153)	693 (705)	468 (481)	575 (588)
Yakima R. Up. Mainstem SuR	55 (56)	49 (50)	145 (149)	155 (157)	390 (410)

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2013-2017 is shown in Table 35 (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017).

Table 35. Average Outmigration for MCR Steelhead (2013-2017).

Origin	Outmigration
Natural	417,206
Listed Hatchery Intact Adipose*	93,680
Listed Hatchery Adipose Clipped*	360,184

*When the above species was listed, NMFS included certain artificially propagated (hatchery-origin) populations in the listing. Some of those listed fish have had their adipose fins clipped at their respective hatcheries and some have not.

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (3) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (4) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.). The numbers—especially for the natural component, are therefore probably greater than those displayed.

Populations in all four of the mid-Columbia steelhead MPGs exhibited similar temporal patterns in brood year returns per spawners. Return rates for brood years 1995−1999 generally exceeded replacement (1:1). Spawner to spawner ratios for brood years 2001−2003 were generally well below replacement for many populations. Brood year return rates reflect the combined impacts of year to year patterns in marine life history stages, upstream and downstream passage survivals as well as density dependent effects resulting from capacity or survival limitations on tributary spawning or juvenile rearing habitats.

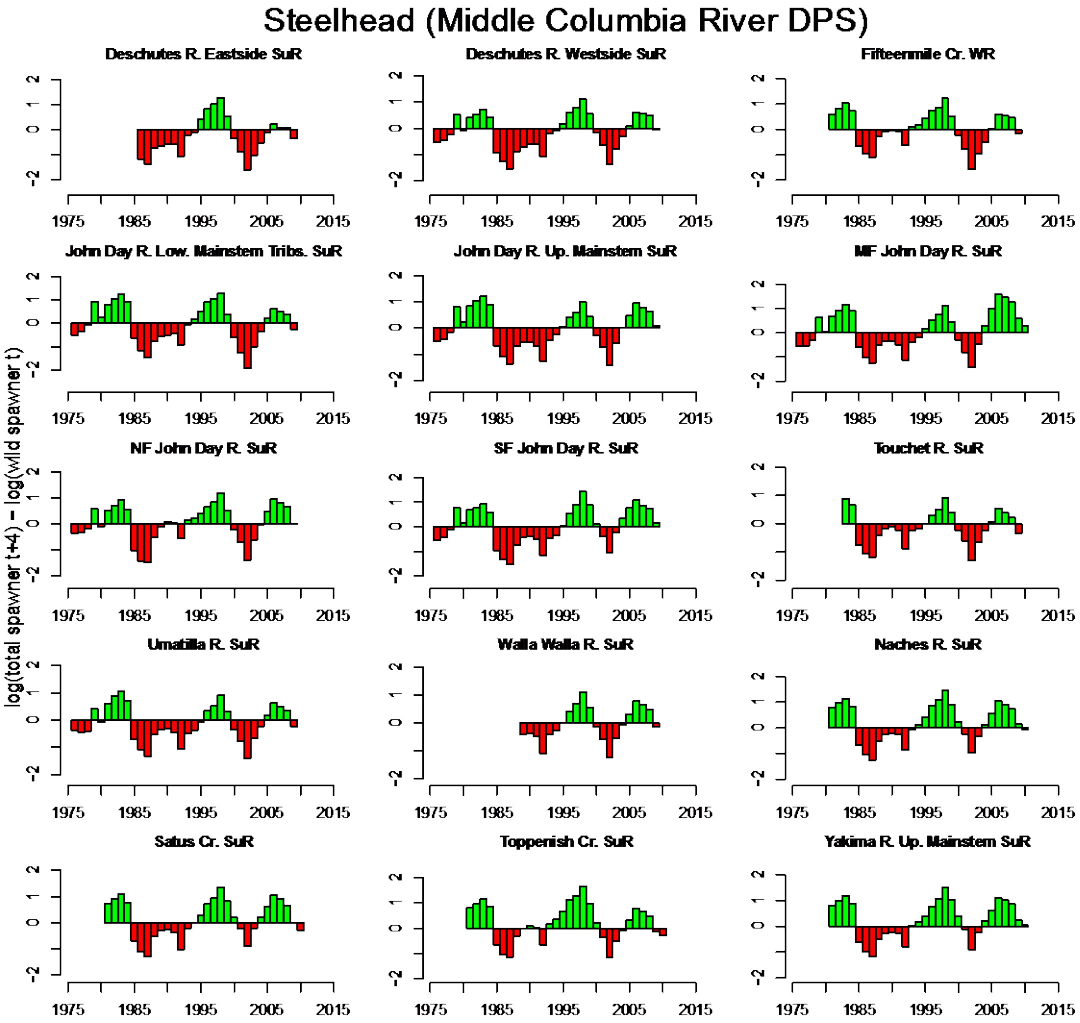


Figure 3 – Trends in population productivity, estimated as the log of the smoothed natural spawning abundance in year *t* – smoothed natural spawning abundance in year (*t* – 4). Spawning years on x axis.

Limiting Factors

The major limiting factors for MCR steelhead are degraded tributary habitat conditions, impaired mainstem and tributary passage, hatchery related effects, and predation, competition, and disease (NMFS 2009 (recovery plan)). With regard to tributary habitat, MCR steelhead are subject to the detrimental effects associated with degraded riparian areas, reduced LWD recruitment, altered sediment routing, low or altered stream flows, degraded water quality especially high water temperatures), impaired floodplain connectivity/function, altered channel structure/complexity, and impaired fish passage. MCR steelhead experience impaired passage at up to four mainstem Columbia River dams and blocked/difficult passage in nearly all main tributaries except the John Day River. The main problems associated with hatchery programs involve out-of-basin hatchery fish straying onto the spawning grounds in all MPGs (especially the Deschutes River). MCR steelhead also are subject to predation (from birds, other fish, and pinnipeds) and disease (primarily in the mainstem) and competition (primarily with rainbow trout) largely in the tributaries—particularly in the Deschutes River (NMFS 2009b).

The limiting factors identified in the recovery plan are:

- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas, fish passage, stream substrate, stream flow, and water quality
- Mainstem Columbia River hydropower-related impacts
- Degraded estuarine and nearshore marine habitat
- Hatchery-related effects
- Harvest-related effects
- Effects of predation, competition, and disease.

Status Summary

Several factors—both population- and habitat-related—have caused this species to decline to the point that it is likely to become endangered in the foreseeable future. While there has been some improvement in a number of areas, particularly with regard to the MCR steelhead's productivity and strong natural component, it is not enough to prevent them from being threatened. Nonetheless, there is some cause for optimism in that the biological requirement risk factors for the species are currently moderate to low in almost every population.

2.2.2.9 Columbia River Chum Salmon

Description and Geographic Range

Columbia River (CR) chum salmon was first listed as threatened on March 25, 1999 (64 FR 14507). When we re-examined the status of this species in 2005 and 2011, we determined that it still warranted listing as threatened (70 FR 37160, 76 FR 50448). The ESU includes all naturally-spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon. Two artificial propagation programs are part of the ESU: the Grays River Program and the Washougal River Hatchery/Duncan Creek Program (79 FR 20802).

CR chum salmon are fall-run fish. Currently, spawning populations of CR chum salmon are limited to tributaries below Bonneville Dam, with most spawning occurring in two areas on the Washington side of the Columbia River: Grays River, near the mouth of the Columbia River, and Hardy and Hamilton Creeks, approximately three miles below Bonneville Dam. Some chum salmon pass Bonneville Dam, but there are no known extant spawning areas in the Bonneville pool. Juveniles (typically the fry stage) outmigrate to seawater almost immediately after emergence from the gravel and do not have a distinct smolt phase like other salmonids. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams. Chum salmon enter the Columbia River from mid-October through early December and spawn from early November to mid-January. Spawning typically occurs in the mainstem and lower portions of river basins. Adults typically mature as 4-year-olds, although age-3 and age-5 fish are also common (Fulton 1970).

Spatial Structure

The Willamette/Lower Columbia River Technical Recovery Team (WLC-TRT) partitioned CR chum salmon into three strata based on ecological zones. Ecological zones range from areas at the mouth of the Columbia River that are influenced by the ocean to the Columbia River gorge above Bonneville Dam. The WLC-TRT analysis suggests that a viable ESU would need multiple viable populations in each stratum. The strata and associated populations are identified in Table 36 (Good et al. 2005).

Table 36. Historical Population Structure and Abundance of CR Chum Salmon.

Ecological Zone	Population	EDT estimate of historical abundance*
Coastal	Youngs Bay	ND
	Grays/Chinook	7,511
	Big Creek	ND
	Elochoman/Skamania	ND
	Clatskanine River	ND
	Mill/Abernathy/Germany	ND
	Scappoose Creek	ND
Cascade	Cowlitz River	141,582
	Kalama River	9,953
	Lewis River	89,671
	Salmon Creek	ND
	Clackamas River	ND
	Sandy River	ND
	Washougal River	15,140
Columbia Gorge	Lower gorge tributaries	>3,141
	Upper gorge tributaries	>8,912
TOTAL		>283,421

ND = no data

* The EDT estimate of historical abundance is based on analysis by WDFW of equilibrium abundance under historical habitat conditions (Busack and Rawding 2003).

Substantial spawning occurs in only two of the 16 historical populations, meaning 88% of the historical populations are extirpated, or nearly so. The two extant populations, Grays River and the lower gorge population, appear to contain only a fraction of the wild historic abundance. Both populations have benefited from artificial spawning channels constructed to provide habitat that is lacking in the Columbia River.

A large portion of the upper gorge chum population is believed to have been inundated by Bonneville Dam. The WDFW and ODFW conducted surveys to determine the distribution and abundance of chum salmon in the lower Columbia. Very small numbers were observed in several locations in Washington; one chum salmon was observed in Oregon out of 30 sites surveyed (Good et al. 2005).

Diversity

The leading factor affecting CR chum salmon diversity is the extirpation (or nearly so) of 14 of the 16 historical populations. The remaining populations are at low abundance, although increases in the early 2000s are encouraging. Chum run-timing is rather fixed, compared to other salmon and steelhead, and thus may not help improve the overall diversity of the ESU.

Hatchery programs are established for CR chum, in the Chinook, Grays, and Washougal Rivers, but it is unknown how they have affected natural CR chum salmon. Chum are released at a small size thus are not externally marked before release, though many are otolith marked. The WDFW collected otoliths from spawning chum salmon, but the data will need to be analyzed before any conclusions regarding the hatchery's effects on CR chum salmon diversity can be made. CR chum salmon diversity may not be adversely affected by hatchery releases because the releases have been relatively small and intermittent compared to other stocks in the Columbia River (McElhaney et al. 2004).

Abundance

Historically, CR chum salmon supported a large commercial fishery that landed more than 500,000 fish per year, and chum salmon were reported in almost every river in the lower Columbia River basin. However, most runs had disappeared by the 1950s. There are now no recreational or directed commercial fisheries for chum salmon in the Columbia River, although chum salmon are taken incidentally in the gill-net fisheries for coho and Chinook salmon, and some tributaries support a minor recreational harvest. The estimated minimum run size for the Columbia River has been relatively stable, although at a very low level, since the run collapsed during the mid-1950s. Current abundance is probably less than 1% of historical levels, and the species has undoubtedly lost some (perhaps most) of its original genetic diversity.

WDFW regularly monitors several natural "index" populations in the basin, in Grays River, two in small streams near Bonneville Dam, and the mainstem area next to those two streams. Average annual natural escapement to the index spawning areas was approximately 1,300 fish from 1990 through 1998. The WDFW surveyed other (nonindex) areas in 1998 and found only small numbers of chum salmon (typically less than 10 fish per stream) in Elochoman, Abernathy, Germany, St. Cloud, and Tanner Creeks and in the North Fork Lewis and the Washougal Rivers. Consistent with the BRT status review (Ford 2011), the ODFW recovery plan concluded that chum are extirpated or nearly so in all Oregon Columbia River populations (ODFW 2010). A few chum are occasionally encountered during surveys or return to hatchery collection facilities, but these are likely either strays from one of the Washington populations or part of a few extremely small and erratic remnant populations. Recent estimates for the lower Columbia Gorge and Grays River chum salmon populations range from 10,000 to 20,000 adults. WDFW spawning surveys in the Grays/Chinook, Washougal, Lower Gorge, and Upper Gorge populations estimated an average of 8,508 adult chum for the years 2007-2011 (WDFW 2014). We do not have recent adult abundance data for any of the other populations.

The Lower Columbia Fish Recovery Board (LCFRB 2010) developed planning ranges for abundance of viable CR chum salmon populations (Table 37). Some abundance goals were not set; the range of abundance is from less than 100 (in the Salmon population) to 6,000 fish (in the Grays/Chinook population). Two of the populations either reach or exceed abundance targets. However, all of the populations are below the planning targets.

Table 37. Recovery Goals for CR Chum Salmon Populations (LCFRB 2010, WDFW 2010a).

Population	Viability Goal	Current Viability	Abundance Goal	Adult Escapement		
				Years	Natural	Hatchery
Grays/Chinook	High+	Low+	6,000	2010-2014	6,604	421
Eloch/Skamania	High	Low	1,100	2002-2004	122	
Mill/Aber/Germany	High	V. Low	1,100	2002-2004	40	
Youngs Bay	High	Unknown				
Big Creek	Low	Unknown				
Clatskanie	Med	Unknown				
Scappoose	Low	Unknown				
Cowlitz	Med	V. Low	600			
Kalama	Low	V. Low	150			
Lewis	High	V. Low	1,100	2011-2013	36	
Salmon	V. Low	V. Low	75			
Washougal	High+	Low	5,200	2010-2014	2,440	
Clackamas	Med	Unknown				
Sandy	High	Unknown				
L. Gorge	High+	Med+	2,800	2010-2014	1,600	5
U. Gorge	Med	V. Low	600	2010-2014	106	
Total					10,644	426

Current abundance numbers are observed 4-year averages or assumed natural spawning escapements.

The NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2013-2017 is shown in Table 38 (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017).

Table 38. Average Estimated Outmigration for Listed CR Chum Salmon (2013-2017).

Origin	Outmigration
Natural	5,362,740
Listed hatchery intact adipose	648,047

The number of natural fish should be viewed with caution. Estimating juvenile abundance is complicated by several variables: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years and (2) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, harvest, etc.). Listed hatchery fish outmigration numbers are also affected by some of these factors; however, releases from hatcheries are generally easier to quantify than is natural production.

Productivity

Trends and growth rate for CR chum salmon are difficult to determine because 14 of the 16 historical populations are extirpated, or nearly so. The two extant populations are at Grays River and the lower Columbia Gorge. The majority of chum salmon spawning in the Grays River currently occurs in less than 1.1 km of the river. Previous to its destruction in a 1998 flood, approximately 50% of the Grays River population spawning occurred in an artificial spawning channel created by the WDFW in 1986. Data from a WDFW analysis conducted in 2000 shows a small upward trend from 1967 to 1998, and a low probability that the population is declining. However, a longer data set indicates that both long- and short-term trends are negative over the period 1950–2000, with a high probability that the trend and growth rate are less than one. Data from the Gorge populations showed a downward trend since the 1950s and a relatively low abundance up to 2000. However, preliminary data indicate that the 2002 abundance showed a substantial increase, estimated to be more than 2,000 chum salmon in Hamilton and Hardy Creeks, plus another 8,000 or more in the mainstem. Overall, due to a limited number of populations and low abundance, CR chum salmon productivity is low (Good et al. 2005).

Limiting Factors and Threats

Chum salmon prefer particular microhabitats for spawning and do not ascend falls or steep gradients like steelhead and other salmon. Overall, fish have been adversely affected by changes in access, stream flow, water quality, sedimentation, habitat diversity, channel stability, riparian conditions, and floodplain interactions. These large scale changes have altered habitat conditions and processes important to migratory and resident fish and wildlife (NMFS 2006).

Habitat conditions for anadromous fish have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control. CR chum salmon are adversely affected by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage, and ecological changes in impoundments. For example, a large portion of the upper gorge chum habitat is believed to have been inundated by Bonneville Dam. Chum are affected to a lesser extent than other salmon and steelhead, but dams in many of the larger subbasins have blocked access to large areas of productive habitat (NMFS 2006).

Chum salmon were once very abundant in the Columbia River Basin, with commercial landings ranging from 1 to 8 million pounds (80,000 to 650,000 fish) in most years before the early 1940s. Chum escapements have been extremely small since the late 1950s, but improved somewhat recently. The total estimated escapement in 2002 was just under 20,000. NMFS biological opinions now limit the incidental impact of Columbia River fisheries targeting other species to an expected 2% and not to exceed 5% of the annual return of chum listed under the ESA. No sport or commercial fisheries specifically target chum salmon and the current impacts of 3% or less are incidental to fisheries for other species. Numbers incidentally taken in current freshwater or ocean fisheries are not significant. Even though no fisheries target chum salmon, incidental catch in sport and commercial fisheries and illegal harvest can affect the species VSP criteria.

Status Summary

Despite improvement in spawner abundance in certain areas, the overall abundance is still only a fraction of historical levels and many of the populations are extirpated, or nearly so. The species' productivity, spatial structure, and diversity are at low levels. Habitat conditions have been fundamentally altered throughout the Columbia River basin by the dams, and overall stream habitat productivity in the lower Columbia has been degraded for all salmon and steelhead. Substantial changes, such as the increase in abundance seen in the early 2000s, are needed before this ESU can recover.

2.2.2.10 Lower Columbia River Chinook Salmon

Description and Geographic Range

We listed Lower Columbia River (LCR) Chinook salmon as threatened on March 24, 1999 (64 FR 14308). When we re-examined the status of these fish in 2005 and 2011, we determined that they still warranted listing as threatened (70 FR 37160; 76 FR 50448). We describe the ESU as all naturally spawned populations of Chinook salmon from the Columbia River and its tributaries from its mouth upstream to a transitional point between Washington and Oregon east of the Hood River and the White Salmon River, and includes the Willamette River to Willamette Falls, Oregon, exclusive of spring-run Chinook salmon in the Clackamas River. The ESU includes fifteen artificial propagation programs: the Big Creek Tule Chinook Program; Astoria High School Salmon-Trout Enhancement Program Tule Chinook Program; Warrenton High School Salmon-Trout Enhancement Program Tule Chinook Program; Cowlitz Tule Chinook Program; North Fork Toutle Tule Chinook Program; Kalama Tule Chinook Program; Washougal River Tule Chinook Program; Spring Creek National Fish Hatchery Tule Chinook Program; Cowlitz Spring Chinook Program in the Upper Cowlitz River and the Cispus River; Friends of the Cowlitz Spring Chinook Program; Kalama River Spring Chinook Program; Lewis River Spring Chinook Program; Fish First Spring Chinook Program; and the Sandy River Hatchery (79 FR 20802).

Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) identify 31 historical demographically independent populations in three strata for the LCR Chinook salmon ESU (Table 39). The strata are groups of populations with similar life history traits within the same ecological zone. Within the LCR Chinook salmon ESU, run timing was the predominant life history criteria used in identifying populations. The recovery plans identify three distinct run times, spring, fall, and late fall. The distribution of populations with distinct run times varies among the three ecological subregions. Fall Chinook salmon historically were found throughout the Lower Columbia River Chinook Salmon ESU, while spring Chinook salmon historically were only found in the upper portions of basins with snowmelt driven flow regimes (western Cascade Crest and Columbia Gorge tributaries). Late fall Chinook salmon populations are found in only two basins in the Cascade strata. In general, late fall Chinook salmon also mature at an older average age than either lower Columbia River spring or fall Chinook salmon, and have a more northerly oceanic migration route.

Table 39. Historical Population Structure and Viability Status for Lower Columbia River Chinook Salmon (VL=very low, L=low, M=moderate, H=high, VH=very high) (ODFW 2010; LCFRB 2010).

Stratum (Run)	Population	Viability Status		
		A&P	Spatial	Diversity
Coastal (Fall)	Youngs	L	VH	L
	Grays/Chinook	VL	H	VL
	Big Creek	VL	H	L
	Elochoman/Skamokowa	VL	H	L
	Clatskanie	VL	VH	L
	Mill/Abernathy/Germany	VL	H	L
	Scappoose	L	H	L
Cascade (Fall)	Coweeman	VL	H	H
	Lower Cowlitz	VL	H	M
	Upper Cowlitz	VL	VL	M
	Toutle	VL	H	M
	Kalama	VL	H	M
	Lewis	VL	H	H
	Clackamas	VL	VH	L
	Washougal	VL	H	M
	Sandy	VL	M	L
Columbia Gorge (Fall)	Lower gorge	VL	M	L
	Upper gorge	VL	M	L
	Hood	VL	VH	L
	Big White Salmon	VL	L	L
Cascade (Late Fall)	Sandy	VH	M	M
	North Fork Lewis	VH	H	H
Cascade (Spring)	Upper Cowlitz	VL	L	M
	Cispus	VL	L	M
	Tilton	VL	VL	VL
	Toutle	VL	H	L
	Kalama	VL	H	L
	Lewis	VL	L	M
	Sandy	M	M	M
Gorge (Spring)	Big White Salmon	VL	VL	VL
	Hood	VL	VH	VL

Spatial Structure and Diversity

LCR Chinook salmon exhibit both spring- and fall-run life histories. Some emigrate to the ocean as subyearlings, but some spring-run populations may have a large proportion of yearling migrants. Chinook populations in the Lower Columbia tend to mature at ages 3 and 4, but there is a considerable range in age at maturity. For example, “tule” fall Chinook salmon return at ages 3 and 4; and “bright” fall Chinook return at ages 4 and 5, with substantial numbers returning at age 6. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater areas throughout the range of the listed species. Parr usually undergo a smolt transformation as subyearlings at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams.

The Oregon and Washington recovery plans rate spatial structure as moderate to very high in 24 out of 31 populations (Table 39). The populations that rate lowest have fish passage barriers. Trap and haul operations on the Cowlitz River pass adults upriver, but downstream passage and survival of juvenile fish is very low. This problem also affects spatial structure in the Cispus and Tilton populations. Merwin Dam blocks access to most of the available spawning habitat in the North Fork Lewis populations. However, the relicensing agreement for Lewis River hydroelectric projects calls for reintroduction of Chinook salmon. Condit Dam on the White Salmon River blocked access to most of the historical spawning habitat but was removed in 2011. Thus, the recovery plans rate LCR Chinook salmon spatial structure as moderate to very high for more than two thirds of the populations, and for three populations with low ratings, management actions are underway to improve the situation (fall and spring runs in the White Salmon and the spring run in the Lewis).

The Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) rate diversity as low to very low in 18 out of 31 populations (Table 39 above). Good et al. (2005) gave this ESU a score for diversity of 3.9 (on a scale of 1 to 5, with 5 being highest risk) and identified this VSP criterion as the highest risk for the ESU. Diversity in salmon populations is represented by differences within and among populations in morphology, 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 and molecular genetic characteristics (McElhany et al. 2000). . Some of these traits are genetically based while others vary as a result of combined environmental and genetic factors. Diversity of LCR Chinook is affected by the loss of 80% of the spring run populations, the high proportion of hatchery fish on the spawning grounds, and habitat loss and degradation (Good et al. 2005; Ford 2011).

Abundance and Productivity

Ford (2011) found that abundance of all LCR Chinook salmon populations increased during the early 2000s but has since declined back to levels close to those in 2000 for all but one population. Abundance of the Sandy spring Chinook salmon population has declined from levels in the early 2000s but remains higher than its 2000 level. In general, abundance of LCR Chinook salmon populations has not changed considerably since the previous status review (Ford 2011).

In 1998, NMFS assessed the abundance in smaller tributary streams in the range of the species to be in the hundreds of fish (Myers et al. 1998). Larger tributaries (e.g., Cowlitz River basin) contained natural runs of Chinook salmon ranging in size from 100 to almost 1,000 fish. In 2005, NMFS calculated adult abundance using the geometric mean of natural-origin spawners in the five years previous to 2003 (Good et al. 2005). In 2005, NMFS estimated the LCR Chinook salmon abundance at approximately 14,130 fish (Good et al. 2005). Data that are more recent place the abundance of naturally produced LCR Chinook salmon at approximately 13,594 spawners (Table 40).

Table 40. 5-year Average Abundance Estimates for LCR Chinook Salmon Populations (ODFW 2016a; WDFW 2016A).

Stratum (Run)	Population	Years	Total	HOR(1)	NOR(2)
Coastal (Fall)	Youngs Bay	2012-2014	5,839	5,606	233
	Grays/Chinook	2010-2014	457	357	100
	Big Creek	2012-2014	1,542	1,510	32
	Elochoman/Skamokowa	2010-2014	696	580	116
	Clatskanie	2012-2014	3,291	3,193	98
	Mill/Abernathy/Germany	2010-2014	897	805	92
Cascade (Fall)	Lower Cowlitz	2010-2013	919	196	723
	Upper Cowlitz	2010-2013	3,834	961	2,873
	Toutle	2010-2014	8,705	5,400	3,305
	Coweeman	2010-2014	1,348	963	385
	Kalama	2010-2014	9,694	8,892	803
	Lewis	2010-2014	3,121	943	2,178
	Washougal	2010-2014	309	116	192
	Clackamas	2012-2014	4,227	2,955	1,272
	Sandy	2012-2014	1,527	320	1,207
Columbia Gorge (Fall)	Lower gorge	2003-2007	146	Unknown	146
	Upper gorge	2010-2012	527	327	200
	White Salmon	2010-2014	1,075	246	829
Cascade (Late Fall)	North Fork Lewis	2010-2014	12,330	0	12,330
Cascade (Spring)	Upper Cowlitz/Cispus	2010-2014	3,893	3,614	279
	Kalama	2011-2014	115	na	115
	North Fork Lewis	2010-2014	217	0	217
	Sandy	2010-2014	3,201	1,470	1,731
Gorge (Spring)	White Salmon	2013-2014	152	140	13
Total			68,061	38,594	29,469

(1) Hatchery Origin (HOR) spawners.
(2) Natural Origin (NOR) spawners.

The Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) rate all but three Chinook populations as low to very low for abundance and productivity (Table 40). The range of abundance recommended for recovery is from 300 (Kalama spring-run) to 7,300 (North Fork Lewis late fall-run). Current abundance estimates from WDFW and ODFW suggest that only five populations are at or have exceeded abundance goals, and for one of these (the White Salmon), we do not know what portion of the spawners are hatchery origin.

The Northwest Fisheries Science Center publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2013-2017 is shown in Table 9 (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017).

Table 41. Average Estimated Outmigration for Listed LCR Chinook Salmon (2013-2017).

Origin	Outmigration
Natural	12,164,845
Listed hatchery intact adipose	1,204,984
Listed hatchery adipose clip	33,631,872

The number of natural fish should be viewed with caution. Estimating juvenile abundance is complicated by a host of variables: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (3) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, harvest, etc.). Listed hatchery fish outmigration numbers are also affected by some of these factors; however, releases from hatcheries are generally easier to quantify than is natural production.

Limiting Factors

The status of lower Columbia River salmon results from the combined effects of habitat degradation, dam building and operation, fishing, hatchery operations, ecological changes, and natural environmental fluctuations. Habitat for LCR Chinook has been adversely affected by changes in access, stream flow, water quality, sedimentation, habitat diversity, channel stability, riparian conditions, channel alternations, and floodplain interactions. These large-scale changes have altered habitat conditions and processes important to migratory and resident fish and wildlife. Additionally, habitat conditions have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control. Lower Columbia salmon are adversely affected by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage, and ecological changes in impoundments. Dams in many of the larger subbasins have blocked anadromous fishes' access to large areas of productive habitat.

Harvest is unique among the limiting factors in that it is both a goal of recovery and a factor that can limit recovery. The compounding effects of high fishery mortality coupled with substantial habitat and ecosystem alteration has reduced the numbers, distribution, resilience, and diversity of LCR Chinook salmon throughout the lower Columbia region (LCFRB 2010). In response to the species listing, ocean and lower Columbia freshwater commercial and recreational fisheries have been substantially reduced as a result of international treaties, fisheries conservation acts, regional conservation goals, the Endangered Species Act, and state and tribal management agreements. Recovery plans have identified a strategy that continues to restrict and further reduce fishery impacts on listed wild fish (LCFRB 2010; ODFW 2010).

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.

Status Summary

Despite the few years of high abundance observed in the early part of the last decade, the overall abundance of LCR Chinook salmon is still only a fraction of historical levels. In general, the populations do not show any dramatic changes in abundance or fraction of hatchery origin spawners since the 2005 status review (ODFW 2010; LCFRB 2010). High proportions of hatchery fish on the spawning grounds continue to threaten diversity of the ESU. The development and implementation of stock transfer policies in Oregon and Washington may help reduce artificial production’s effects on natural fish. However, the process is just starting and more time is needed before we can know the effect of these actions. Trap and haul programs have begun to re-introduce Chinook salmon to many miles of habitat, potentially improving the spatial structure and diversity of the species.

2.2.2.11 Lower Columbia River Coho Salmon

Description and Geographic Range

Lower Columbia River (LCR) coho salmon was first listed as threatened on June 28, 2005 (70 FR 37160). On August 15, 2011, we re-affirmed our previous listing of LCR coho salmon as a threatened species (76 FR 50448). The listing includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia River up to and including the Big White Salmon and Hood Rivers, and including the Willamette River to Willamette Falls, Oregon. Twenty artificial propagation programs are part of the ESU and are also listed (79 FR 20802; Table 42).

Table 42. Hatchery Stocks Included in the LCR Coho Salmon ESU.

Artificial Propagation Program	Run	Location (State)
Grays River	Type-S	Grays River (Washington)
Peterson Coho Project	Type-S	Grays River (Washington)
Big Creek Hatchery (ODFW stock # 13)	n/a	Big Creek (Oregon)
Astoria High School (STEP) Coho Program	n/a	Youngs Bay (Oregon)
Warrenton High School (STEP) Coho Program	n/a	Youngs Bay (Oregon)
Cowlitz Type-N Coho Program	Type-N	Upper & Lower Cowlitz River (Washington)
Cowlitz Game and Anglers Coho Program	n/a	Lower Cowlitz River (Washington)
Friends of the Cowlitz Coho Program	n/a	Lower Cowlitz River (Washington)
North Fork Toutle River Hatchery	Type-S	Cowlitz River (Washington)
Kalama River Coho Program	Type-N	Kalama River (Washington)
Kalama River Coho Program	Type-S	Kalama River (Washington)
Lewis River Type-N Coho Program	Type-N	North Fork Lewis River (Washington)
Lewis River Type-S Coho Program	Type-S	North Fork Lewis River (Washington)

Fish First Wild Coho Program	n/a	North Fork Lewis River (Washington)
Fish First Type-N Coho Program	Type-N	North Fork Lewis River (Washington)
Syverson Project Type-N Coho Program	Type-N	Salmon River (Washington)
Washougal River Type-N Coho Program	Type-N	Washougal River (Washington
Eagle Creek National Fish Hatchery Program	n/a	Clackamas River (Oregon)
Sandy Hatchery (ODFW stock # 11)	Late	Sandy River (Oregon)
Bonneville/Cascade/Oxbow Complex (ODFW stock # 14)	n/a	Lower Columbia River Gorge (Oregon)

Coho salmon is a widespread species of Pacific salmon, occurring in most major river basins around the Pacific Rim from Monterey Bay, California, north to Point Hope, Alaska, through the Aleutians, and from the Anadyr River south to Korea and northern Hokkaido, Japan. From central British Columbia south, the vast majority of coho salmon adults are 3-year-olds, having spent approximately 18 months in fresh water and 18 months in salt water. Both early-and late-run stocks were present historically and still persist in the lower Columbia River. Type S is an early type that enters the river from mid-August to September, spawns in mid-October to early November, and generally spawns in higher tributaries. Ocean migration for these fish is coastal Washington, Oregon, and Northern California. Type N is a late type that enters the river from late September to December, spawns in November to January, and generally spawns in lower tributaries. Ocean migration for these fish is coastal British Columbia, Washington, and Oregon.

The LCR coho salmon ESU includes 25 populations that historically existed in the Columbia River basin from the Hood River downstream (Table 43). Until recently, Columbia River coho salmon were managed primarily as a hatchery stock. Coho were present in all lower Columbia River tributaries but the run now consists of very few wild fish. Twenty-one of the 24 populations in the ESU are at a very high risk of extinction (Table 43). It is possible that some native coho populations are now extinct, but the presence of naturally spawning hatchery fish makes it difficult to ascertain. The strongest remaining populations occur in Oregon and include the Clackamas River and Scappoose Creek (both at moderate risk of extinction).

Table 43. Historical Population Structure and Viability Status for LCR Coho Salmon (ODFW 2010; LCFRB 2010).

Stratum	Population	Viability Status		
		A&P	Spatial	Diversity
Coastal	Grays/Chinook	VL	H	VL
	Elochoman/Skamokawa	VL	H	VL
	Mill/Abernathy/Germany	VL	H	L
	Youngs	VL	VH	VL
	Big Creek	VL	H	L
	Clatskanine	L	VH	M
	Scappoose	M	H	M
Cascade	Lower Cowlitz	VL	M	M
	Upper Cowlitz	VL	M	L
	Cispus	VL	M	L
	Tilton	VL	M	L
	South Fork Toutle	VL	H	M

	North Fork Toutle	VL	M	L
	Coweeman	VL	H	M
	Kalama	VL	H	L
	North Fork Lewis	VL	L	L
	East Fork Lewis	VL	H	M
	Salmon Creek	VL	M	VL
	Washougal	VL	H	L
	Clackamas	M	VH	H
	Sandy	VL	H	M
Gorge	Lower Gorge	VL	M	VL
	White Salmon	VL	M	VL
	Hood	VL	VH	L

Spatial Structure

For the spatial structure analysis, the Oregon and Washington recovery plans evaluated the proportion of stream miles currently accessible to the species relative to the historical miles accessible (ODFW 2010; LCFRB 2010). The recovery plans adjusted the rating downward if portions of the currently accessible habitat were qualitatively determined to be seriously degraded. The recovery plans also adjusted the rating downward if the portion of historical habitat lost was a key production area. The Oregon and Washington recovery plans rate spatial structure as moderate to very high in nearly all populations of LCR coho. The populations that rate lowest have fish passage barriers. Trap and haul operations on the Cowlitz River pass adults upriver, but downstream passage and survival of juvenile fish is very low. This problem also affects spatial structure in the Cispus and Tilton populations. Merwin Dam blocks access to most of the available spawning habitat in the North Fork Lewis populations. The relicensing agreement for Lewis River hydroelectric projects calls for reintroduction of coho salmon but adequate passage through the system must be achieved to realize the habitat potential. Condit Dam on the White Salmon River blocked access to most of the historical spawning habitat but was removed in 2011. Thus, the LCR coho salmon spatial structure is less diverse than historically, but management actions are underway to improve the situation.

Diversity

The Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) rate diversity to be low to very low in most of the coho populations (Table 43 above). Pervasive hatchery effects and small population bottlenecks have greatly reduced the diversity of coho salmon populations (LCFRB 2010). Hatchery-origin fish typically comprise a large fraction of the spawners in natural production areas. Widespread inter-basin (but within ESU) stock transfers have homogenized many populations. The Oregon and Washington recovery plans state that there were no observations of coho spawning in lower Columbia River tributaries during the 1980s and 1990s (ODFW 2010; LCFRB 2010). While historical population structure likely included significant genetic differences among populations in each watershed, we can no longer distinguish genetic differences in natural populations of coho salmon in the lower Columbia River (excluding the Clackamas and Sandy rivers in Oregon).

Abundance and Productivity

Wild coho in the Columbia basin have been in decline for the last 50 years. The number of wild coho returning to the Columbia River historically was at least 600,000 fish (Chapman 1986). At a recent low point in 1996, the total return of wild fish may have been as few as 400 fish. Coinciding with this decline in total abundance has been a reduction in the number of self-sustaining wild populations. Of the 24 historical populations that comprised the LCR coho ESU, only in the case of the Clackamas and Sandy is there direct evidence of persistence during the adverse conditions of the 1990s. Since 2000, the numbers of wild coho have increased in both the Clackamas and Sandy basins. During this same period, naturally reproducing coho populations have become re-established in the Scappoose and Clatskanie basins (ODFW 2010).

Table 44 displays the available information on abundance of naturally produced and hatchery LCR coho salmon. Based on the best available data and using a three-year average, the average number of LCR coho salmon spawning in the wild is 32,986 naturally produced fish and 23,082 hatchery produced fish.

Table 44. Estimated Abundance of Adult Lower Columbia River Coho Spawners (ODFW 2016a; WDFW 2016A).

Stratum	Population	Years	Hatchery	Natural
Coastal	Grays/Chinook	2010-2012	2,155	445
	Elochoman/Skamokawa	2010-2012	1,185	730
	Mill/Abernathy/Germany	2010-2012	51	340
	Youngs	2010-2012	178	119
	Big Creek	2010-2012	136	283
	Clatskanine	2012-2014	250	1,396
	Scappoose	2010-2012	-	823
Cascade	Lower Cowlitz	2010-2012	711	4,834
	Upper Cowlitz/Cispus	2010-2012	9,543	4,015
	Tilton	2010-2012	4,936	1,418
	South Fork Toutle	2010-2012	296	1,357
	North Fork Toutle	2010-2012	467	360
	Coweeman	2010-2012	225	2,976
	Kalama	2010-2012	367	37
	North Fork Lewis	2010-2012	31	533
	East Fork Lewis	2010-2012	365	2,023
	Salmon Creek	2010-2012	426	1,573
	Washougal	2010-2012	253	629
	Clackamas	2012-2014	666	5,151
	Sandy	2012-2014	97	2,591
Gorge	Lower Gorge	2010-2012	269	882
	Upper Gorge/White Salmon	2011-2013		104
	Hood	2012-2014	477	367
	Total		23,082	32,986

The Northwest Fisheries Science Center publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2013-2017 is shown in Table 45 (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017).

Table 45. Average Estimated Outmigration for Listed LCR Coho Salmon (2013-2017).

Origin	Outmigration
Natural	639,015
Listed hatchery intact adipose	215,952
Listed hatchery adipose clipped	7,424,506

The number of natural fish should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (3) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, harvest, etc.). Listed hatchery fish outmigration numbers are also affected by some of these factors; however, releases from hatcheries are generally easier to quantify than is natural production.

Limiting Factors and Threats

The status of LCR coho results from the combined effects of habitat degradation, dam building and operation, fishing, hatchery operations, ecological changes, and natural environmental fluctuations. Habitat for LCR coho has been adversely affected by changes in access, stream flow, water quality, sedimentation, habitat diversity, channel stability, riparian conditions, channel alternations, and floodplain interactions. These large-scale changes have altered habitat conditions and processes important to migratory and resident fish and wildlife. Additionally, habitat conditions have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control. LCR coho are adversely affected by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage, and ecological changes in impoundments. Dams in many of the larger subbasins have blocked anadromous fishes' access to large areas of productive habitat.

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.

The primary fisheries targeting Columbia River hatchery coho salmon occur in West Coast ocean and Columbia River mainstem fisheries. Most of these fisheries have hatchery-selective harvest regulations or time and area strategies to limit impacts to wild coho. The exploitation rate of coho prior to the 1990s fluctuated from approximately 60% to 90% but now the aggregate annual exploitation rate of wild coho is about 20% or less, while the exploitation of hatchery coho is significantly greater because of mark-selective fisheries. It is unclear whether current exploitation rate limitations for wild coho provide adequate protection for the weak populations included in the aggregate. Wild coho are harvested in Washington, Oregon, California, and Canadian Ocean commercial and sport fisheries (about 9% of the total run), and in Columbia River sport, commercial, and treaty Indian fisheries and tributary sport fisheries (about 9% more). Regulations in most fisheries specify the release of all wild (non-fin clipped) coho but some coho are likely retained and others die after release. Fishing-related threats to wild coho salmon escapements include: (1) Ocean and in-river harvest; (2) Release mortalities from hatchery-selective fisheries; and (3) Illegal harvest.

Status Summary

The most serious concern for this ESU is the scarcity of naturally produced spawners and the attendant risks associated with small populations—loss of diversity and fragmentation and isolation among the remaining naturally produced fish. Trap and haul programs have begun to re-introduce coho salmon to many miles of habitat, improving the spatial structure and diversity of the species. Additionally, recent adult returns were up noticeably in some areas, and we have seen evidence for limited natural production in some areas outside the Sandy and Clackamas Rivers. However, more time is needed before we will know if their status will improve.

2.2.2.12 Lower Columbia River Steelhead

Description and Geographic Range

The Lower Columbia River (LCR) steelhead DPS was first listed as a threatened species on March 19, 1998 (63 FR 13347). When we re-examined the status of this species in 2006 and 2011, we determined that it still warranted listing as threatened (71 FR 834, 76 FR 50448). The listing included all naturally spawned populations of steelhead in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers, Washington (inclusive) and the Willamette and Hood Rivers, Oregon (inclusive). Steelhead in the upper Willamette River basin above Willamette Falls and steelhead from the Little and Big White Salmon Rivers in Washington are excluded. This DPS includes steelhead from seven artificial propagation programs: the Cowlitz Trout Hatchery Late Winter-run Program; Kalama River Wild Winter-run and Summer-run Programs; Clackamas Hatchery Late Winter-run Program; Sandy Hatchery Late Winter-run Program; Hood River Winter-run Program; and the Lewis River Wild Late-run Winter Steelhead Program.

The LCR steelhead DPS includes 30 historical populations in five strata (Table 46). LCR steelhead have both winter and summer runs, and several river basins have both (e.g., Kalama

River, Sandy River, Clackamas River, and Hood River). Most steelhead in the Lower Columbia River smolt at two years and spend two years in salt water before re-entering fresh water, where they may remain up to a year before spawning. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of this listed species. Parr usually undergo a smolt transformation as 2-year-olds, at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams.

Table 46. Historical Population Structure and Viability Status for LCR Steelhead (ODFW 2010; LCFRB 2010).

Stratum (Run)	Population	A&P	Spatial	Diversity
Cascade (Winter)	Lower Cowlitz	L	M	M
	Upper Cowlitz	VL	M	M
	Cispus	VL	M	M
	Tilton	VL	M	M
	South Fork Toutle	M	VH	H
	North Fork Toutle	VL	H	H
	Coweeman	L	VH	VH
	Kalama	L	VH	H
	North Fork Lewis	VL	M	M
	East Fork Lewis	M	VH	M
	Salmon Creek	VL	H	M
	Washougal	L	VH	M
	Clackamas	M	VH	M
	Sandy	L	M	M
Cascade (Summer)	Kalama	H	VH	M
	North Fork Lewis	VL	VL	VL
	East Fork Lewis	VL	VH	M
	Washougal	M	VH	M
Gorge (Winter)	Lower Gorge	L	VH	M
	Upper Gorge	L	M	M
	Hood	M	VH	M
Gorge (Summer)	Wind	VH	VH	H
	Hood	VL	VH	M

Unlike Pacific salmon, steelhead are iteroparous—capable of spawning more than once before death. However, it is rare for steelhead to spawn more than once before dying, and almost all that do so are females (Nickelson et al. 1992). Busby et al. (1996) reviewed data on North American populations, and first time (maiden) spawners comprised 94% of adults in the Columbia River. The majority of repeat spawners are female, presumably due to the extended time and energy males spend on the spawning ground competing for and guarding females and nests.

Spatial Structure

For the spatial structure analysis, the Oregon and Washington recovery plans evaluated the proportion of stream miles currently accessible to the species relative to the historical miles accessible (ODFW 2010; LCFRB 2010). The recovery plans adjusted the rating downward if portions of the currently accessible habitat were qualitatively determined to be seriously degraded. The recovery plans also adjusted the rating downward if the portion of historical habitat lost was a key production area.

The Oregon and Washington recovery plans rate spatial structure to be moderate to very high in nearly all populations of LCR steelhead. The populations that rate lowest have fish passage barriers. Trap and haul operations on the Cowlitz River pass adults upriver, but downstream passage and survival of juvenile fish is very low. This problem also affects spatial structure in the Cispus and Tilton populations. Merwin Dam blocks access to most of the available spawning habitat in the North Fork Lewis populations. However, the relicensing agreement for Lewis River hydroelectric projects calls for reintroduction of steelhead. Condit Dam on the White Salmon River blocked access to most of the historical spawning habitat up until the date it was removed in 2011. Thus, the LCR steelhead current spatial structure is less diverse than its historical structure, but management actions are underway to improve the situation.

Diversity

The Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) rate diversity to be moderate to high in all but one population (Table 31). One of the leading factors affecting the diversity of this DPS is the loss of habitat associated with construction of dams. As described above, many of the historical populations were affected by dams built 60 to 90 years ago in upper tributaries.

Artificial propagation has been identified as another major factor affecting diversity of LCR steelhead. For many basins, the number of stocks planted, the size and frequency of annual releases, and the percentage of smolts released changed a great deal between the time periods before and after 1985. At present, fewer stocks are used, fewer hatchery fish are released, and a higher percentage of the fish that are released are ready to quickly migrate to the ocean. This change came about in response to the development of wild fish policies in Oregon and Washington. In Washington, the development and implementation (in 1991) of a new stock transfer policy (WDF 1991) designed to foster local brood stocks resulted in a substantial reduction in the transfer of eggs and juveniles between watersheds. The policy mandates that hatchery programs use local brood stocks in rivers with extant indigenous stocks.

Abundance and Productivity

Since the last status evaluation, all populations increased in abundance during the early 2000s, generally peaking in 2004. Abundance of most populations has since declined back to levels close to the long-term mean. Exceptions are the Washougal summer and North Fork Toutle winter populations, for which abundance is higher than the long-term average, and the Sandy, for which abundance is below the long-term average. The North Fork Toutle winter steelhead population appears to be experiencing an increasing trend dating back to 1990, which is likely partially the result of recovery of habitat since the eruption of Mt. St. Helens in 1980. In general, the LCR steelhead populations do not show any sustained, dramatic changes in abundance since the previous status review (Ford et al. 2010).

Table 47. Abundance Estimates for LCR Steelhead Populations (Streamnet 2016; WDFW 2016A; ODFW 2016a).

Stratum (Run)	Population	Years	Total	HOR(1)	NOR(2)	Recovery Target(3)
Cascade (Winter)	Lower Cowlitz	2009	4,559	4559		
	Upper Cowlitz/Cispus	2010-2014	489	51	438	500
	Tilton	2010-2013	279	0	279	200
	South Fork Toutle	2010-2014	508	7	501	500
	North Fork Toutle	2010-2014	507	121	387	600
	Coweeman	2010-2014	462	166	296	600
	Kalama	2011-2015	930	455	475	600
	North Fork Lewis	2007-2011	2,355	2,126	129	400
	East Fork Lewis	2010-2014	364	0	364	500
	Washougal	2010-2014	362	195	167	350
	Clackamas	2014-2015	5,483	1,876	3,607	10,655
	Sandy	2013-2015	4,094	284	3,810	1,510
Cascade (Summer)	Kalama	2011-2015	626	499	127	500
	North Fork Lewis	2009	10,508	10,508		
	East Fork Lewis	2011-2015	928	168	760	500
	Washougal	2012-2015	723	621	102	500
Gorge (Winter)	Upper Gorge	2010-2014	36		36	322
	Hood	2003-2007	818	380	438	1,633
Gorge (Summer)	Wind	2010-2014	805	42	763	1,000
	Hood	2003-2007	480	239	241	1,988
Total			35,316	22,297	12,920	

(1) Hatchery Origin (HOR) spawners.
(2) Natural Origin (NOR) spawners.

The recovery plans identified 16 populations as currently at low to very low viability and five with moderate viability. The Wind River and Kalama River summer-run populations are the only ones that rated high to very high for abundance and productivity. The Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) developed planning ranges for abundance of viable LCR steelhead populations (Table 47). Some abundance goals were not set; the range of abundance is from 322 in the Upper Gorge to 10,655 in the Clackamas. The viability ratings are based on long-term trends whereas recent abundance estimates show a slightly different picture (Table 47). Several populations appear to be approaching the abundance targets, and one (the E.F. Lewis) exceeded it.

Data availability for abundance of naturally spawning adult steelhead is highly variable (Table 47). The years of record vary considerably for each population and for some populations we could only find one data year. Based on the best available data, the estimated spawning population of LCR steelhead is 22,297 hatchery origin and 12,920 natural origin adult spawners.

The Northwest Fisheries Science Center publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2013-2017 is shown in Table 48 (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017).

Table 48. Average Estimated Outmigration for Listed LCR Steelhead (2013-2017).

Origin	Outmigration
Natural	323,607
Listed hatchery intact adipose	22,649
Listed hatchery adipose clipped	1,194,301

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (3) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (4) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, harvest, etc.).

Limiting Factors and Threats

The status of lower Columbia River steelhead results from the combined effects of habitat degradation, dam building and operation, fishing, hatchery operations, ecological changes, and natural environmental fluctuations. Habitat for LCR steelhead has been adversely affected by changes in access, stream flow, water quality, sedimentation, habitat diversity, channel stability, riparian conditions, channel alternations, and floodplain interactions. These large-scale changes have altered habitat conditions and processes important to migratory and resident fish and wildlife. Additionally, habitat conditions have been fundamentally altered throughout the Columbia River basin by the construction and operation of a complex of tributary and mainstem dams and reservoirs for power generation, navigation, and flood control. Lower Columbia steelhead are adversely affected by hydrosystem-related flow and water quality effects, obstructed and/or delayed passage, and ecological changes in impoundments. Dams in many of the larger subbasins have blocked anadromous fishes’ access to large areas of productive habitat.

Fishery impacts on wild summer steelhead are currently limited to incidental mortality in freshwater fisheries. Populations above Bonneville are also subject to treaty tribal subsistence and commercial fisheries. Interception of steelhead in ocean salmon fisheries is rare. Fishing rates on wild steelhead have been reduced from their historical peaks in the 1960s by over 90% following prohibition of commercial steelhead harvest in the mainstem (except the mainstem above Bonneville) and hatchery-only retention regulations for recreational fisheries. Wild steelhead mortality is incidental (less than 10% of the wild run). Ongoing threats to wild steelhead populations from fishing include illegal harvest and the incidental mortality from fisheries targeting hatchery fish and other species.

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.

Status Summary

Most LCR steelhead populations are at relatively low abundance, and those with enough data to be modeled are estimated to have a relatively high extinction probability. The WLC-TRT described two historical populations as either extinct or at very high risk; most other populations are at high risk. The hatchery contribution to natural spawning remains high in many populations. Some populations, particularly summer run, have shown higher returns in recent years. Additionally, trap and haul programs are re-introducing steelhead to many miles of habitat improving the spatial structure and diversity of the species. However, more time is needed before we will know if their status will improve.

2.2.2.13 Upper Willamette River Chinook Salmon

Description and Geographic Range

We listed Upper Willamette River (UWR) Chinook salmon as threatened on March 24, 1999 (64 FR 14308). When we re-examined the status of these fish in 2005 and 2011, we determined that they still warranted listing as threatened (70 FR 37160; 76 FR 50448). We describe the ESU as all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River and its tributaries above Willamette Falls, Oregon. Also included in the ESU are spring-run Chinook salmon from six artificial propagation programs: the McKenzie River Hatchery Program; Marion Forks Hatchery/North Fork Santiam River Program; South Santiam Hatchery Program; Willamette Hatchery Program; and the Clackamas Hatchery Program (79 FR 20802).

The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (ODFW 2011b) identifies seven demographically independent populations of spring Chinook salmon: Clackamas, Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and the Middle Fork Willamette. The populations are delineated based on geography, migration rates, genetic attributes, life history patterns, phenotypic characteristics, population dynamics, and environmental and habitat characteristics. The plan identifies the Clackamas, North Santiam, McKenzie and Middle Fork Willamette populations as “core populations” and the McKenzie as a “genetic legacy population.” Core populations are those that were historically the most productive populations. The McKenzie population is also important for meeting genetic diversity goals. All the populations are part of the same stratum, the Cascades Tributaries Stratum, for the ESU.

Table 49. Historical Population Structure and Viability Status for UWR Chinook Salmon (ODFW 2011b).

Population	Population Classification	Viability Status		
		A&P	Spatial	Diversity
Clackamas	Core population	M	H	M
Molalla		VL	L	L
N. Santiam	Core population	VL	L	L
S. Santiam		VL	M	M
Calapooia		VL	VL	L
McKenzie	Core and Genetic Legacy	VH	M	M
Middle Fork	Core population	VL	L	L

Spatial Structure

UWR Chinook salmon exhibit both “ocean type” (i.e., emigration to the ocean as subyearlings) and “stream type” (emigration as yearlings) life histories. Populations tend to mature at ages 4 and 5. Historically, 5-year-old fish dominated the spawning migration runs; recently, however, most fish have matured at age 4. The timing of the spawning migration is limited by Willamette Falls. High flows in the spring allow access to the upper Willamette basin, whereas low flows in the summer and autumn prevent later-migrating fish from ascending the falls. As with UWR steelhead, low flows may serve as an isolating mechanism, separating this species from others nearby. Spring Chinook salmon in the Clackamas River are of uncertain origin, but we consider natural-origin spring Chinook salmon from this subbasin to be part of the listed species. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of the listed species. Parr usually undergo a smolt transformation in the spring at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams.

A population’s spatial structure is made up of both the geographic distribution of individuals in the population and the processes that generate that distribution (McElhany et al. 2000). For the spatial structure analysis, the Oregon recovery plan evaluated the proportion of stream miles currently accessible to the species relative to the historical miles accessible (ODFW 2011b). Oregon adjusted the rating downward if portions of the currently accessible habitat were qualitatively determined to be seriously degraded. Oregon also adjusted the rating downward if the portion of historical habitat lost was a key production area. The Oregon recovery plan rates spatial structure to be low to very low in four populations, moderate in two and high in one. The populations that rate lowest have fish passage barriers, stream channel modifications, and water quality problems limiting distribution of the species.

Diversity

Willamette Falls, a natural barrier before it was laddered, prevented fall-run Chinook salmon from occupying the upper Willamette River. Thus the UWR Chinook salmon were historically composed of only the spring run. The ladder allows other life history traits to occupy areas in the upper Willamette River, however none are considered part of the historical populations or the ESU.

The Oregon recovery plan (ODFW 2011b) rates diversity to be moderate to low in the UWR Chinook ESU (Table 6 above). Loss of habitat above dams and hatchery production are two factors that have had a negative influence on diversity (Good et al. 2005). As described above, dams and other habitat alterations have reduced or eliminated tributary and mainstem areas. Introduction of fall-run Chinook and laddering the falls have increased the potential for genetic introgression between wild spring and hatchery fall Chinook.

Good et al. (2005) identified artificial propagation as a major factor affecting the variation in diversity traits of UWR Chinook salmon. Large numbers of fish from the upper Willamette River (Santiam, McKenzie, and middle fork Willamette rivers) have been introduced since the 1960s. Changes in spawning timing have been observed over the last 100 years. Regardless of origin, the existing spring run has maintained a low to moderate level of natural production (and local adaptation) for a number of generations (NMFS 2004).

Abundance and Productivity

The spring run of Chinook has been counted at Willamette Falls since 1946, but “jacks” (sexually mature males that return to freshwater to spawn after only a few months in the ocean) were not differentiated from the total count until 1952. The average estimated run size from 1946 through 1950 was 43,300 fish, compared to an estimate of only 3,900 in 1994. Even though the number of naturally spawning fish has increased gradually in recent years, many are first generation hatchery fish. Juvenile spring Chinook produced by hatchery programs are released throughout the basin and adult Chinook returns to the ESU are typically 80-90% hatchery origin fish. In the recovery plan, ODFW (2011b) found the UWR Chinook ESU to be extremely depressed, likely numbering less than 10,000 fish, with the Clackamas and McKenzie populations accounting for most of the production (Table 50).

Table 50. Estimated Recent Abundance, Viability Goals, and Abundance Targets for Upper Willamette Chinook Populations (ODFW 2011b).

Population	Wild Abundance (1990-2004)	Viability Goal	Abundance Goal
Clackamas	1,100	Very High	2,046
Molalla	25	High	1,434
N. Santiam	50	High	5,450
S. Santiam	50	High	4,910
Calapooia	25	High	1,225
McKenzie	1,995	Very High	5,486
Middle Fork	50	High	5,870

The Oregon recovery plan (ODFW 2011b) rates all but two of the populations as very low for abundance and productivity (Table 10). Most populations of the UWR Chinook ESU are far below the recovery goal (Table 11). Abundance in the Clackamas population would need to nearly double, and in the North and South Santiam and Middle Fork populations a 100-fold increase is needed to meet recovery goals.

Recent data on returning adults are summarized in Table 51. Abundance of adult UWR spring Chinook has declined since the highs witnessed around the turn of this century. Over the past five years, natural escapement has ranged from a low of 6,341 to a high of 15,416. The 5-year average return for UWR spring Chinook salmon is 11,443 naturally produced adults and 34,454 hatchery adults (2011-2015).

Table 51. Adult Upper Willamette River Spring Chinook Escapement to the Clackamas River and Willamette Falls Fish Ladder (ODFW and WDFW 2012a, 2013a, 2014a, 2015a; ODFW 2016b).

Year	Total Escapement	Hatchery Escapement	Natural Escapement
2011	51,922	36,506	15,416
2012	43,012	32,334	10,678
2013	35,714	24,332	11,382
2014	37,300	30,959	6,341
2015	61,534	48,137	13,397
Average	45,896	34,454	11,443

The NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The average outmigration for the years 2013-2017 is shown in Table 52 (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017).

Table 52. Average Estimated Outmigration for Listed UWR Chinook Salmon (2013-2017).

Origin	Outmigration
Natural	1,275,681
Listed hatchery intact adipose	16,278
Listed hatchery adipose clipped	5,543,371

The number of natural fish should be viewed with caution. Estimating juvenile abundance is complicated by a host of variables: (1) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (2) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (3) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, harvest, etc.). Listed hatchery fish outmigration numbers are also affected by some of these factors; however, releases from hatcheries are generally easier to quantify than is natural production.

Limiting Factors

The general limiting factors categories for UWR Chinook are habitat access, physical habitat quality/quantity, water quality, competition, disease, food web, population traits, and predation (ODFW 2011b). The primary threats to UWR Chinook are human impacts, including flood control/hydropower system operations, land use practices (e.g., road building, riparian development, etc.), harvest, hatchery operations, and other species.

Impacts of land management on UWR Chinook 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 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 (ODFW 2011b). 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. Land use practices in the estuary have degraded or eliminated much of the rearing habitat for UWR Chinook. 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).

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.

Harvest impacts 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 (ODFW 2011b) by implementing selective harvest of hatchery-origin fish in commercial and recreational fisheries, with all unmarked, wild spring Chinook being released. Current exploitation (mortality) of naturally produced Chinook in ocean fisheries averages 11% (1996-2006) and freshwater fisheries 9% (2000-2010) (ODFW 2011b).

Many UWR Chinook populations are characterized by high proportions of hatchery fish on the spawning grounds (ODFW 2011b). The vast majority of the UWR Chinook escapement is hatchery fish (Table 16). The major concern with hatcheries is the negative effect hatchery fish spawning in the natural environment have on productivity and long-term fitness of naturally spawning populations.

ODFW identified negative effects of both native and introduced plant and animal species as limiting factors and threats to UWR Chinook (ODFW 2011b). Ecosystem alterations attributable to hydropower dams and to modification of estuarine habitat have increased predation on UWR Chinook. 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).

Status Summary

The updated information provided in Oregon's recovery plan (2011b) and the information contained in previous UWR Chinook salmon status reviews indicate that most spring-run populations are likely extirpated, or nearly so. The only populations considered potentially self-sustaining are the Clackamas and McKenzie River populations, but abundance is relatively low, with most fish being of hatchery origin. Substantial changes, such as an increase in abundance and a reduction in hatchery influences, are needed before this ESU can recover. Dams, as well as other habitat alterations and hatchery and harvest effects have affected the listed species. NMFS' Willamette Project biological opinion addresses fish passage and water temperature issues. Efforts to make the dams more fish-friendly and to improve river water temperatures should improve the status of the species, but the process has just begun, and more time is needed before we can know the effect of these actions.

2.2.2.14 Upper Willamette River Steelhead

Description and Geographic Range

The Upper Willamette River steelhead DPS was first listed as a threatened species on August 18, 1997 (62 FR 43937). When we re-examined the status of this species in 2006 and 2011, we determined that it still warranted listing as threatened (71 FR 834, 76 FR 50448). The listing included all naturally spawned populations of winter-run steelhead in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River, inclusive. No artificially propagated steelhead stocks are considered part of the listed species. The hatchery summer-run steelhead in the basin are an out-of-basin stock and not considered part of the DPS.

UWR steelhead are late-migrating winter steelhead, entering fresh water primarily in January through April (ODFW 2011). This atypical run timing appears to be an adaptation for ascending Willamette Falls, which functioned as an isolating mechanism for the Upper Willamette basin before the falls were laddered. Reproductive isolation resulting from passing above the falls may explain the genetic distinction between steelhead from the upper Willamette River and those in the lower river. A resident form of O. mykiss co-occurs with the anadromous form and juvenile life stages of the two forms can be very difficult to differentiate.

The UWR late-migrating steelhead are ocean-maturing fish. Most return at age 4, although a small proportion return as 5-year-old fish. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of the listed species. Parr usually undergo a smolt transformation as 2-year-olds, at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams.

Unlike Pacific salmon, steelhead are iteroparous—capable of spawning more than once before death. However, it is rare for steelhead to spawn more than once before dying, and almost all that do so are females (Nickelson et al. 1992). Busby et al. (1996) reviewed data on North American populations, and first time (maiden) spawners comprised 94% of adults in the Columbia River. The majority of repeat spawners are female, presumably due to the extended time and energy males spend on the spawning ground competing for and guarding females and nests.

The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (ODFW 2011) identifies four demographically independent populations of steelhead: Molalla, North Santiam, South Santiam, and Calapooia (Table 53). Winter steelhead have been reported spawning in the west-side tributaries to the Willamette River, but these tributaries were not considered to have constituted an independent population historically. The west-side tributaries may serve as a population sink for the DPS (Myers et al. 2006). Additionally, 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.

Table 53. Historical Population Structure and Viability Status for UWR Chinook Salmon (ODFW 2011).

Population	Viability Status		
	A&P	Spatial	Diversity
Molalla	M	M	M
N. Santiam	H	L	M
S. Santiam	H	M	M
Calapooia	M	VL	M

Spatial Structure and Diversity

For the spatial structure analysis, the Oregon recovery plan evaluated the proportion of stream miles currently accessible to the species relative to the historical miles accessible (ODFW 2010). Oregon adjusted the rating downward if portions of the currently accessible habitat were qualitatively determined to be seriously degraded. Oregon also adjusted the rating downward if the portion of historical habitat lost was a key production area. The Oregon recovery plan rates the viability of spatial structure to be low to very low in the North Santiam and Calapooia populations, and moderate in the other two populations (Table 46). The low ratings are due to fish passage barriers, stream channel modifications, and water quality problems limiting survival of the species.

The Oregon recovery plan (ODFW 2010) rated the diversity of UWR steelhead as very low (Table 46). One of the leading factors affecting the diversity of this DPS is the loss of habitat associated with construction of dams. As described above, the UWR steelhead has been affected by dams.

Artificial propagation has been identified as another major factor affecting diversity of UWR steelhead. Although releases of summer steelhead have been reduced and releases of non-listed early winter-run steelhead have been discontinued, the hatchery fish continue to be a threat because the summer and early winter-run steelhead (and any natural production from them) still negatively interact with the late-run winter fish.

Abundance and Productivity

Overall, numbers of native winter steelhead in the Upper Willamette basin declined in the early 1970s, exhibited large fluctuations in abundance from the late 1970s through late 1980s, declined to very low numbers in the 1990s, and rebounded to moderate levels in the early 2000s. However, population abundance peaked in 2002 and has since returned to the relatively low abundance of the 1990s.

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. Adult winter-run steelhead are counted at the Willamette Falls fishway ladder where the counts begin in November and end mid-May of the following year (Table 54). The number of winter-run steelhead passing over Willamette Falls during the winter of 2014-15 was 4,503 and the most recent five-year average is only at 5,971.

Table 54. Upper Willamette Winter-run Steelhead Abundance (ODFW 2016b).

Year	Natural-origin Spawners
2010-2011	7,441
2011-2012	7,616
2012-2013	4,944
2013-2014	5,349
2014-2015	4,503
Average	5,971

The Oregon recovery plan (ODFW 2011) rates the populations as moderate to high viability potential (Table 54). However, there is a considerable amount of uncertainty in these ratings. 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.

It is difficult to accurately estimate juvenile UWR steelhead abundance during the coming year. However, the average estimated outmigration (2013-2017) of naturally-produced smolts is 143,898 (Zabel 2014a; Zabel 2014b; Zabel 2015; Zabel 2016; Zabel 2017). As with other species, it is reasonable to assume that this figure could be substantially higher when other juvenile life stages are included. In addition, non-listed juvenile rainbow trout and unlisted juvenile steelhead occur in the same areas as the listed UWR steelhead; and it is very difficult to distinguish between them.

Limiting Factors

The general limiting factors categories for UWR steelhead are habitat access, physical habitat quality/quantity, water quality, competition, disease, food web, population traits, and predation (ODFW 2011). The primary threats to UWR steelhead are human impacts, including flood control/hydropower system operations, land use practices (e.g., road building, riparian development, etc.), harvest, hatchery operations, and other species.

Impacts of land management on UWR 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 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 steelhead (ODFW 2011). 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. Land use practices in the estuary have degraded or eliminated much of the rearing habitat for UWR 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).

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.

The Oregon recovery plan finds that harvest is not a limiting factor. Steelhead are not intercepted in ocean fisheries to a measurable degree and the current exploitation rate on wild steelhead from sport fisheries is 3% (ODFW 2011).

There are no winter-run steelhead hatchery programs in the Upper Willamette subbasin. Non-native summer steelhead are raised at most of the rearing facilities in the upper Willamette River subbasins, and released as smolts in the North and South Santiam, McKenzie and Middle Fork Willamette subbasins. Differences in spawn timing among these stocks may limit (but not eliminate) the potential for interbreeding. 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). For example, Kostow and Zhou (2006) suggested that because adult 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.

ODFW identified negative effects of both native and introduced plant and animal species as limiting factors and threats to UWR steelhead (ODFW 2011). Ecosystem alterations attributable to hydropower dams and to modification of estuarine habitat have increased predation on UWR steelhead. 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).

Status Summary

All four UWR steelhead populations are at relatively low abundance. Although hatchery production has been reduced or eliminated, effects on natural spawning remain high. No single population has been identified as naturally self-sustaining. Dams have substantially affected the Santiam populations' spatial structure and habitat and have most likely had a negative effect on the DPS as a whole. NMFS' Willamette Project biological opinion addresses fish passage and water temperature. Efforts to make the dams more fish-friendly and to improve river water temperatures should improve the status of the species biological requirements. But the process has just begun, and more time is needed before we can know the effect of these actions.

2.2.2.15 Oregon Coast Coho Salmon

Description and Geographic Range

Oregon Coast (OC) coho salmon was first listed as threatened on August 10, 1998 (63 FR 42587). After a court decision and the delisting of the species, we relisted OC coho as threatened on February 11, 2008 (73 FR 7816). On June 20, 2011, we re-affirmed our previous listing of OC coho salmon as a threatened species (76 FR 35755). The listing includes all naturally spawned populations of coho salmon in coastal streams south of the Columbia River and north of

Cape Blanco. The listing also includes the Cow Creek hatchery coho stock, produced at the Rock Creek Hatchery.

In contrast to the life history patterns of other anadromous salmonids, coho salmon generally exhibit a relatively short and fixed 3-year life cycle. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas for up to 15 months. Parr typically undergo a smolt transformation in their second spring, at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams. Adults typically begin their spawning migration in the late summer and fall, spawn by mid-winter, then die. Coho salmon typically spend two growing seasons in the ocean before returning to their natal stream to spawn as 3-year-olds. Some precocious males, called “jacks,” return to spawn after only six months at sea (i.e., as 2-year-olds).

Spatial Structure and Diversity

The Oregon/Northern California Coast Technical Recovery Team identified 56 historical coho populations for the Oregon Coast coho salmon ESU (Lawson et al. 2007). The Oregon/Northern California Coast Technical Recovery Team classified historical populations into three distinct groups: functionally independent, potentially independent, and dependent (Table 55). In general, Oregon Coast drainage basins of intermediate to large size may have supported a coho population capable of persisting indefinitely in isolation, though some of them may have been demographically influenced by adult coho straying into spawning areas from elsewhere in the ESU. Those persistent populations with minimal demographic influence from adjacent populations are classified as functionally independent (13 populations). Populations that appear to be capable of persisting in isolation but are demographically influenced by adjacent populations are classified as potentially independent (8 populations). Coho salmon populations in smaller coastal basins that may not have been able to maintain themselves continuously for periods as long as hundreds of years without the demographic boost provided by migrating spawners from other populations are classified as dependent (35 populations).

Table 55. Historical coho populations in the Oregon Coast ESU (Lawson et al. 2007).

Population	Population type	Population	Population type
Necanicum	Potentially independent	Alsea	Functionally independent
Ecola	Dependent	Big (near Alsea)	Dependent
Arch Cape	Dependent	Vingie	Dependent
Short Sands	Dependent	Yachats	Dependent
Nehalem	Functionally independent	Cummins	Dependent
Spring	Dependent	Bob	Dependent
Watseco	Dependent	Tenmile Creek	Dependent
Tillamook Bay	Functionally independent	Rock	Dependent
Netarts	Dependent	Big	Dependent
Rover	Dependent	China	Dependent
Sand	Dependent	Cape	Dependent
Nestucca	Functionally independent	Berry	Dependent

Neskowin	Dependent	Sutton (Mercer Lake)	Dependent
Salmon	Potentially independent	Siuslaw	Functionally independent
Devils Lake	Dependent	Siltcoos	Potentially independent
Siletz	Functionally independent	Tahkenitch	Potentially independent
Schoolhouse	Dependent	Threemile	Dependent
Fogarty	Dependent	Lower Umpqua	Functionally independent
Depoe Bay	Dependent	Middle Umpqua	Functionally independent
Rocky	Dependent	North Umpqua	Functionally independent
Spencer	Dependent	South Umpqua	Functionally independent
Wade	Dependent	Tenmile	Potentially independent
Coal	Dependent	Coos	Functionally independent
Moolack	Dependent	Coquille	Functionally independent
Big (near Yaquina)	Dependent	Johnson	Dependent
Yaquina	Functionally independent	Twomile	Dependent
Theil	Dependent	Floras/New	Potentially independent
Beaver	Potentially independent	Sixes	Potentially independent

Spatial structure was identified as a problem in the 1980s and 1990s when it was observed that river systems on the North Coast had substantially lower spawner escapements than those on the South Coast (Stout et al. 2011). Causes of these disproportionately lower escapements were never clearly identified, but contributing factors may have included more intense fisheries north of Cape Falcon near the mouth of the Columbia River and high percentages of hatchery fish on the spawning grounds. Harvest was generally reduced in 1994 (although not as severely north of Cape Falcon as south). Hatchery releases in the Nehalem and Trask Rivers have been reduced or eliminated so that the percentage of hatchery fish on the spawning grounds has declined from a high of 67% in 1996 to less than 5% in most recent years. Since about 1999 the north coast basins have had escapements more on a par with the rest of the ESU.

Current concerns for spatial structure focus on the Umpqua River (Stout et al. 2011). Of the four populations in the Umpqua stratum, two, the North Umpqua and South Umpqua, were of particular concern. The North Umpqua is controlled by Winchester Dam and has historically been dominated by hatchery fish. Hatchery influence has recently been reduced, but the natural productivity of this population remains to be demonstrated.

In the recent past, the effect of hatchery releases had a significant effect on life history diversity in the OC coho salmon ESU (Stout et al. 2011). ODFW has significantly reduced hatchery releases of coho salmon, therefore the effect of hatchery fish on native population diversity should be abating, although there is little information about the duration of hatchery genetic effects on naturally spawning populations. Because of significant reduction in hatchery releases of coho, the hatchery fraction of spawners observed on the spawning grounds has been substantially reduced (ODFW 2009). This should lead to improvement of diversity in naturally produced OC coho salmon in those populations once dominated by hatchery fish.

Since 1990 there have been years with extremely low escapements in some systems and many small systems have shown local extirpations, presumably reducing diversity due to loss of dependent populations. For example, Cummins Creek, on the central coast, had no spawners observed in 1998, indicating the potential loss of a brood cycle. These small systems are apt to be repopulated by stray spawners most likely from larger adjacent populations during periods of higher abundance (Lawson et al. 2007) and recent local extirpations may represent loss of genetic diversity in the context of normal metapopulation function.

Current status of diversity shows improvement through the waning effects of hatchery fish on populations of OC coho salmon. In addition, recent efforts in several coastal estuaries to restore lost wetlands should be beneficial. However the loss of diversity brought about by legacy effects of both freshwater and tidal habitat loss coupled with the restriction of diversity from very low returns over the past 20 years led us to conclude that diversity is lower than it was historically.

Abundance and Productivity

Based on historic commercial landing numbers and estimated exploitation rates, coho salmon escapement to coastal Oregon rivers was estimated to fall between one million and 1.4 million fish in the early 1900s, and the harvest level at that time was nearly 400,000 fish (Mullen 1981, Lichatowich 1989). The ODFW (1995) made estimates of coho salmon abundance at several points of time from 1900 to the present. These data show a decline of about 75% from 1900 to the 1950s and an additional 15% decline since the 1950s.

Spawning escapement estimates from the late 1990s using stratified random surveys give an annual average of 47,356 returning adults (Jacobs et al. 2002). Lichatowich (1989) attributed much of the species’ overall decline to a nearly 50% reduction in habitat production capacity. While the contrasting methods of estimating total returns make it difficult to compare historical and recent escapements, these numbers suggest that current abundance of coho salmon on the Oregon coast may be less than 5% of what is was in the early 1900s.

Though the overall trend has been distinctly downward throughout the century, OC coho salmon populations are highly variable from year to year. From 1950 through 2009, the number of naturally produced adult coho (prior to harvest) has ranged from a high of 788,290 in 1951 to a low of 26,888 in 1997 (ODFW 2010). Over the past ten years abundance has been cyclical and the trend nearly flat. Since 2000, abundance twice fluctuated to fewer than 80,000 and then rose to nearly 300,000.

Table 56. Estimated Abundance of Hatchery and Naturally Produced Adult OC Coho (ODFW 2016a).

Population	Origin	2011	2012	2013	2014	Average
Necanicum R.	Hatchery	39	0	0	98	34
	Natural	2,120	902	798	5,727	2,387
Nehalem R.	Hatchery	64	0	0	764	207
	Natural	15,322	2,963	4,539	30,577	13,350
Tillamook Bay	Hatchery	0	0	304	460	191
	Natural	19,250	1,686	4,402	20,090	11,357
Nestucca R.	Hatchery	0	0	37	0	9
	Natural	7,857	1,751	946	6,369	4,231

NC Dependents	Hatchery	0	0	0	111	28
	Natural	1,341	218	271	4,607	1,609
Salmon R.	Hatchery	0	0	0	27	7
	Natural	3,636	297	1,165	3,680	2,195
Siletz R.	Hatchery	0	0	0	71	18
	Natural	33,094	4,495	7,660	19,496	16,186
Yaquina R.	Hatchery	0	0	0	0	0
	Natural	19,074	6,268	3,553	25,582	13,619
Beaver Cr.	Hatchery	0	0	0	0	0
	Natural	2,389	1,878	2,015	6,564	3,212
Alsea R.	Hatchery	81	0	0	0	20
	Natural	28,337	8,470	9,283	25,786	17,969
Siuslaw R.	Hatchery	803	314	0	0	279
	Natural	28,082	11,946	14,118	38,896	23,261
MC Dependents	Hatchery	0	0	0	118	30
	Natural	4,487	492	1,929	1,890	2,200
Lower Umpqua R.	Hatchery	0	0	0	0	0
	Natural	18,715	3,731	7,792	36,942	16,795
Middle Umpqua R.	Hatchery	71	0	0	0	18
	Natural	19,962	2,447	4,272	13,939	10,155
North Umpqua R.	Hatchery	335	669	622	105	433
	Natural	3,679	3,134	2,774	3,979	3,392
South Umpqua R.	Hatchery	1,130	0	193	1,022	586
	Natural	49,958	11,636	12,178	11,412	21,296
Coos R.	Hatchery	0	0	0	0	0
	Natural	10,999	9,414	6,884	38,880	16,544
Coquille R.	Hatchery	442	0	148	148	185
	Natural	55,667	5,911	23,637	41,660	31,719
Floras Cr.	Hatchery	0	0	0	0	0
	Natural	9,217	2,502	1,936	1,022	3,669
Sixes R.	Hatchery	0	3	0	0	1
	Natural	334	31	567	410	336
Siltcoos Lake	Hatchery	0	0	0	0	0
	Natural	6,352	3,945	3,797	7,178	5,318
Tahkenitch Lake	Hatchery	0	0	3	0	1
	Natural	6,665	5,675	3,413	3,691	4,861
Tenmile Lake	Hatchery	0	0	0	0	0
	Natural	7,284	9,302	6,449	11,141	8,544
Total	Hatchery	2,965	986	1,307	2,924	2,046
	Natural	353,821	99,094	124,378	359,518	234,203

While we currently lack data on how many natural juvenile coho salmon this ESU produces, it is possible to make rough estimates of juvenile abundance from adult return data. The three-year average of natural origin spawners for the years 2010-2012 is estimated at 229,872 total spawners (Table 56). Sandercock (1991) published fecundity estimates for several coho salmon stocks; average fecundity ranged from 1,983 to 5,000 eggs per female. By applying a very conservative value of 2,000 eggs per female to an estimated 115,000 females returning (roughly half of 229,872) to this ESU, one may expect approximately 230 million eggs to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around 7%. Thus, we can estimate that roughly 16 million juvenile coho salmon are produced annually by the Oregon Coast ESU.

As stated previously, the ESU includes the Cow Creek hatchery stock which is produced at the Rock Creek Hatchery. The hatchery plan calls for an annual release of 60,000 adipose fin-clipped juvenile coho in the south Umpqua River (ODFW 2010).

A review of ODFW's stratified random surveys for the years 1990-2002 shows positive trends for 11 major river systems (Good et al. 2005). The biggest increases (>10% per year) were found on the north coast (Necanicum, Nehalem, Tillamook, Nestucca), mid coast (Yaquina, Siuslaw), and the Umpqua, while smaller increases were seen on the central (Siletz, Siuslaw) and south (Coos, Coquille) coasts. Thirteen-year trends in preharvest recruits show a less favorable picture. Necanicum, Nehalem, Tillamook, Nestucca, Yaquina, and Umpqua all showed positive trends of about 8% to 13% per year. Siletz, Alsea, and Coquille showed declines ranging from 1% to 4% per year. Long-term (33-year) trends in spawner abundance for both the lakes and rivers have been relatively flat, with lakes increasing about 2% per year and rivers increasing about 1% per year. In both the lakes and rivers, long-term trends in recruits have declined about 5% per year since 1970. For the ESU as a whole, spawners and recruits have declined at a 5% rate over the past 33 years.

Stout et al. (2011) found that recruits from the return years 1997–1999 failed to replace parental spawners: a recruitment failure occurred in all three brood cycles even before accounting for harvest-related mortalities. This was the first time this had happened since data collection began in the 1950's. Ocean conditions improved for the 1998 brood year, and recruits since 2001 have returned to spawn in numbers higher than we have previously observed. However, in the return years 2005, 2006, and 2007, recruits again failed to replace parental spawners.

Limiting Factors

Some threats, in particular hatchery production and harvest, have been greatly reduced over the last decade and appear to have been largely eliminated as significant sources of risk. Other factors, such as habitat degradation and water quality, are considered to be ongoing threats that appear to have changed little over the last decade (NMFS 2011a). Changes to freshwater and marine habitat due to global climate change are also considered to be threats likely to become manifest in the future.

Historical harvest rates on Oregon Production Index area coho salmon were in the range of 60% to 90% from the 1960s into the 1980s (NMFS 2011a). Modest harvest reductions were achieved in the late 1980s, but rates remained high until a crisis was perceived, and most directed coho salmon harvest was prohibited in 1994. Subsequent fisheries have been severely restricted and most reported mortalities are estimates of indirect (noncatch) mortality in Chinook fisheries and selective fisheries for marked (hatchery) coho. Estimates of these indirect mortalities are somewhat speculative, and there is a risk of underestimation (PFMC 2009, Lawson and Sampson 1996). Freshwater fisheries have been allowed in recent years based on the provision in the salmon fishery management plan that terminal fisheries can be allowed on strong populations as long as the overall exploitation rate for the ESU does not exceed the allowable rate, and population escapement is not reduced below full seeding of the best available habitat.

Hatchery production continues to be reduced with the cessation of releases in the North Umpqua River and Salmon River populations. The near-term ecological benefits from these reductions may result in improved natural production for these populations in future (NMFS 2011a). In addition, reductions in hatchery releases that have occurred over the past decade may continue to produce some positive effects on the survival of the ESU in the future, due to the time it may take for past genetic impacts to become attenuated.

ODFW has been monitoring freshwater rearing habitat for the OC coho salmon ESU over the past decade (1998 to present) collecting data during the summer low flow period (Anlauf et al., 2009). The goal of this program is to measure the status and trend of habitat conditions throughout the range of the ESU through variables related to the quality and quantity of aquatic habitat for coho salmon: stream morphology, substrate composition, instream roughness, riparian structure, and winter rearing capacity (Moore, 2008). ODFW concluded that for the most part, at the ESU and strata scale, habitat for the OC coho salmon has not changed significantly in the last decade. They did find some small but significant trends. For instance, the Mid-South Coast stratum did show a positive increase in winter rearing capacity.

In 2010, the BRT found that habitat complexity, for the most part, decreased across the ESU over the period of consideration (1998–2008) (Stout et al. 2011). They noted that legacy effects of splash damming, log drives, and stream cleaning activities still affect the amount and type of wood and gravel substrate available and, therefore, stream complexity across the ESU (Miller, 2010; Montgomery et al., 2003). Road densities remain high and affect stream quality through hydrologic effects like runoff and siltation and by providing access for human activities. Beaver (Castor canadensis) activities, which produce the most favorable coho salmon rearing habitat especially in lowland areas, appear to be reduced. Stream habitat restoration activities may be having a short-term positive effect in some areas, but the quantity of impaired habitat and the rate of continued disturbance outpace agencies' ability to conduct effective restoration.

Status Summary

The degree to which the OC coho salmon's biological requirements are being met in the action area with respect to population numbers and distribution has not improved substantially since the 1990s. Ongoing efforts to protect OC coho salmon and their habitat, as described in the previous section, are likely to provide some benefit to this ESU (75 FR 29489). Considered collectively, however, these efforts do not comprehensively address the threats to the OC coho salmon ESU from ongoing and future land management activities and global climate change (75 FR 29489). Though recent trends in abundance are highly variable, the trend appears to be slowly increasing. The early part of this decade saw the highest returns on record. However, their habitat (critical and otherwise) has shown a steady decrease in area and function since the turn of the 20th century and that trend continues. Therefore, while there is some cause for optimism, there has been no genuine change in the species' status since we listed them, and the most likely scenario is that their biological requirements are not being met with respect to abundance, distribution, and overall trend.

2.2.2.16 Southern Oregon/Northern California Coasts Coho Salmon

Description and Geographic Range

The Southern Oregon/Northern California Coasts (SONCC) coho salmon was first listed as threatened on May 6, 1997. When we re-examined the status of this species in 2005 and 2011, we determined that it still warranted listing as threatened (70 FR 37160, 76 FR 50448). The listing includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California. The ESU includes coho salmon from three hatchery programs: the Cole Rivers Hatchery Program (ODFW Stock #52); Trinity River Hatchery Program; and the Iron Gate Hatchery Program (79 FR 20802).

In contrast to the life history patterns of other anadromous salmonids, coho salmon generally exhibit a relatively short and fixed 3-year life cycle. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas for up to 15 months. Parr typically undergo a smolt transformation in their second spring, at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams. Adults typically begin their spawning migration in the late summer and fall, spawn by mid-winter, then die. Coho salmon typically spend two growing seasons in the ocean before returning to their natal stream to spawn as 3-year-olds. Some precocious males, called “jacks,” return to spawn after only six months at sea (i.e., as 2-year-olds).

Spatial Structure and Diversity

Williams et al. (2006) characterized the SONCC ESU as three large populations that penetrate far inland (interior basins) and multiple smaller coastal populations (coastal basins). Populations that had minimal demographic influence from adjacent populations and were viable-in-isolation were classified as functionally independent populations. Populations that appeared to have been viable-in-isolation but were demographically influenced by adjacent populations were classified as potentially independent populations. Small populations that do not have a high likelihood of sustaining themselves over a 100-year time period in isolation and receive sufficient immigration to alter their dynamics and extinction risk were classified as dependent. The last category, ephemeral populations, do not have a high likelihood of sustaining themselves over a 100-year time period in isolation, and do not receive sufficient immigration to affect this likelihood. The habitat supporting an Ephemeral population is expected to be only rarely occupied.

The interior sub-basin strata were divided into substrata representing the three major sub-basins of the Rogue, Klamath, and Eel basins (Table 57). However, sufficient geographical and environmental variability occurs within the Klamath basin, therefore the Klamath basin was split into sub-strata of the Klamath River (upstream of the confluence with the Trinity River) and the Trinity River. The lower portions of these three large basins were included in the coastal basins sub-strata because they are more similar to other coastal basins in terms of the environmental and ecological characteristics examined than interior portions of the large basins.

Table 57. Arrangement of historical populations of the Southern Oregon/Northern California Coast coho salmon ESU. Population types are functionally independent (F), potentially independent (P), dependent (D) and, ephemeral (E).

Diversity Stratum	Pop. Type	Population	Diversity Stratum	Pop. Type	Population
Northern Coastal	F	Elk River	Southern Coastal	F	Humboldt Bay tribs
	P	Lower Rogue River		F	Low. Eel/Van Duzen
	F	Chetco River		P	Bear River
	P	Winchuck River		F	Mattole River
	E	Hubbard Creek		D	Guthrie Creek
	E	Euchre Creek	Interior – Rogue	F	Illinois River
	D	Brush Creek		F	Mid. Rogue/Applegate
	D	Mussel Creek		F	Upper Rogue River
	D	Hunter Creek	Interior – Klamath	P	Middle Klamath River
	D	Pistol River		F	Upper Klamath River
Central Coastal	F	Smith River		P	Salmon River
	F	Lower Klamath River		F	Scott River
	F	Redwood Creek		F	Shasta River
	P	Maple Creek/Big	Interior – Trinity	F	South Fork Trinity
	P	Little River		P	Lower Trinity River
	F	Mad River		F	Upper Trinity River
	D	Elk Creek	Interior – Eel River	F	South Fork Eel River
	D	Wilson Creek		P	Mainstem Eel River
	D	Strawberry Creek		P	Mid. Fork Eel River
	D	Norton/Widow White		F	Mid. Mainstem Eel River
				P	Up. Mainstem Eel River

Across the coastal basins of the SONCC Coho Salmon ESU, there existed sufficient geographical and environmental variability resulting in the TRT dividing the coastal basins into three sub-strata. The northern sub-stratum includes basins from the Elk River to the Winchuck River, including the lower portion of the Rogue River. The central substratum includes coastal basins from the Smith River to the Mad River, including the lower portion of the Klamath River. The southern stratum includes the Humboldt Bay tributaries south to the Mattole River, including the lower Eel River and Van Duzen River.

The primary factors affecting the genetic and life history diversity of SONCC coho salmon appear to be low population abundance and the influence of hatcheries and out-of-basin introductions. Although the operation of a hatchery tends to increase the abundance of returning adults, the reproductive success of hatchery-born salmonids spawning in the wild can be less than that of naturally produced fish (Araki et al. 2007). As a result, the higher the proportion of hatchery-born spawners, the lower the overall productivity of the population, as demonstrated by Chilcote (2003). Williams et al. (2008) considered a population to be at least at a moderate risk of extinction if the contribution of hatchery coho salmon spawning in the wild exceeds 5 percent. Populations have a lower risk of extinction if no or negligible ecological or genetic effects resulting from past or current hatchery operations can be demonstrated. Because the main stocks in the SONCC coho salmon ESU (i.e., Rogue River, Klamath River, and Trinity River) remain heavily influenced by hatcheries and have little natural production in mainstem rivers (Weitkamp et al. 1995; Good et al. 2005), some of these populations are at high risk of extinction relative to the genetic diversity parameter.

In addition, some populations are extirpated or nearly extirpated (i.e., Middle Fork Eel, Bear River, Upper Mainstem Eel) and some brood years have low abundance or may even be absent in some areas (e.g., Shasta River, Scott River, Mattole River, Mainstem Eel River), which further restricts the diversity present in the ESU. The ESU's current genetic variability and variation in life history likely contribute significantly to long-term risk of extinction. Given the recent trends in abundance across the ESU, the genetic and life history diversity of populations is likely very low and is inadequate to contribute to a viable ESU.

NMFS recognizes that artificial propagation can be used to help recover ESA-listed species, but it does not consider hatcheries to be a substitute for conserving the species in its natural habitat. Potential benefits of artificial propagation for natural populations include reducing the short-term risk of extinction, helping to maintain a population until the factors limiting recovery can be addressed, reseeding vacant habitat, and helping speed recovery. Artificial propagation could have negative effects on population diversity by altering life history characteristics such as smolt age and migration, and spawn timing.

Abundance and Productivity

Although long-term data on coho abundance in the SONCC Coho Salmon ESU are scarce, all available evidence from shorter-term research and monitoring efforts indicate that conditions have worsened for populations in this ESU since the early 2000's (Williams et al. 2011). For all available time series (except the parietal counts from West Branch and East Fork of Mill Creek), recent population trends have been downward. The longest existing time series at the "population unit" scale is from the Shasta River, which indicates a significant negative trend. The two extensive time series from the Rogue Basin both have recent negative trends, although neither is statistically significant (Williams et al. 2011).

Good et al. (2005) noted that the 2001 boodyear appeared to be the strongest of the last decade and that the Rogue River stock had an average increase in spawners over the last several years (as of Good et al. 2005 review). In the 2011 status evaluation, none of the time series examined (other than West Branch and East Fork Mill Creek) had a positive short-term trend and examination of these time series indicates that the strong 2001 broodyear was followed by a decline across the entire ESU (Williams et al. 2011). The exception being the Rogue Basin estimate from Huntley Park that exhibited a strong return year in 2004, stronger than 2001, followed by a decline to 414 fish in 2008, the lowest estimate since 1993 and the second lowest going back to 1980 in the time series.

Counts of adult coho salmon at Huntley Park, about 8 miles from the mouth of the Rogue River, provide a view of this species' abundance over a thirty-two year period (ODFW 2016a). The time series data from Huntley Park indicate that populations in the Rogue River have declined since the 2005 status review (Good et al. 2005; NMFS 2011b). The time series from the Rogue Basin show recent negative trends, although the trend is not considered to be statistically significant (NMFS 2011b).

Recent returns of naturally-produced adults to the Rogue, Trinity, Shasta, and Scott rivers have been highly variable. Wild coho salmon estimates derived from the beach seine surveys at Huntley Park on the Rogue River ranged from 414 to 24,481 naturally produced adults between 2003 and 2012 (Table 58). Similar fluctuation are noted in the Trinity, Shasta, and Scott river populations. Overall, the average annual abundance, for populations where we have abundance data, of naturally produced fish is only 5,586. However, abundance data is lacking for the Eel, Smith, and Chetco rivers, the other major populations in the ESU, as well as the numerous smaller coastal populations. Actual abundance is therefore likely to be higher than this estimate.

Table 58. Estimates of the Natural and Hatchery Adult Coho Returning to the Rogue, Trinity, and Klamath rivers (ODFW 2016a, Kier et al 2015, CDFW 2012).

YEAR	Rogue River		Trinity River		Klamath River		
					Shasta [a]	Scott [a]	Salmon
	Hatchery	Natural	Hatchery	Natural	Natural	Total	Natural
2008	158	414	3,851	944	30	62	
2009	518	2,566	2,439	542	9	81	
2010	753	3,073	2,863	658	44	927	
2011	1,156	3,917	9,009	1,178	62	355	
2012	1,423	5,440	8,662	1,761		201	
2013	1,999	11,210	11,177	4,097			
2014	829	2,409	8,712	917			
Average [b]	1,417	6,353	9,517	2,258	38	357	50 [c]

[a] Hatchery proportion unknown, but assumed to be low.
[b] 3-year average of most recent years of data.
[c] Annual returns of adults are likely less than 50 per year (NMFS 2012).

While we currently lack data on naturally-produced juvenile coho salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. Quinn (2005) published estimates for salmonids in which average fecundity for coho salmon is 2,878 eggs per female. By applying the average fecundity of 2,878 eggs per female to the estimated 9,995 females returning (half of the average total number of spawners), approximately 28 million eggs may be expected to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around 7%. Thus, we can state that the ESU could produce roughly 2 million juvenile natural SONCC coho salmon each year. In addition, hatchery managers could produce approximately 775,000 listed hatchery juvenile coho each year (Table 59).

Table 59. SONCC Coho Salmon Listed Hatchery Stock Annual Juvenile Production Goals (ODFW 2010f;California HSRG 2012).

Artificial propagation program	Location (State)	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clipped
Cole Rivers Hatchery (ODFW stock #52)	Rogue River (Oregon)	0	200,000
Trinity River Hatchery	Trinity River (California)	500,000	N/A
Iron Gate Hatchery	Klamath River (California)	75,000	N/A

The productivity of a population (i.e., production over the entire life cycle) can reflect conditions (e.g., environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany et al. 2000). In general, declining productivity equates to declining population abundance. As discussed above in the population abundance section, available data indicates that many populations have declined, which reflects a declining productivity. For instance, the Shasta River population has declined in abundance by almost 50 percent from one generation to the next (Williams et al. 2011 and NMFS 2012). Two partial counts from Prairie Creek, a tributary of Redwood Creek, and Freshwater Creek, a tributary of Humboldt Bay indicate a negative trend (NMFS 2012). Data from the Rogue River basin also show recent negative trends. In general, SONCC coho salmon have declined substantially from historic levels. Because productivity appears to be negative for most, if not all SONCC coho salmon populations, this ESU is not currently viable in regard to population productivity.

Limiting Factors

Harvest impacts include mark-selective (hatchery) coho fisheries and Chinook-directed fisheries in Oregon and non-retention impacts in California. California has prohibited coho salmon-directed fisheries and coho salmon retention in the ocean since 1996. The Rogue/Klamath coho salmon ocean exploitation rate averaged 6% from 2000–2007 before declining to 1% and 3% in 2008 and 2009, respectively, due to closure of nearly all salmon fisheries south of Cape Falcon, Oregon. For 2010, the forecasted rate was 10% (PFMC 2010) primarily due to the resumption of recreational fishing off California and Oregon.

Tribal harvest is not considered to be a major threat. Estimates of the harvest rate for the Yurok fishery averaged 4% from 1992–2005 and 5% from 2006–2009 (Williams 2010). We do not have harvest rate estimates for the other two tribal fisheries.

Recreational harvest of SONCC coho salmon has not been allowed since 1994, with the exception being a mark-selective recreational coho salmon fishery that has taken place in recent years in the Rogue River and Oregon coastal waters. The PFMC (2007) estimated that 3.3% of Rogue/Klamath coho salmon accidentally caught in this mark-selective fishery would die on release. However, no recent assessments of coho salmon bycatch have occurred in Oregon or California. Overall, the threat to the SONCC coho salmon ESU from recreational fishing is unknown, but is likely to be a factor for decline (NMFS 2011c).

Recent studies have raised concerns about the potential impacts of hatchery fish predation on natural coho salmon populations. Hatchery fish can exert predation pressure on juvenile coho salmon in certain watersheds. Released at larger sizes than naturally produced juveniles and in great quantity, hatchery-reared salmonids will often prey on naturally-produced juvenile coho (Kostow 2009). There is evidence that predation by hatchery fish may result in the loss of tens of thousands of naturally produced coho salmon fry annually in some areas of the Trinity River (Naman 2008).

The Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventories Project, started in 1990, and the Oregon Plan Habitat Survey, begun in 1998, randomly surveyed streams for both summer and winter habitat. In addition to characterizing a site's streamside and upland processes, the surveys detailed specific attributes such as large wood, pools, riparian structure, and substrate. It established the following benchmark thresholds as indicators of habitat quality: (1) pool area greater than 35% of total habitat area; (2) fine sediments in riffle units less than 12% of all sediments; (3) volume of large woody debris greater than 20 m3 per 100-m stream length; (4) shade greater than 70%; and (5) large riparian conifers more than 150 trees per 305-m stream length.

For the combined 1998–2000 surveys in the Oregon portion of the SONCC ESU, 6% of sites surveyed met none of the benchmarks, 29% met one, 38% met two, 20% met three, 5% met four, and 2% met all five benchmarks. No trends in habitat condition can yet be assessed from these data, but they are being developed and will eventually be used to assess changes in habitat quality (Good et al. 2005). It is likely that human demands for natural resources in southern Oregon will increase, and thereby continue to negatively affect SONCC coho critical habitat.

Status Summary

The Good et al. (2005) review concluded that the SONCC coho salmon ESU was likely to become endangered. Since that review, the apparent negative trends across the ESU are of great concern as is the lack of information necessary to determine if there has been a substantial improvement in freshwater habitat and survival. However, these recent negative trends must be considered in the context of the apparent extremely low marine survival rates over the past five years that most likely contributed to the observed declines. Overall, this new information, while cause for concern, does not appear to indicate there has been a change in biological extinction risk since the last status review. There has been no recent improvement in the species' spatial structure or diversity. Habitat already in poor condition is likely to deteriorate with increasing human demands for natural resources. Abundance, productivity, diversity, and habitat conditions need to improve before this ESU can recover.

2.2.2.17 California Coastal Chinook Salmon

Description and Geographic Range

On September 16, 1999, NMFS listed naturally spawned CC Chinook salmon as a threatened species (64 FR 50394). The listing status has been reaffirmed in two subsequent status reviews (Good et al. 2005, Williams et al. 2011) This listing noted that artificially propagated populations of this ESU are not considered part of this listing. Historically there were seven artificial propagation programs for CC Chinook salmon, however all seven programs were terminated prior to 2011 (Williams et al. 2011). The 2005 Biological Review Team (BRT) concluded that the CC Chinook salmon ESU is likely to become endangered (Good et al. 2005). Widespread declines in abundance and the present distribution of small populations with sometimes sporadic occurrences contribute to the risks faced in this ESU. The BRT is concerned about the paucity of information and resultant uncertainty associated with estimates of abundance, natural productivity, and distribution of Chinook salmon in this ESU (Good et al. 2005). NMFS promulgated 4(d) protective regulations for CC Chinook salmon on January 9, 2002 (67 FR 1116), and the 4(d) protective regulations were amended on June 28, 2005 (70 FR 37160).

The CC Chinook salmon ESU includes all naturally spawned populations of Chinook salmon in rivers and streams from Redwood Creek (Humboldt County) south to the Russian River (Sonoma county), inclusive. The extant ESU consists of only a fall-run life history type (Good et al. 2005).

Spatial Structure and Diversity

Bjorkstedt et al. (2005) concluded that the CC Chinook salmon ESU was historically composed of approximately 32 Chinook salmon populations. However, various status reviews have noted that many of these populations (14 to 17) were independent, or potentially independent, meaning they had a high likelihood of surviving for 100 years absent anthropogenic impacts, with the remaining populations being likely dependent on the existence of nearby populations in order to persist (Bjorkstedt et al. 2005, Good et al. 2005, Spence et al. 2008, Williams et al. 2011). Table 60 lists the historical CC Chinook functionally and potentially independent populations (Bjorkstedt et al. 2005). Spence et al. (2008) concluded that the CC Chinook salmon ESU historically supported 16 Independent populations of fall-run Chinook salmon (11 Functionally Independent and five potentially Independent), six populations of spring-run Chinook, and an unknown number of dependent populations. However, based on the data available, eight of the 16 populations were classified as data deficient, one population (Mattole River) was classified as being at a Moderate/High risk of extirpation, and six populations (Ten Mile River, Noyo River, Big River, Navarro River, Garcia River, and Gualala River) were classified as being at a High risk of extirpation. Overall, Spence et al. (2008) concluded that the CC Chinook salmon ESU is at an elevated risk of extirpation, which was consistent with previous status reviews (Myers et al. 1998, Good et al. 2005).

CC Chinook salmon populations remain widely distributed throughout much of the ESU. Notable exceptions include the area between the Navarro River and Russian River and the area between the Mattole and Ten Mile River populations (Lost Coast area). The lack of Chinook salmon populations both north and south of the Russian River (the Russian River is at the southern end of the species' range) makes it one of the most isolated populations in the ESU. Myers et al. (1998) reports no viable populations of Chinook salmon south of San Francisco, California.

Because of their prized status in the sport and commercial fishing industries, CC Chinook salmon have been the subject of many artificial production efforts, including out-of-basin and out-of-ESU stock transfers (Bjorkstedt et al. 2005). It is therefore likely that CC Chinook salmon genetic diversity has been adversely affected despite the relatively wide distribution of populations in the ESU. An apparent loss of the spring-run Chinook life history in the Eel River Basin and elsewhere in the ESU also indicates risks to the diversity of the ESU.

Table 60. Historical CC Chinook Functionally and Potentially Independent Populations (Bjorkstedt et al. 2005).

Population Groups	Run	Populations
Northern Mountain Interior	Fall	Lower Eel River, Van Duzen River, Upper Eel River, North Fork Eel River, Middle Fork Eel River
	Spring	Redwood Creek, Mad River, Van Duzen River, North Fork Eel River, Middle Fork Eel River, Upper Fork Eel River
North Coastal	Fall	Redwood Creek, Little River, Mad River, Humboldt Bay, Lower Eel River, South Fork Eel River, Bear River, Mattole River
North-Central Coastal	Fall	Ten Mile River, Noyo River, Big River
Central Coastal	Fall	Navarro River, Garcia River, Gualala River, Russian River

Abundance and Productivity

Historic data on CC Chinook abundance are sparse and of varying quality (Bjorkstedt et al. 2005). No estimates of absolute abundance are available for any population in this ESU (Myers et al. 1998). In 1965, CDFG (1965) estimated escapement for this ESU at over 76,000. Most were in the Eel River (55,500), with smaller populations in Redwood Creek (5,000), Mad River (5,000), Mattole River (5,000), Russian River (500) and several smaller streams in Humboldt County (Myers et al. 1998).

Williams et al. (2011) indicated that a lack of population-level estimates of abundance for CC Chinook salmon populations continued. The available data evaluated by Williams et al (2011), a mixture of partial population estimates and spawner/redd indexes showed somewhat mixed patterns, with few of the trends being statistically significant, and significant trends were not consistent in direction (Williams et al. 2011). Williams et al. (2011) did not find evidence of a substantial change in the status of the CC Chinook ESU since the previous status review (Good et al. 2005). However, they noted the deleterious loss of representation from one diversity stratum, the loss of the spring-run life history type, and the diminished connectivity between populations in the northern and southern half of the ESU.

Although there is limited population-level estimates of abundance for CC Chinook salmon populations, Table 61 summarizes the information that is available for the major watersheds in the ESU. Based on this limited information, the current average run size for CC Chinook ESU is 7,034 adults (Table 61). While we currently lack data on naturally-produced juvenile CC Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. Juvenile CC Chinook salmon population abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Average fecundity for female CC Chinook is not available. However, Healey and Heard (1984) indicates that average fecundity for Chinook salmon in the nearby Klamath River is 3,634 eggs for female. By applying an average fecundity of 3,634 eggs per female to the estimated 3,517 females returning (half of the average total number of spawners), and applying an estimated survival rate from egg to smolt of 10 percent, the ESU could produce roughly 1,278,078 natural outmigrants annually.

Table 61. Abundance Geometric Means for Adult CC Chinook Salmon Natural-origin Spawners (Metheny and Duffy 2014, PFMC 2013, Ricker et al. 2014, http://www.pottervalleywater.org/van_arsdale_fish_counts.html, Mattole Salmon Group 2011, http://www.scwa.ca.gov/chinook/).

Population	Years	Spawners	Expected Number of Outmigrants[ab]
Redwood Creek	2009-2013	1,745	317,067
Mad River	2010-2015	71	12,900
Freshwater Creek	2010-2015	6	1,090
Eel River mainstem	2010-2015	1,198	217,677
Eel River (Tomki Creek)	2010-2015	70	12,719
Eel River (Sproul Creek)	2010-2015	103	18,715
Mattole River	2007-2009, 2012, 2013	648	117,742
Russian River	2009 - 2014	3,137	569,993
Ten Mile River	2009 - 2014	6	1,090
Noyo River	2009 - 2014	14	2,544
Big River	2009 - 2014	13	2,362
Albion River	2009 - 2014	15	2,726
Navarro River	2009 - 2014	3	545
Garcia River	2009 - 2014	5	909
Total		**7,034**	**1,278,078**

[a] Expected number of outmigrants=Total spawners*50% proportion of females*3,634 eggs per female*10% survival rate from egg to outmigrant.

[b] Based upon number of natural-origin spawners.

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; and (4) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Threats and Limiting Factors

Many stressors and threats have contributed to the decline in CC Chinook salmon populations, including: (1) logging and road construction, (2) estuarine alteration, (3) dams and barriers, (4) climate change, (5) urbanization and agriculture, (6) gravel mining, (7) alien species, and (8) hatcheries (Moyle et al. 2008). Logging and associated stream crossing roads have altered the substrate composition, increased the sediment load, and reduced riparian cover, resulting in abiotic conditions that did not promote juvenile salmonid growth or survival. Estuaries at the mouths of Redwood Creek, Humboldt Bay tributaries, and the Eel River have lost complexity and habitat as a result of draining and diking (Moyle et al. 2008).

Dams on the Mad, Eel, and Russian, including an interbasin transfer of Eel River flows into the Russian river, have diminished downstream habitats through altered flow regimes and gravel recruitment (Moyle et al. 2008). Urbanization and agriculture occurring low in many of these watersheds result in degraded water quality from urban pollution and agricultural runoff. Gravel mining in the Mad, Eel, Van Duzen, Russian River, and Redwood Creek has created barriers to migration, stranding of adults, and promoted spawning in locations that do not maintain flows for incubation (Moyle et al. 2008). Alien fish predators, most notably Sacramento Pikeminnow, which are native to the Russian River but were introduced to the Eel River, are likely suppressing salmon populations in the Eel and other rivers (Moyle et al. 2008). Finally, several small hatchery operations historically produced and released CC Chinook salmon without monitoring the effects of hatchery releases on wild spawners (Moyle et al. 2008).

Status Summary

Using an updated analysis approach, Williams et al. (2011) did not find evidence of a substantial change in conditions since the last status review (Good et al. 2005). Williams et al.'s (2011) analysis found that the loss of representation from one diversity stratum, the loss of the spring-run history type in two diversity substrata, and the diminished connectivity between populations in the northern and southern half of the ESU pose a concern regarding viability for this ESU. Based on consideration of this updated information, Williams et al. (2011) concluded the extinction risk of the CC Chinook salmon ESU has not changed since the last status review. On August 15, 2011, NMFS affirmed no change to the determination that the CC Chinook salmon ESU is a threatened species, as previously listed (NMFS 2011d, 76 FR 50447). A status review is currently near completion.

2.2.2.18 Northern California Steelhead

Description and Geographic Range

On June 7, 2000, NMFS listed NC steelhead—both natural and some artificially-propagated fish—as a threatened species (65 FR 36074). NMFS concluded that the NC steelhead DPS was likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. Two artificial propagation programs were listed as part of the DPS—Yager Creek and North Fork Gualala River/Gualala River steelhead Project winter-run steelhead hatchery stocks; but both programs were terminated in the mid-2000's (NMFS 2007). NMFS promulgated 4(d) protective regulations for NC steelhead on January 5, 2006 (71 FR 834). The section 4(d) protections (and limits on them) apply to natural NC steelhead.

The DPS includes all naturally spawned populations of steelhead in rivers and streams from Redwood Creek (Humboldt County) south to the Gualala River (Mendocino County). Extant summer-run populations are found in Redwood Creek, Mad River, Eel River (Middle Fork), and Mattole River. The Central California Coast steelhead DPS begins at the Russian River and extends south to Aptos Creek. This leaves several *O. mykiss* populations in small watersheds between the Gualala and Russian rivers that are not currently assigned to either DPS. The NC steelhead DPS is comprised of both winter- and summer-run steelhead populations.

Spatial Structure and Diversity

Bjorkstedt et al. (2005) concluded that the NC steelhead DPS historically comprised 42 independent populations of winter-run steelhead (19 functionally independent and 23 potentially independent), and as many as 10 independent populations (all functionally independent) of summer-run steelhead. In addition, this DPS likely contained a minimum of 65 (and likely more) dependent populations of winter-run steelhead in smaller coastal watersheds, as well as small tributaries to the Eel River. Table 62 lists the historical NC steelhead independent populations, many of which are assumed to be extant (NMFS 2011a).

Table 62. Historical NC Steelhead Independent Populations (NMFS 2011a).

Population Groups	Run	Populations
Northern Coastal	Summer	Mad River (lower), Mattole River, Redwood Creek (lower), South Fork Eel River
	Winter	Humboldt Bay, Little River, Mattole River, Redwood Creek (lower), South Fork Eel River
Lower Interior	Winter	Woodman Creek, Chamise Creek, Tomki Creek, Outlet Creek
Northern Mountain Interior	Summer	Mad River (upper), Redwood Creek (upper), Upper Mid-mainstem Van Duzen Creek
	Winter	Larabee Creek, Middle Fork Eel River, North Fork Eel River, Redwood Creek (upper), Van Duzen Creek
North-Central Coastal	Winter	Big River, Caspar Creek, Noyo River, Ten Mile River, Usal Creek, Wages Creek
Central Coastal	Winter	Garcia River, Gualala River, Navarro River

Abundance and Productivity

Short- and long-term trends have been calculated for a few rivers in this DPS (Table 63). Abundance trends for Little River have been significantly negative with the annual abundance having not been above 20 during the past decade (Gallagher and Wright 2009, 2011, and 2012, Williams et al. 2011, Gallagher et al. 2013). In Redwood Creek, dive surveys have been conducted annually since 1981. The recent (16-year) trend has been positive ($p = 0.029$); however, the critically low abundance overshadows this recent trend (Williams et al. 2011). For the Upper Eel River, abundance data is gathered from the Van Arsdale Fish Station. The short-term trend for the upper Eel River is positive, but there were no significant trends for the other three rivers; Freshwater Creek, South Fork (SF) Noyo River, and Gualala River (Williams et al. 2011).

Table 63. Short- and Long-term Trends in NC Steelhead Abundance Based on Partial Population Estimates and Population Indices. Trends in Bold are Significantly Different from 0 at α=0.05 (Williams et al. 2011).

Stratum	Population (run)	Short-term Trend (95 percent CI)	Long-term Trend (95 percent CI)
Northern Coastal	Freshwater Creek (winter)	-0.046 (-0.245, 0.153)	-
	Little River (winter)	**-0.231** (-0.418, -0.043)	
	Redwood Creek (summer)	**0.093** (0.011, 0.175)	-0.012 (-0.054, 0.029)
North Mountain-Interior	Upper Eel River (winter)	**0.062** (0.001, 0.123)	-
North-Central Coastal	SF Noyo River (winter)	0.004 (-0.115, 0.123)	-
Central Coast	Gualala River, Wheatfield Fork (winter)	0.000 (-0.361, 0.361)	-

From these studies, we estimate that the NC steelhead DPS has an annual abundance of 7,221 adults (Table 64).

Table 64. Geometric Mean Abundances of NC Steelhead Spawners by Population (Gallagher and Wright 2009, 2011, and 2012; Gallagher et al. 2013, Mattole Salmon Group 2011, Duffy 2011, Counts at Van Arsdale Fisheries Station (http://www.pottervalleywater.org/files/VAFS_fish_counts.csv), Harris and Thompson 2014, De Haven 2010, Metheny and Duffy 2014, Ricker et al. 2014, additional unpublished data provided by the NMFS SWFSC)

Stratum	Waterbody	Run	Years	Abundance	Expected Number of Outmigrants[a]

Northern Coastal	**Elk Creek**	**Winter**	2011, 2014	13	1,479
	Little River	**Winter**	2010-2014	10	1,138
	Mattole River	**Winter**	2012-2013	558	63,473
	Mattole River	**Summer**	2011-2015	92	10,465
	Redwood Creek	**Winter**	2010-2013	610	69,388
	Redwood Creek	**Summer**	2010-2014	7	796
	Prairie Creek	**Winter**	2007, 2008, 2010-2012	22	2,503
	Humboldt Bay	**Winter**	2011-2014	52	5,915
	Freshwater Creek	**Winter**	2010-2014	102	11,603
North Mountain-Interior	**Eel River**	**Winter**	2011-2015	389	44,249
	South Fork Eel River	**Winter**	2011-2014	574	65,293
	Van Duzen River	**Summer**	2011-2015	115	13,081
	Middle Fork Eel River	**Summer**	2010-2014	796	90,545
North-Central Coastal	**Big River**	**Winter**	2010-2014	465	52,894
	Caspar Creek	**Winter**	2010-2014	31	3,526
	Cottoneva Creek	**Winter**	2010, 2012, 2014	83	9,441
	Hare Creek	**Winter**	2010-2014	2	228
	Juan Creek	**Winter**	2012	39	4,436
	Noyo River	**Winter**	2010-2014	442	50,278
	SF Noyo River	**Winter**	2010-2014	79	8,986
	Pudding Creek	**Winter**	2010-2014	34	3,868
	Ten Mile River	**Winter**	2010-2014	382	43,453
	Usal Creek	**Winter**	2010-2013	54	6,143
	Wages Creek	**Winter**	2010, 2011, 2014	55	6,256
Central Coastal	**Albion River**	**Winter**	2010-2014	45	5,119
	Big Salmon Creek	**Winter**	2012-2013	84	9,555
	Brush Creek	**Winter**	2010-2014	6	683
	Garcia River	**Winter**	2010-2014	340	38,675
	Gualala River	**Winter**	2006-2010	1,066	121,258
	Navarro River	**Winter**	2010-2014	332	37,765
	North Fork Navarro River	**Winter**	2013-2014	342	38,903
Total				**7,221**	**821,389**

[a] Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile NC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile NC steelhead abundance estimates come from the escapement data (Table 64). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 3,611 females), 12.6 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 821,389 natural outmigrants annually (Table 64).

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Threats and Limiting Factors

Many factors and threats have contributed to the decline of NC steelhead, including: (1) dams and other barriers, (2) logging, (3) agriculture, (4) ranching, (5) fisheries, and (6) hatcheries. Two of the largest rivers, Eel and Mad rivers, in the DPS are dammed. Scott Dam blocks 90 percent of the habitat on the Upper Eel River and reduces the flows into the mainstem Eel River. Ruth Dam block 36 percent of potential steelhead habitat in Mad River. Elsewhere throughout the DPS, culverts and bridges create impassable barriers (Moyle et al. 2008). Logging throughout the region has increased stream sedimentation and temperatures, reduced canopy cover, destroyed instream habitat, and altered flow timing and volume (Moyle et al. 2008). Agriculture and ranching land practices can lead to destabilized and denuded stream banks, stream channelization, large woody debris removal, increased sedimentation, and water pollution (Spence et al. 1996, Moyle et al. 2008). Though fishery take on NC steelhead is prohibited, hatcheries produce steelhead for the fishery resulting in incidental captures of and competition with natural-origin steelhead (Moyle et al. 2008). Other threats to NC steelhead include gravel extraction, streambed alteration, predation from introduced species (i.e. Sacramento pikeminnow), poaching, and human disturbance (Moyle et al. 2008).

Status Summary

In summary, Williams et al. (2011) found little new evidence to suggest that the status of the NC Steelhead DPS has changed appreciably in either direction since publication of the last status review (Good et al. 2005). One major concern is the persistence of the summer-run steelhead, for only the Middle Fork Eel River population appears viable (Moyle et al. 2008). The winter-run of this DPS appears in better condition, but needs to have some of its limiting factors addressed to recover. Another concern is the loss of smaller populations that could lead to isolation and loss of larger populations (Moyle et al. 2008).

2.2.2.19 Central California Coast Steelhead

Description and Geographic Range

On August 18, 1997, NMFS listed CCC steelhead—both natural and some artificially-propagated fish—as a threatened species (62 FR 43937). NMFS concluded that the CCC steelhead DPS was likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. Two artificial propagation programs were listed as part of the DPS—Scott Creek/Kingfisher Flat Hatchery (includes San Lorenzo River production) and Don Clausen Fish Hatchery (includes Coyote Valley Fish Facility production) winter-run steelhead hatchery stocks (Table 65). NMFS promulgated updated 4(d) protective regulations for CCC steelhead on January 5, 2006 (71 FR 834). The section 4(d) protections (and limits on them) apply to natural and hatchery CCC steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

The CCC steelhead DPS includes winter-run steelhead populations from the Russian River (Sonoma County) south to Aptos Creek (Santa Cruz County) inclusive and eastward to Chipps Island (confluence of the Sacramento and San Joaquin rivers) and including all drainages of San Francisco, San Pablo, and Suisun bays.

Table 65. Approximate annual releases of hatchery CCC steelhead (J. Jahn, pers. comm., July 2, 2013).

Artificial propagation program	Adipose Fin-Clipped
Scott Creek/Kingfisher Flat Hatchery	3,220
San Lorenzo River	19,125
Don Clausen Fish Hatchery	380,338
Coyote Valley Fish Facility	246,208
Total Annual Release Number	648,891

Spatial Structure and Diversity

Bjorkstedt et al. (2005) concluded that the CCC steelhead DPS historically comprised 37 independent populations (11 functionally independent and 26 potentially independent) and perhaps 30 or more dependent populations of winter-run steelhead (Table 66). These populations were placed in five geographically based diversity strata (Bjorkstedt et al. 2005;

modified in Spence et al. 2008). Most of the coastal populations are assumed to be extant, however many of the Coastal San Francisco Bay and Interior San Francisco Bay populations are likely at high risk of extirpation due to the loss of historical spawning habitat and the heavily urbanized nature of these watersheds (Williams et al. 2011).

Table 66. Historical CCC Steelhead Populations (NMFS 2011a).

Diversity Strata	Populations
North Coastal	Austin Creek, Salmon Creek, Walker Creek, Lagunitas Creek, Green Valley Creek
Interior	Dry Creek, Maacama Creek, Mark West Creek, Upper Russian River
Santa Cruz Mountains	Aptos Creek, Pescadero Creek, Pilarcitos Creek, San Lorenzo Creek, San Gregorio Creek, Scott Creek, Soquel Creek, Waddell Creek
Coastal San Francisco Bay	Corte Madera Creek, Guadalupe River, Miller Creek, Novato Creek, San Francisquito Creek
Interior San Francisco Bay	Alameda Creek, Coyote Creek, Napa River, Petaluma River, San Leandro Creek, San Lorenzo Creek

Abundance and Productivity

Historic CCC steelhead abundance is unknown. In the mid-1960's, CDFG estimated CCC steelhead abundance at 94,000 fish (CDFG 1965). The CDFG estimate, however, is just a midpoint number in the CCC steelhead's abundance decline—at the point the estimate was made, there had already been a century of commercial harvest and urbanization. Current CCC steelhead abundance is still not well known. Multiple short-term studies using different methodologies have occurred over the past decade.

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile CCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCC steelhead abundance estimates come from the escapement data (Table 67). All returnees to the hatcheries do not contribute to the natural population and are not used in this calculation. For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of natural-origin spawners – 1,094 females), 3.8 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 248,771 natural outmigrants annually (Table 67).

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Table 67. Geometric Mean Abundances of CCC Steelhead Spawners Escapements by Population (Ettlinger et al. 2012, Jankovitz 2013, Source: http://marinwater.org/documents/1_WalkerCreekReportandRefs_March2010.pdf, Natural abundance: Manning and Martini-Lamb (ed.) 2012; Hatchery abundance source: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=44269&inline=true, Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoU%3D&tabid=1772, Atkinson 2010, Williams et al. 2011, Koehler and Blank 2012, additional unpublished data provided by the NMFS SWFSC).

			Abundance		
Stratum	Waterbody	Years	Natural Origin	Hatchery Origin	Expected Number of Outmigrants[ab]
Northern Coastal	Austin Creek	2010-2012	63	-	7,166
	Lagunitas Creek	2009-2013	71	-	8,076
	Pine Gulch Creek	2010-2014	37		4,209
	Redwood Creek	2010-2014	18		2,048
	Walker Creek	2007-2010	29	-	3,299
Interior	Dry Creek	2011-2012	33	-	3,754
	Russian River	2008-2012	230	3,451	26,163
Santa Cruz Mountains	Aptos Creek	2007-2011	249	-	28,324
	Pescadero	2013-2015	361	-	41,064
	Gazos Creek	2013-2015	30	-	3,413
	Waddell Creek	2013-2014	73	-	8,304
	San Gregorio Creek	2014-2015	135	-	15,356
	San Lorenzo Creek	2013-2015	423	319	48,116
	San Pedro Creek	2013	38		4,323
	San Vicente Creek	2013-2015	35		3,981
	Scott Creek	2011-2015	120	96	13,650
	Soquel Creek	2007-2011	230	-	26,163
Central Coastal	Napa River	2009-2012	12	-	1,365
		Totals	2,187	3,866	248,771

[a] Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant

[b] Based upon natural-origin spawner numbers

CCC steelhead have experienced serious declines in abundance, and long-term population trends suggest a negative growth rate (Good et al. 2005). This indicates the DPS may not be viable in the long term. DPS populations that historically provided enough steelhead strays to support dependent populations may no longer be able to do so, placing dependent populations at increased risk of extirpation. However, because CCC steelhead have maintained a wide distribution throughout the DPS, roughly approximating the known historical distribution, CCC steelhead likely possess a resilience that is likely to slow their decline relative to other salmonid species in worse condition (*e.g.*, CCC coho salmon).

Current abundance trend data for the CCC steelhead remains extremely limited. Only the Scott Creek population provides enough of a time series to examine trends, and this population is influenced by hatchery origin fish. Natural-origin spawners have experienced a significant downward trend (slope = -0.220; p = 0.036) (Williams et al. 2011). Since we only have trend information on Scott Creek, trends for the majority of the DPS is unknown although most of the populations are presumed to be extant.

Threats and Limiting Factors

Several factors and threats have contributed to the decline of CCC steelhead. Moyle et al. (2008) summarized these into four broad categories: (1) dams and other barriers, (2) stream habitat degradation, (3) estuarine habitat degradation, and (4) hatcheries. For the DPS, an estimated 22 percent of the historical habitat is currently blocked by man-made barriers (Good et al. 2005). Besides blocking the upstream migration of steelhead, these barriers often change the characteristics of the stream by decreasing peak flows and changing water temperatures making them unfavorable for steelhead (Moyle et al. 2008). Stream habitat has been degraded by urbanization, agriculture (i.e. vineyards), road building, logging, mining, sewage discharge, and other actions (Moyle et al. 2008). The Russian River (one of the most productive steelhead streams in the DPS) is listed as an impaired water body by the federal Clean Water Act due to high fecal pathogens, excessive sediment loads, and mercury pollution (Source: http://www.waterboards.ca.gov/northcoast/water_issues/programs/tmdls/russian_river/). Excessive sediment loads and encroachment degrade estuary habitat by urbanization and agriculture (Moyle et al. 2008). Other limiting factors include pollution, gravel mining, fisheries, floodplain connectivity, lack of large woody debris, predation, and competition (Moyle et al. 2008).

Status Summary

In summary, Williams et al. (2011) found little new evidence to suggest that the status of the DPS has changed appreciably in either direction since publication of the last status review (Good et al. 2005). The scarcity of information on CCC steelhead abundance makes it difficult to assess whether conditions have changed appreciably (Williams et al. 2011). The high numbers of hatchery fish in the Russian River suggest that risks associated with hatchery production are a significant concern (Williams et al. 2011). The status of populations in the two San Francisco Bay strata is likewise highly uncertain, though many populations, particularly those where historical habitat is now inaccessible, are likely at high risk of extirpation (Williams et al. 2011). A status review is currently underway and is nearing completion.

2.2.2.20 Central Valley Spring-run Chinook Salmon

Description and Geographic Range

CVS Chinook salmon were originally listed as threatened on September 16, 1999 (64 FR 50394), and was reconfirmed on June 28, 2005 (70 FR 37160). This ESU consists of spring-run Chinook salmon occurring in the Sacramento and San Joaquin rivers and their tributaries. The Feather River Fish Hatchery (FRFH) spring-run Chinook salmon population has been included as part of the CVS Chinook salmon ESU. The San Joaquin component of the ESU, previously extirpated, has been reintroduced and designated as a nonessential experimental population (NEP) under Section 10(j) of the ESA. Although FRFH spring-run Chinook salmon production is included in the ESU, these fish do not have a section 9 take prohibition since they are all adipose fin clipped. Between 2009 and 2013, the Feather River hatchery released an average of 2,178,601 juvenile adipose clipped CVS Chinook salmon in the Sacramento basin (Table 68). The Feather River hatchery also released 60,114 experimental CVS Chinook salmon juveniles to the San Joaquin River just above the confluence with the Merced River in 2014 (NMFS 2015), and 54,000 experimental juveniles in 2015 (SJRRP 2015). In addition, the Feather River hatchery plans to release an annual average of 354,375 smolts in the San Joaquin Basin between 2016 and 2020, with 151,875 releases occurring in 2017 (Table 69, NMFS 2016).

Table 68. Average CVS Chinook salmon smolt release in the Sacramento Basin (Regional Mark Processing Center 2014).

Artificial propagation program	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Feather River Hatchery	Spring	2,178,601	-
Total		2,178,601	

Table 69. Projected juvenile releases and broodstock source population for the San Jaoquin River experimental population (NMFS 2016).

Brood Year of Collected Donor Stock	Offspring Release Year	Expected Number of Juveniles Released
2012	2016	120,000
2013	2017	151,875
2014	2018	200,000
2015	2019	600,000
2016	2020	700,000

In August 2011, NMFS completed an updated status review of five Pacific Salmon ESUs, including CVS Chinook salmon, and concluded that the species' status should remain as previously listed (76 FR 50447). The 2011 Status Review (NMFS 2011a) additionally stated that although the listings will remain unchanged since the 2005 review, and the original 1999 listing (64 FR 50394), the status of these populations has worsened over the past five years and recommended that the status be reassessed in two to three years as opposed to waiting another five years. The recommended two to three year reassessment did not occur, but a 5-year status review was completed in 2015.

Spring-run Chinook salmon spawning occurs in September and October (Moyle 2002). Chinook salmon typically mature between 2 and 6 years of age (Myers et al. 1998), but primarily at age 3 (Fisher 1994). Between 56 and 87 percent of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins et al. 1940, Fisher 1994); spring-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months.

Spatial Structure and Diversity

The Central Valley Technical Review Team estimated that historically there were 18 or 19 independent populations of CVS Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Lindley et al. 2004). Of these 18 populations, only three populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group (Table 70).

Table 70. Historical Populations of CVS Chinook salmon (adapted from Lindley et al. 2004).

Stratum	Population [1]	Status	Comment
Southern Cascades	Little Sacramento River	*Extirpated*	Blocked by Keswick and Shasta dams
	Pit River/Fall River/Hat Creek	*Extirpated*	Blocked by Keswick and Shasta dams
	McCloud River	*Extirpated*	Blocked by Keswick and Shasta dams
	Battle Creek	*Extirpated*	Hydro operations, water diversions
	Mill Creek	Extant	Either two independent populations or a single panmictic population
	Deer Creek	Extant	
	Butte Creek	Extant	-
	Big Chico Creek	Intermittent	-
	Antelope Creek	Intermittent	-
Coast Range	*Clear Creek*	*Extirpated*	-
	Cottonwood / Beegum creeks	Intermittent	Beegum Creek intermittent, Cottonwood Creek extirpated
	Thomes Creek	*Extirpated*	-
	Stony Creek	*Extirpated*	-
Northern Sierra	West Branch Feather River	*Extirpated*	Blocked by Oroville Dam
	North Fork Feather River	*Extirpated*	Blocked by Oroville Dam
	Middle Fork Feather River	*Extirpated*	Blocked by Oroville Dam

Stratum	Population [1]	Status	Comment
	South Fork Feather River	*Extirpated*	Blocked by Oroville Dam
	Yuba River	*Extirpated*	Blocked by Englebright Dam
	North and Middle Fork American River	*Extirpated*	Blocked by Nimbus Dam
	South Fork American River	*Extirpated*	Blocked by Nimbus Dam
Southern Sierra	Mokelumne River	*Experimental reintroduction*	Blocked by Camanche Dam
	Stanislaus River	*Experimental reintroduction*	Blocked by New Melones and Tulloch dams
	Tuolumne River	*Experimental reintroduction*	Blocked by La Grange and Don Pedro dams
	Merced River	*Experimental reintroduction*	Blocked by McSwain and New Exchequer dams
	Middle and Upper San Joaquin River	*Experimental reintroduction*	Blocked by Friant Dam
	Kings River	*Experimental reintroduction*	Blocked by dry streambeds and Pine Flat Dam

[1] Italicized populations are dependent populations

Additionally, smaller populations are currently persisting in Antelope and Big Chico creeks, and the Feather and Yuba rivers in the northern Sierra Nevada diversity group (CDFG 1998). All historical populations in the basalt and porous lava diversity group and the southern Sierra Nevada diversity group have been extirpated, although Battle Creek in the basalt and porous lava diversity group has had a small persistent population in Battle Creek since 1995, and the upper Sacramento River may have a small persisting population spawning in the mainstem river as well. The northwestern California diversity group did not historically contain independent populations, and currently contains two small persisting populations, in Clear Creek, and Beegum Creek (tributary to Cottonwood Creek) that are likely dependent on the northern Sierra Nevada diversity group populations for their continued existence.

Lindley et al. (2007) found that the Mill Creek, Deer Creek, and Butte Creek populations were at or near low risk of extirpation. The ESU as a whole, however, could not be considered viable because there were no extant populations in the three other diversity groups. In addition, Mill, Deer and Butte creeks are close together, decreasing the independence of their extirpation risks due to catastrophic disturbance (Williams et al. 2011).

Since Lindley et al.'s (2007) assessment, two of the three extant independent populations slipped from low or moderate extirpation risk to high extirpation risk. Butte Creek remains at low risk, although being on the verge of moving towards high risk. Counteracting these developments, Chinook salmon in Battle and Clear creeks have increased in abundance over the last decade, reducing their extirpation risk to moderate. Both populations have increased at least in part due to extensive habitat restoration, although in the case of Clear Creek, it is not yet clear the degree to which hatchery strays have driven this dramatic increase (Williams et al. 2011).

At the ESU level, the reintroduction of spring-run Chinook salmon to Battle Creek and increasing abundance of spring-run Chinook salmon in Clear Creek is benefiting the status of CVS Chinook salmon. Further efforts, such as those underway to get some production in the San Joaquin River below Friant Dam and to facilitate passage above Englebright Dam on the Yuba River, will be needed to make the ESU viable (Williams et al. 2011).

Abundance and Productivity

Historically spring-run Chinook salmon were the second most abundant salmon run in the Central Valley and one of the largest on the west coast (CDFG 1990). These fish occupied the upper and middle elevation reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1872, Rutter 1904, Clark 1929).

The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 – 500,000 adults returning annually (CDFG 1990). Construction of Friant Dam on the San Joaquin River began in 1939, and when completed in 1942, blocked access to all upstream habitat.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CVS Chinook salmon ESU as a whole because these streams contain the majority of the abundance, and are currently the only independent populations in the ESU. Generally, these streams have shown a positive escapement trend since 1995, displaying broad fluctuations in adult abundance, ranging from 4,429 in 2009 to 26,663 in 2001 (Table 71). Escapement numbers are dominated by Butte Creek returns, which averaged over 9,092 fish from 1995 to 2015 (peaking in 1998 at over 20,000 fish and then declined to only 569 in 2015). During this same period, adult returns on Mill and Deer creeks have averaged 674 and 1,076 fish total, respectively. From 2001 to 2005, the CVS Chinook salmon ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good et al. 2005). Although trends were generally positive during this time, annual abundance estimates display a high level of fluctuation, and the overall number of CVS Chinook salmon remained well below estimates of historic abundance.

Table 71. CVS Chinook salmon population estimates from CDFW (2016b) and Feather River Hatchery counts (pers. comm. 2017).

Year	Sacramento River Basin Escapement Run Size	Feather River Hatchery Fish	Feather River Naturally Produced Fish	Tributary Populations
2006	24,059	13,334	4104	10,725
2007	13,084	3,856	5,900	9,228
2008	12,736	861	1,024	11,875
2009	4,572	1,132	333	3,440
2010	6,122	3,160	342	2,962

2011	10,269	4,464	1559	5,805
2012	25,095	6,407	1058	18,688
2013	37,658	18,256	1801	19,402
2014	13,868	6,743	546	7,125
2015	6,391	5,196	159	1,195
5-year Average	18,656	8,213	1,025	10,443

From 2005 through 2011, abundance numbers in most of the tributaries declined. Adult returns from 2006 to 2009, indicate that population abundance for the entire Sacramento River basin is declining from the peaks seen in the five years prior to 2006. Declines in abundance from 2005 to 2011, placed the Mill Creek and Deer Creek populations in the high extirpation risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011c). Butte Creek has sufficient abundance to retain its low extirpation risk classification, but the rate of population decline in years 2006 through 2011 is nearly sufficient to classify it as a high extirpation risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extirpation include, Butte, Deer and Mill creeks (NMFS 2011c). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. Year 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers combined for Butte, Mill and Deer creeks increased (over 17,000), which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1998. However, 2015 appears to be lower with approximately 5,635 fish, which indicates a highly fluctuating and unstable ESU.

From 1993 to 2007 the 5-year moving average of the tributary population Cohort Replacement Rate remained over 1.0, but then declined to a low of 0.47 in years 2007 through 2011 (NMFS 2011c). The productivity of the Feather River and Yuba River populations and contribution to the CVS Chinook salmon ESU is currently unknown, however the FRFH currently produces 2,000,000 juveniles each year. The cohort replacement rate (CRR) for the 2012 combined tributary population was 3.84, and 8.68 in 2013, due to increases in abundance for most populations.

While we currently lack data on naturally-produced juvenile CVS Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. The CDFG (1998) published estimates in which average fecundity of spring-run Chinook salmon is 4,161 eggs per female. By applying the average fecundity of 4,161 eggs per female to the estimated 5,734 females returning (half of the most recent five-year average of spawners), and applying an estimated survival rate from egg to smolt of 10 percent, the Sacramento River basin portion of the ESU could produce roughly 2.4 million natural outmigrants annually. In addition, hatchery managers could produce over two million listed hatchery juvenile CVS Chinook salmon each year for the Sacramento River basin, and are expected to produce several hundreds of thousands of smolts for the experimental San Joaquin River basin (Table 3, Table 4). For the San Joaquin River experimental population, it is possible that some of the experimental hatchery fish released in previous years will return to spawn this year. However, the outmigration and ocean survival rate of that group is unknonwn, so no estimate of their abundance is available. Therefore, an estimate of the abundance of the natural outmigrants those fish could produce is also not available.

Threats and Limiting Factors

Good et al. (2005) found that the CVS Chinook salmon was likely to become endangered with the major concerns being low diversity, poor spatial structure and low abundance. Major factors and threats affecting, or potentially affecting, the CVS Chinook status include: (1) dams, (2) diversions, (3) urbanization and rural development, (4) logging, (5) grazing, (6) agriculture, (7) mining, (8) estuarine alteration, (9) fisheries, (10) hatcheries, and (11) ‘natural’ factors (Moyle et al. 2008). Early reductions occurred with the hydraulic mining, logging, and overfishing of the California gold rush era (Yoshiyama et al. 1998). Currently, dams block access to 90 percent of historic spawning and summer holding areas including all of the San Joaquin River basin, the northern Sacramento River basin, and many central Sierra Nevada streams and basins (Yoshiyama et al. 1998). Besides blocking habitat, dams alter river flow regimes and temperatures. This combined with agriculture and associated water diversions further impacts CVS Chinook salmon habitat (Moyle et al. 2008). For juvenile rearing habitat, the Sacramento River is mostly channelized, the Sacramento/San Joaquin River Delta diked, and the San Francisco estuary greatly modified and degraded, thus reducing developmental opportunities for juvenile salmon (Moyle et al. 2008). MacFarlane and Norton (2002) found that Chinook salmon passing through the San Francisco Estuary grow little and emerge into the ocean in a depleted condition with no accumulation of lipid energy reserves. Whether this is a result of a different evolutionary strategy or the result of an altered estuary, this is different than what is observed in other Chinook populations (MacFarlane and Norton 2002).

Status Summary

The most recent viability assessment of CVS Chinook salmon was conducted during NMFS’ 2011 status review (NMFS 2011c). This review found that the biological status of the ESU had worsened since the last status review (2005) and recommend that its status be reassessed in two to three years as opposed to waiting another five years, if the decreasing trend continues and the ESU does not respond positively to improvements in environmental conditions and management actions. In 2012 and 2013, the combined Mill, Deer, and Butte creek populations have had an increase in returning adults, averaging over 13,000, in contrast to returns in 2006 through 2011 averaging less than 5,000; however, 2015 was again lower, approximately 5,635 fish.

2.2.2.21 California Central Valley Steelhead

Description and Geographic Range

On March 19, 1998, NMFS listed CCV steelhead—both natural and some artificially-propagated fish—as a threatened species (63 FR 13347). NMFS concluded that the CCV steelhead DPS was likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. Two artificial propagation programs were listed as part of the DPS—Coleman National Fish Hatchery and Feather River Hatchery winter-run steelhead hatchery stocks (Table 72).

On January 5, 2006, NMFS reaffirmed the threatened status of the CCV steelhead and applied the DPS policy to the species because the resident and anadromous life forms of *O. mykiss* remain "markedly separated" as a consequence of physical, ecological and behavioral factors, and therefore warranted delineation as a separate DPS and promulgated 4(d) protective regulations for CCV steelhead (71 FR 834). The section 4(d) protections (and limits on them) apply to natural and hatchery CCV steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. On August 15, 2011, NMFS completed another 5-year status review of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (NMFS 2011a).

Table 72. Expected Annual CCV Steelhead Hatchery Releases (CHSRG 2012).

Artificial propagation program	Clipped Adipose Fin
Nimbus Hatchery (American River)	439,490
Feather River Hatchery (Feather River)	273,398
Coleman NFH (Battle Creek)	715,712
Mokelumne River Hatchery (Mokelumne River)	172,053
Total Annual Release Number	1,600,653

The CCV steelhead DPS includes steelhead populations spawning in the Sacramento and San Joaquin rivers and their tributaries.

Spatial Structure and Diversity

About 80 percent of the historical spawning and rearing habitat once used by anadromous *O. mykiss* in the Central Valley is now upstream of impassible dams (Lindley et al. 2006). The extent of habitat loss for steelhead most likely was much higher than that for salmon because steelhead were undoubtedly more extensively distributed. Due to their superior jumping ability, the timing of their upstream migration which coincided with the winter rainy season, and their less restrictive preferences for spawning gravels, steelhead could have utilized at least hundreds of miles of smaller tributaries not accessible to the earlier-spawning salmon (Yoshiyama et al. 1996). Many historical populations of CCV steelhead are entirely above impassable barriers and may persist as resident or adfluvial rainbow trout, although they are presently not considered part of the DPS. Steelhead were found as far south as the Kings River (and possibly Kern River systems in wet years) (McEwan 2001). Native American groups such as the Chunut people have had accounts of steelhead in the Tulare Basin (Latta 1977).

Steelhead are well-distributed throughout the Central Valley below the major rim dams (Good et al. 2005, NMFS 2011b). Zimmerman et al. (2009) used otolith microchemistry to show that *O. mykiss* of anadromous parentage occur in all three major San Joaquin River tributaries, but at low levels, and that these tributaries have a higher percentage of resident *O. mykiss* compared to the Sacramento River and its tributaries.

Monitoring has detected small numbers of steelhead in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer & Associates 2000). A counting weir has been in place in the Stanislaus River since 2002 and in the Tuolumne River since 2009 to detect adult salmon; these weirs have also detected *O. mykiss* passage. In 2012, 15 adult *O. mykiss* were detected passing the Tuolumne River weir and 82 adult *O. mykiss* were detected at the Stanislaus River weir (FISHBIO 2012, FISHBIO 2013a). In addition, rotary screw trap sampling has occurred since 1995 in the Tuolumne River, but only one juvenile *O. mykiss* was caught during the 2012 season (FISHBIO 2013b). Rotary screw traps are well known to be very inefficient at catching steelhead smolts, so the actual numbers of smolts produced in these rivers could be much higher. Rotary screw trapping on the Merced River has occurred since 1999. A fish counting weir was installed on this river in 2012. Since installation, one adult *O. mykiss* has been reported passing the weir. Juvenile *O. mykiss* were not reported captured in the rotary screw traps on the Merced River until 2012, when a total of 381 were caught (FISHBIO 2013c). The unusually high number of *O. mykiss* captured may be attributed to a flashy storm event that rapidly increased flows over a 24 hour period. Annual Kodiak trawl surveys are conducted on the San Joaquin River at Mossdale by CDFW. A total of 17 *O. mykiss* were caught during the 2012 season (CDFW 2013).

The low adult returns to the San Joaquin tributaries and the low numbers of juvenile emigrants typically captured suggest that existing populations of CCV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed. The loss of these populations would severely impact CCV steelhead spatial structure and further challenge the viability of the CCV steelhead DPS.

Efforts to provide passage of salmonids over impassable dams have the potential to increase the spatial diversity of CCV populations if the passage programs are implemented for steelhead. In addition, the San Joaquin River Restoration Program calls for a combination of channel and structural modifications along the San Joaquin River below Friant Dam, releases of water from Friant Dam to the confluence of the Merced River, and the reintroduction of spring-run and fall-run Chinook salmon. If the San Joaquin River Restoration Program is successful, habitat improved for spring-run Chinook salmon could also benefit CCV steelhead (NMFS 2011b).

CCV steelhead abundance and growth rates continue to decline, largely the result of a significant reduction in the amount and diversity of habitats available to these populations (Lindley et al. 2006). Recent reductions in population size are also supported by genetic analysis (Nielsen et al. 2003). (Garza and Pearse 2008), analyzed the genetic relationships among Central Valley steelhead populations and found that unlike the situation in coastal California watersheds, fish below barriers in the Central Valley were often more closely related to below barrier fish from other watersheds than to *O. mykiss* above barriers in the same watershed. This pattern suggests the ancestral genetic structure is still relatively intact above barriers, but may have been altered below barriers by stock transfers.

The genetic diversity of CCV steelhead is also compromised by hatchery origin fish, which likely comprise the majority of the annual spawning runs, placing the natural population at a high risk of extirpation (Lindley et al. 2007). There are four hatcheries (Coleman National Fish Hatchery (CNFH), FRFH, Nimbus Fish Hatchery, and Mokelumne River Fish Hatchery) in the Central Valley which combined release approximately 1.6 million yearling steelhead smolts each year. These programs are intended to mitigate for the loss of steelhead habitat caused by dam construction, but hatchery origin fish now appear to constitute a major proportion of the total abundance in the DPS. Two of these hatchery stocks (Nimbus and Mokelumne River hatcheries) originated from outside the DPS (primarily from the Eel and Mad rivers) and are not presently considered part of the DPS.

Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms, based on their state of sexual maturity at the time of river entry and the duration of their time in freshwater before spawning. Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams (Moyle 2002, McEwan and Jackson 1996). Summer-run steelhead have been extirpated due to a lack of suitable holding and staging habitat, such as cold-water pools in the headwaters of CCV streams, presently located above impassible dams (Lindley et al. 2006).

Abundance and Productivity

Historic CCV steelhead run sizes are difficult to estimate given the paucity of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Hallock et al. (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River upstream of the Feather River. Steelhead counts at the Red Bluff Diversion Dam (RBDD) declined from an average of 11,187 for the period from 1967 to 1977, to an average of approximately 2,000 through the early 1990's, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations, and comprehensive steelhead population monitoring has not taken place in the Central Valley since then, despite 100 percent marking of hatchery steelhead smolts since 1998. Efforts are underway to improve this deficiency, and a long term adult escapement monitoring plan is being planned (Eilers et al. 2010).

Population trend data remain extremely limited for CCV steelhead. Current abundance data is limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data is the most reliable, as redd surveys for steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period. The best population-level trend data come from Battle Creek, where CNFH operates a weir. The 10-year trend is -0.17, placing the population in the high extirpation risk category (Table 73). The percentage of fish passing the weir that were of hatchery origin has been highly variable, ranging from five percent to 70 percent, with an average of 29 percent over the 2002-2010 period. This level of hatchery influence corresponds to a moderate risk of extirpation (Williams et al. 2011).

Table 73. Viability Metrics for CCV Steelhead (Williams et al. 2011).

Population	$\hat{S}$	N	10- year trend (95 percent CI)	Recent Decline (percent)
Battle Creek	469	1,410	-0.17 (-0.29, -0.055)	68
Coleman NFH	1,870	5,610	0.018 (-0.10, 0.14)	6.6
Feather River Hatchery	2,200	6,590	0.10 (-0.64, 0.27)	-

Historic CCV steelhead abundance is unknown. In the mid-1960's, the California Department of Fish and Game (CDFG) (now CDFW) estimated CCV steelhead abundance at 26,750 fish (CDFG 1965). The CDFG estimate, however, is just a midpoint number in the CCV steelhead's abundance decline—at the point the estimate was made, there had already been a century of commercial harvest, dam construction, and urbanization.

An estimated 100,000 to 300,000 naturally produced juvenile steelhead are estimated to leave the Central Valley annually, based on rough calculations from sporadic catches in trawl gear (Good et al. 2005). The Mossdale trawls on the San Joaquin River conducted annually by CDFW and USFWS capture steelhead smolts, although usually in very small numbers. These steelhead recoveries, which represent migrants from the Stanislaus, Tuolumne, and Merced rivers, suggest that the productivity of CCV steelhead in these tributaries is very low. In addition, the Chipps Island midwater trawl dataset from the United States Fish and Wildlife Service (USFWS) provides information on the trend (Williams et al. 2011).

In contrast to the data from Chipps Island and the Central Valley Project and State Water Project fish collection facilities, some populations of wild CCV steelhead appear to be improving (Clear Creek) while others (Battle Creek) appear to be better able to tolerate the recent poor ocean conditions and dry hydrology in the Central Valley compared to hatchery produced fish (NMFS 2011b). Since 2003, fish returning to the CNFH have been identified as wild (adipose fin intact) or hatchery produced (ad-clipped). Returns of wild fish to the hatchery have remained fairly steady at 200-300 fish per year, but represent a small fraction of the overall hatchery returns. Numbers of hatchery origin fish returning to the hatchery have fluctuated much more widely; ranging from 624 to 2,968 fish per year.

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile CCV steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCV steelhead abundance estimates come from the escapement data (Table 74). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 2,771 females), 9.7 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 630,403 naturally produced outmigrants annually. In addition, hatchery managers could produce approximately 1.6 million listed hatchery juvenile CCV steelhead each year (Table 72).

Table 74. Abundance geometric means for adult CCV steelhead natural- and hatchery-origin spawners (CHSRG 2012, Hannon and Deason 2005, Teubert et al. 2011, additional unpublished data provided by the NMFS SWFSC)

Population	Years	Natural-origin Spawners	Hatchery-origin Spawners	Expected Number of Outmigrants[ab]
American River	2011-2015	208	1,068	145,145
Antelope Creek	2007	140	0	15,925
Battle Creek	2010-2014	410	1,563	224,429
Bear Creek	2008-2009	119	0	13,536
Cottonwood Creek[f]	2008-2009	27	0	3,071
Clear Creek	2011-2015	463	0	52,666
Cow Creek	2008-2009	2	0	228
Feather River	2011-2015	41	1,092	128,879
Mill Creek	2010-2015	166	0	18,883
Mokelumne River	2006-2010	110	133	27,641
Total		1,686	3,856	630,403

[a] Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant

[b] Based upon number of natural-origin spawners

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

Threats and Limiting Factors

Many threats and factors have contributed to the decline of CCV steelhead, including, (1) major dams, (2) water diversions, (3) barriers, (4) levees and bank protection, (5) dredging and sediment disposal, (6) mining, (7) contaminants, (8) alien species, (9) fisheries, and (10) hatcheries (Moyle et al. 2008). Dams have had a large impact on CCV steelhead with 80 percent of steelhead habitat blocked by dams (Lindley et al. 2006). Even dams that provide enough water downstream of dams may not provide cool enough temperatures for steelhead during summer and fall months (Moyle et al. 2008). Hatcheries produce a magnitude more juveniles than what is now naturally produced. These hatchery fish have a negative impact by displacing wild steelhead juveniles through competition and predation, hatchery adults competing with wild adults for limited spawning habitat, and hybridization with fish from outside the basin (Moyle et al. 2008). Though harvest of natural-origin CCV steelhead is prohibited in the Central Valley, there is a fishery upon the hatchery-produced steelhead. Incidental catch and releases may be having a deleterious impact upon the natural populations (Moyle et al. 2008).

Status Summary

All indications are that natural CCV steelhead have continued to decrease in abundance and in the proportion of natural fish over the past 25 years (Good et al. 2005, NMFS 2011b); the long-term trend remains negative. Hatchery production and returns are dominant over natural fish, and one of the four hatcheries is dominated by Eel/Mad River origin steelhead stock (which are from the NC steelhead DPS).

Continued decline in the ratio between naturally produced juvenile steelhead to hatchery juvenile steelhead in fish monitoring efforts indicates that the wild population abundance is declining. Hatchery releases (100 percent adipose fin-clipped fish since 1998) have remained relatively constant over the past decade, yet the proportion of adipose fin-clipped hatchery smolts to unclipped naturally produced smolts has steadily increased over the past several years.

Although there have been recent restoration efforts in the San Joaquin River tributaries, CCV steelhead populations in the San Joaquin Basin continue to show an overall very low abundance, and fluctuating return rates. Lindley et al. (2007) developed viability criteria for Central Valley salmonids. Using data through 2005, Lindley et al. (2007) found that data were insufficient to determine the status of any of the naturally-spawning populations of CCV steelhead, except for those spawning in rivers adjacent to hatcheries, which were likely to be at high risk of extirpation due to extensive spawning of hatchery origin fish in natural areas.

The widespread distribution of wild steelhead in the Central Valley provides the spatial structure necessary for the DPS to survive and avoid localized catastrophes. However, most wild CCV populations are very small, are not monitored, and may lack the resiliency to persist for protracted periods if subjected to additional stressors, particularly widespread stressors such as climate change (NMFS 2011b). The genetic diversity of CCV steelhead has likely been impacted by low population sizes and high numbers of hatchery fish relative to wild fish. The life-history diversity of the DPS is mostly unknown, as very few studies have been published on traits such as age structure, size at age, or growth rates in CCV steelhead.

The most recent status review of the CCV steelhead DPS NMFS (2011b) found that the status of the population appears to have worsened since the 2005 status review (Good et al. 2005), when it was considered to be in danger of extinction.

2.2.2.22 South-Central California Coast Steelhead

Description and Geographic Range

On August 18, 1997, NMFS listed SCCC steelhead—only natural-origin fish—as a threatened species (62 FR 43937). NMFS concluded that the SCCC steelhead DPS was likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. NMFS promulgated 4(d) protective regulations for SCCC steelhead on January 5, 2006 (71 FR 834). The section 4(d) protections (and limits on them) apply to natural and hatchery SCCC steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

SCCC steelhead occupy rivers from the Pajaro River (Santa Cruz County, California), inclusive, south to, but not including, the Santa Maria River (San Luis Obispo County, California). Most rivers in this DPS drain from the San Lucia Mountain range, the southernmost section of the California Coast Ranges. Many stream and rive mouths in this area are seasonally closed by sand berms that form during the low water flows of summer. The climate is drier than for the more northern DPSs with vegetation ranging from coniferous forest to chaparral and coastal scrub.

Spatial Structure and Diversity

SCCC steelhead populations are broken into four population groups: Interior Coast Range, Carmel River Basin, Big Sur Coast, and San Luis Obispo Terrace (Table 75). The Interior Coast Range population group is the furthest north population containing long alluvial valleys and montane summer climate refugia. The Carmel River Basin population group resides in a medium valley with a montane/marine summer climate refugia. The Big Sur Coast population group uses short, steep canyons with a marine refugia. And the southernmost population group, San Luis Obispo Terrace, uses coastal terrace with a marine/montane refugia. In 2002, NMFS surveyed 36 watersheds and found that between 86 and 94 percent of the historic watersheds were still occupied. Also, occupancy was determined for 18 watershed basins with no historical record of steelhead (NMFS 2012b).

Table 75. Historical SCCC Steelhead Populations (NMFS 2012b).

Population Groups	Populations (north to south)
Interior Coast Range	Pajaro River, Gabilan Creek, Arroyo Seco, Upper Salinas Basin
Carmel River Basin	Carmel River
Big Sur Coast	San Jose Creek, Malpaso Creek, Garrapata Creek, Rocky Creek, Bixby Creek, Little Sur River, Big Sur River, Partington Creek, Big Creek, Vicente Creek, Limekiln Creek, Mill Creek, Prewitt Creek, Plaskett Creek, Willow Creek (Monterey Co.), Alder Creek, Villa Creek (Monterey Co.), Salmon Creek
San Luis Obispo Terrace	Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, Pico Creek, San Simeon Creek, Santa Rosa Creek, Villa Creek (SLO Co.), Cayucos Creek, Old Creek, Toro Creek, Morro Creek, Chorro Creek, Los Osos Creek, Islay Creek, Coon Creek, Diablo Canyon, San Luis Obispo Creek, Pismo Creek, Arroyo Grande Creek

Abundance and Productivity

Historic SCCC steelhead abundance is unknown. In the mid-1960s, CDFG estimated SCCC steelhead abundance at 17,750 fish (CDFG 1965). The CDFG estimate, however, is just a midpoint number in the SCCC steelhead's abundance decline—at the point the estimate was made, there had already been a century of commercial harvest and coastal development. Current SCCC steelhead abundance is still not well known. Multiple short-term studies using different methodologies have occurred over the past decade.

Table 76. Geometric Mean Abundances of SCCC Steelhead Spawners Escapements by Population.

Stratum	Waterbody	Years	Abundance	Expected Number of Outmigrants[a]
Interior Coast Range	Pajaro River[b]	2007-2011	35	3,981
	Salinas River[c]	2011-2013	21	2,389
Carmel River Basin	Carmel River[d]	2009-2013	318	36,173
Big Sur Coast	Big Sur River[e]	2010	11	1,251
	Garrapata Creek[f]	2005	17	1,934
San Luis Obispo Terrace	Arroyo Grande Creek[g]	2006	18	2,048
	Chorro Creek[h]	2001	2	228
	Coon Creek[i]	2006	3	341
	Los Osos Creek[h]	2001	23	2,616
	San Simeon Creek[j]	2005	4	455
	Santa Rosa Creek[k]	2002-2006	243	27,641
Total			695	79,057

[a] Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant

[b] Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoU%3D&tabid=1772

[c] Kraft et al. 2013

[d] Sources: http://www.mpwmd.dst.ca.us/fishcounter/fishcounter.htm and http://www.mpwmd.dst.ca.us/wrd/lospadres/lospadres.htm.

[e] Allen and Riley 2012

[f] Garrapata Creek Watershed Council 2006

[g] Source: http://www.coastalrcd.org/zone1-1a/Fisheries%20Studies/AG_Steelhead_Report_Draft-small.pdf

[h] Source: http://www.coastalrcd.org/images/cms/files/MB%20Steelhead%20Abund%20and%20Dist%20Report.pdf

[i] City of San Luis Obispo 2006

[j] Baglivio 2012

[k] Stillwater Sciences et al. 2012

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile SCCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. The estimated average adult run size is 695 (Table 76). Juvenile SCCC steelhead abundance estimates come from the escapement data (Table 76). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 348 females), 1.2 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 79,057 natural outmigrants annually.

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is complicated by a host of variables, including the facts that: (1) the available data is not inclusive of all populations; (2) spawner counts and associated sex ratios and fecundity estimates can vary widely between years; (3) multiple juvenile age classes (fry, parr, smolt) are present yet comparable data sets may not exist for all of them; (4) it is very difficult to distinguish between non-listed juvenile rainbow trout and listed juvenile steelhead; and (5) survival rates between life stages are poorly understood and subject to a multitude of natural and human-induced variables (e.g., predation, floods, fishing, etc.).

The Carmel River contains the biggest spawning run of the DPS (Williams et al. 2011). Two dams and reservoirs (Los Padres and San Clemente) are built in the drainage and are monitored for fish abundance. In 2013, the San Clemente dam has begun to be removed, and when completed the Carmel River will be rerouted. While improving steelhead habitat, this will remove one of the few locations where steelhead are monitored within the DPS. The Santa Rosa Creek has the second most abundant run for the DPS, but it is poorly studied. Overall, this steelhead DPS is too data poor for abundance to statistically test abundance trends.

Threats and Limiting Factors

There are several factors and threats that have contributed to the decline of SCCC steelhead. NMFS (2012a) outlines these as the following: (1) dams, surface water diversions, and groundwater extraction; (2) agricultural and urban development, roads, and other passage barriers; (3) flood control, levees, and channelization; (4) non-native species; (5) estuarine loss; (6) marine environment threats; (7) natural environmental variability; and (8) pesticide use. The principal threats to SCCC steelhead viability are associated with the four major river systems – the Pajaro, Salinas, Nacimiento/Arroyo Seco, and the Carmel rivers (Williams et al. 2011). Loss of surface flows or other passage impediments along rivers adversely affect upstream tributary productivity, which provide spawning and rearing habitat. Further, dams negatively affect the hydrology, sediment transport processes, and drainage geomorphology (NMFS 2012b). Agricultural development on lower floodplains has resulted in channelization, riparian vegetation removal, and of channel structure simplification, as well as increase fine sediments and other types of pollution (i.e. pesticides, fertilizers). Urban development, in general, is concentrated in the coastal terraces and middle and lower portions of watershed (NMFS 2012b). Flood control practices, associated stream channelization, and levee placement impair stream habitat function and quality (NMFS 2012b). Non-native game fish species have been intentionally introduced (i.e. striped bass) as well as many other non-native species of wildlife and plant species into the watersheds of this DPS, which potentially can displace native species, or adversely affect aquatic habitat conditions (NMFS 2012b). Estuarine environments are important for steelhead development, but approximately 75 percent of the habitat has been lost with the remaining 25 percent impacted by agricultural and urban development, levees, and transportation corridors (NMFS 2012b). Steelhead spend a majority of their lives in the ocean and are impacted by the changes and threats in the marine environment (NMFS 2012b). The SCCC steelhead reside in a Mediterranean climatic zone, which is characterized by two distinct annual seasons, with a high degree of inter-annual and decadal variability. Freshwater habitat conditions are strongly influenced by the intra- and inter-annual pattern of short-duration cyclonic storms with little snowfall (NMFS 2012b). Pesticides are used extensively for commercial agricultural purposes and can have deleterious effects upon steelhead (NMFS 2012b).

Status Summary

SCCC steelhead recovery will require reducing threats to the long-term persistence of wild populations, maintaining multiple interconnected populations of steelhead across the diverse habitats of their native range, and preserving the diversity of steelhead life history strategies that allow the species to withstand natural environmental variability—both intra-annually and over the long-term (NMFS 2012a). Currently, nearly half of this DPS reside in one river – the Carmel River. Most of the other streams and rivers have small populations that can be stochastically driven to extirpation. A status review is currently underway and is nearing completion.

2.2.2.23 Eulachon

Description and Geographic Range

On March 16, 2010, NMFS listed the southern DPS of Pacific eulachon (hereafter, “eulachon”) as a threatened species (75 FR 13012). This DPS encompasses all populations within the states of Washington, Oregon, and California and extends from the Skeena River in British Columbia south to the Mad River in Northern California (inclusive).

In May of 2011, the Committee on the Status for Endangered Wildlife in Canada (COSEWIC) released their assessment and status report for eulachon in Canada. COSEWIC divided the Canadian portion of the US designated Southern DPS into three designatable units (DUs) – Nass/Skeena Rivers population, Central Pacific Coast population, and Fraser River population (COSEWIC 2011a). DUs are discrete evolutionarily significant units, where “significant” means that the unit is important to the evolutionary legacy of the species as a whole and if lost would likely not be replaced through natural dispersion (COSEWIC 2009). Thus, DUs are biologically similar to ESU and DPS designations under the ESA. The Fraser River population (the closest Canadian population to the conterminous U.S.) was assessed as endangered by COSEWIC, and the listing decision for the Species at Risk Act (SARA) registry is currently scheduled for 2014 or later (COSEWIC 2011b).

Eulachon are endemic to the northeastern Pacific Ocean; they range from northern California to southwest and south-central Alaska and into the southeastern Bering Sea. Puget Sound lies between two of the larger eulachon spawning rivers (the Columbia and Fraser rivers) but lacks a regular eulachon run of its own (Gustafson et al. 2010). Within the conterminous U.S., most eulachon production originates in the Columbia River Basin and the major and most consistent spawning runs return to the Columbia River mainstem and Cowlitz River. Adult eulachon have been found at several Washington and Oregon coastal locations, and they were previously common in Oregon's Umpqua River and the Klamath River in northern California. Runs occasionally occur in many other rivers and streams but often erratically, appearing in some years but not in others and only rarely in some river systems (Hay and McCarter 2000, Willson et al. 2006, Gustafson et al. 2010). Since 2005, eulachon in spawning condition have been observed nearly every year in the Elwha River by Lower Elwha Tribe Fishery Biologists (Lower Elwha Tribe, 2011). The Elwha is the only river in the United States' portion of Puget Sound and the Strait of Juan de Fuca that supports a consistent eulachon run.

Eulachon generally spawn in rivers fed by either glaciers or snowpack and that experience spring freshets. Since these freshets rapidly move eulachon eggs and larvae to estuaries, it is believed that eulachon imprint and home to an estuary into which several rivers drain rather than individual spawning rivers (Hay and McCarter 2000). From December to May, eulachon typically enter the Columbia River system with peak entry and spawning during February and March (Gustafson et al. 2010). They spawn in the lower Columbia River mainstem and multiple tributaries of the lower Columbia River.

Eulachon eggs, averaging 1 mm in size, are commonly found attached to sand or pea-sized gravel, though eggs have been found on a variety of substrates, including silt, gravel-to-cobble sized rock, and organic detritus (Smith and Saalfeld 1955, Langer et al. 1977, Lewis et al. 2002). Eggs found in areas of silt or organic debris reportedly suffer much higher mortality than those found in sand or gravel (Langer et al. 1977). Length of incubation ranges from about 28 days in 4°-5° C waters to 21-25 days in 8° C waters. Upon hatching, stream currents rapidly carry the newly hatched larvae, 4-8 mm in length, to the sea. Young larvae are first found in the estuaries of known spawning rivers and then disperse along the coast. After yolk sac depletion, eulachon larvae acquire characteristics to survive in oceanic conditions and move off into open marine environments as juveniles. Eulachon return to their spawning river at ages ranging from two to five years as a single age class. Prior to entering their spawning rivers, eulachon hold in brackish waters while their bodies undergo physiological changes in preparation for fresh water and to synchronize their runs. Eulachon then enter the rivers, move upstream, spawn, and die to complete their semelparous life cycle (COSEWIC 2011a).

Adult eulachon weigh an average of 40 g each (approximately 11.2 eulachon per pound) and are 15 to 20 cm long with a maximum recorded length of 30 cm. They are an important link in the food chain between zooplankton and larger organisms. Small salmon, lingcod, white sturgeon, and other fish feed on small larvae near river mouths. As eulachon mature, a wide variety of predators consume them (Gustafson et al. 2010).

Spatial Structure and Diversity

There are no distinct differences among eulachon throughout the range of the southern DPS. However, the eulachon Biological Review Team (BRT) did separate the DPS into four subpopulations in order to rank threats they face. These are the Klamath River (including the Mad River and Redwood Creek), the Columbia River (including all of its tributaries), the Fraser River, and the BC coastal rivers (north of the Fraser River up to, and including, the Skeena River). Eulachon population structure has not been analyzed below the DPS level. The COSEWIC assessed eulachon populations in Canada and designated them with the following statuses: Nass/Skeena Rivers population (threatened), Central Pacific population (endangered), and Fraser River population (endangered) (COSEWIC 2011a).

Eulachon of the southern DPS are distinguished from eulachon occurring north of the DPS range by a number of factors including genetic characteristics. Significant microsatellite DNA variation in eulachon has been reported from the Columbia River to Cook Inlet, Alaska (Beacham et al. 2005). Within the range of the southern DPS, Beacham et al. (2005) found genetic affinities among the populations in the Fraser, Columbia, and Cowlitz rivers and also among the Kemano, Klinaklini, and Bella Coola rivers along the central British Columbia coast. In particular, there was evidence of a genetic discontinuity north of the Fraser River, with Fraser and Columbia/Cowlitz samples diverging three to six times more from samples further to the north than they did from each other. Similar to the study of McLean et al. (1999), Beacham et al. (2005) found that genetic differentiation among populations was correlated with geographic distances. The authors also suggested that the pattern of eulachon differentiation was similar to that typically found in studies of marine fish, but less than that observed in most salmon species.

The BRT was concerned about risks to eulachon diversity due to its semelparity (spawn once and die) and data suggesting that Columbia and Fraser River spawning stocks may be limited to a single age class. These characteristics likely increase their vulnerability to environmental catastrophes and perturbations and provide less of a buffer against year-class failure than species such as herring that spawn repeatedly and have variable ages at maturity (Gustafson et al. 2010).

Abundance and Productivity

Eulachon are a short-lived, high-fecundity, high-mortality forage fish; and such species typically have extremely large population sizes. Fecundity estimates range from 7,000 to 60,000 eggs per female with egg to larva survival likely less than 1% (Gustafson et al. 2010). Among such marine species, high fecundity and mortality conditions may lead to random “sweepstake recruitment” events where only a small minority of spawning individuals contribute to subsequent generations (Hedgecock 1994).

Prior to 2011, few direct estimates of eulachon abundance existed. Escapement counts and spawning stock biomass estimates are only available for a small number of systems. Catch statistics from commercial and First Nations fisheries are available for some systems in which no direct estimates of abundance are available. However, inferring population status or even trends from yearly catch statistic changes requires making certain assumptions that are difficult to corroborate (e.g., assuming that harvest effort and efficiency are similar from year to year, assuming a consistent relationship among the harvested and total stock portion, and certain statistical assumptions, such as random sampling). Unfortunately, these assumptions cannot be verified, few fishery-independent sources of eulachon abundance data exist, and in the United States, eulachon monitoring programs just started in 2011. However, the combination of catch records and anecdotal information indicates that there were large eulachon runs in the past and that eulachon populations have severely declined (Gustafson et al. 2010). As a result, eulachon numbers are at, or near, historically low levels throughout the range of the southern DPS.

Similar abundance declines have occurred in the Fraser and other coastal British Columbia rivers (Hay and McCarter 2000, Moody 2008). Over a three-generation time of 10 years (1999-2009), the overall Fraser River eulachon population biomass has declined by nearly 97% (Gustafson et al. 2010). In 1999, the biomass estimates were 418 metric tons[3]; and by 2010, had dropped to just 4 metric tons (Table 77). Abundance information is lacking for many coastal British Columbia subpopulations, but Gustafson et al. (2010) found that eulachon runs were universally larger in the past. Furthermore, the BRT was concerned that four out of seven coastal British Columbia subpopulations may be at risk of extirpation as a result of small population concerns such as Allee[4] effects and random genetic and demographic effects (Gustafson et al. 2010). Under SARA, Canada designated the Fraser River population as endangered in May 2011 due to a 98% decline in spawning stock biomass over the previous 10 years (COSEWIC 2011a). From 2011 through 2015, the Fraser River eulachon spawner population estimate is 2,378,000 adults (Table 77).

Table 77. Eulachon spawning estimates for the lower Fraser River, British Columbia (data from http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/herring-hareng/herspawn/pages/river1-eng.html).

Year	Biomass estimate (metric tons)	Estimated spawner population[a]
2008	10	246,918
2009	14	345,685
2010	4	98,767
2011	31	765,445
2012	120	2,963,013
2013	100	2,469,177
2014	66	1,629,657
2015	317	7,827,292
2016	44	1,086,438
2017	35	864,211
2013-2017[b]	**80**	**1,968,688**

[a] Estimated population numbers are calculated as 25,000 adults/metric ton (eulachon average 40g per adult).
[b] Five-year geometric mean of eulachon biomass estimates (2009-2013).

The Columbia River and its tributaries support the largest known eulachon run. Although direct estimates of adult spawning stock abundance are limited, commercial fishery landing records begin in 1888 and continue as a nearly uninterrupted data set to 2010 (Gustafson et al. 2010). From about 1915 to 1992, historic commercial catch levels were typically more than 500 metric tons, occasionally exceeding 1,000 metric tons. In 1993, eulachon catch levels began to decline

---

[3] The U.S. ton is equivalent to 2,000 pounds and the metric ton is equivalent to 2,204 pounds.

[4] The negative population growth observed at low population densities. Reproduction—finding a mate in particular— for migratory species can be increasingly difficult as the population density decreases.

and averaged less than five metric tons from 2005-2008 (Gustafson et al. 2010). Persistent low eulachon returns and landings in the Columbia River from 1993 to 2000 prompted the states of Oregon and Washington to adopt a Joint State Eulachon Management Plan (WDFW and ODFW 2001). From 2011 through 2013, all recreational and commercial fisheries for eulachon were closed in Washington and Oregon; but the fisheries were reopened in 2014. Beginning in 2011, ODFW and WDFW began eulachon biomass surveys similar to those conducted on the Fraser River. Four years of surveys have now been completed resulting in an estimate of 33,787,000 eulachon spawning adults for the Columbia River and its tributaries (Table 78).

Table 78. Annual Columbia River eulachon run size 2000-2017; pounds converted to numbers of fish at 11.16 fish/pound (WDFW and ODFW 2016). The estimates were calculated based on methods developed by Parker (1985), Jackson and Cheng (2001), and Hay et al. (2002) to estimate spawning biomass of pelagic fishes. For 2000 through 2010 estimates were back-calculated using historical larval density data.

Year	Maximum Estimates	Mean Estimates	Minimum Estimates
2000	8,971,500	5,421,500	3,205,200
2001	128,960,500	77,512,900	35,121,600
2002	76,645,800	59,114,500	42,541,900
2003	99,395,400	64,670,000	45,137,700
2004	—	—	—
2005	1,450,800	783,400	226,500
2006	3,527,700	1,233,200	387,300
2007	3,272,100	1,605,900	863,800
2008	6,510,700	2,418,400	713,100
2009	10,034,000	4,873,600	1,984,200
2010	4,281,000	1,759,900	612,700
2011	69,661,800	36,775,900	17,860,400
2012	61,437,400	35,722,100	20,008,600
2013	197,943,400	107,794,900	45,546,700
2014	323,778,300	185,965,200	84,243,100
2015	207,570,500	123,582,000	57,525,700
2016	111,991,000	54,556,500	21,654,800
2017	34,071,100	18,307,100	8,148,600
2013-2017[a]	138,390,008	75,629,327	32,968,415

[a] Five-year geometric mean of eulachon biomass estimates (2013-2017).

In Northern California, no long-term eulachon monitoring programs exist. In the Klamath River, large eulachon spawning aggregations once regularly occurred but eulachon abundance has declined substantially (Fry 1979, Moyle et al. 1995, Larson and Belchik 1998, Hamilton et al. 2005). Recent reports from Yurok Tribal fisheries biologists mentioned only a few eulachon captured incidentally in other fisheries.

Beacham et al. (2005) reported that marine sampling by trawl showed that eulachon from different rivers mix during their 2 to 3 years of pre-spawning life in offshore marine waters, but not thoroughly. Their samples from southern British Columbia comprised a mix of fish from multiple rivers, but were dominated by fish from the Columbia and Fraser River populations. The combined estimate from the Columbia and Fraser rivers is 81.74 million eulachon.

Limiting Factors

Climate change impacts on ocean habitat are the most serious threat to persistence of the southern DPS of eulachon (Gustafson et al. 2010), thus it will be discussed in greater detail in this section. Scientific evidence strongly suggests that global climate change is already altering marine ecosystems from the tropics to polar seas. Physical changes associated with warming include increases in ocean temperature, increased stratification of the water column, and changes in the intensity and timing of coastal upwelling. These changes will alter primary and secondary productivity and the structure of marine communities (ISAB 2007).

Although the precise changes in ocean conditions cannot be predicted they present a potentially severe threat to eulachon survival and recovery. Increases in ocean temperatures have already occurred and will likely continue to impact eulachon and their habitats. In the marine environment, eulachon rely upon cool or cold ocean regions and the pelagic invertebrate communities therein (Willson et al. 2006). Warming ocean temperatures will likely alter these communities, making it more difficult for eulachon and their larvae to locate or capture prey (Roemmich and McGowan 1995, Zamon and Welch 2005). Warmer waters could also allow for the northward expansion of eulachon predator and competitor ranges, increasing the already high predation pressure on the species (Rexstad and Pikitch 1986, McFarlane et al. 2000, Phillips et al. 2007).

Climate change along the entire Pacific Coast is expected to affect fresh water as well. Changes in hydrologic patterns may pose challenges to eulachon spawning because of decreased snowpack, increased peak flows, decreased base flow, changes in the timing and intensity of stream flows, and increased water temperatures (Morrison et al. 2002). In most rivers, eulachon typically spawn well before the spring freshet, near the seasonal flow minimum. This strategy typically results in egg hatch coinciding with peak spring river discharge. The expected alteration in stream flow timing may cause eulachon to spawn earlier or be flushed out of spawning rivers at an earlier date. Early emigration may result in a mismatch between entry of larval eulachon into the ocean and coastal upwelling, which could have a negative impact on marine survival of eulachon during this critical transition period (Gustafson et al. 2010).

In the past, commercial and recreational harvests likely contributed to eulachon decline. The best available information for catches comes from the Columbia River, where from 1938 to 1993 landings have averaged almost 2 million pounds per year (approximately 24.6 million fish), and have been as high as 5.7 million pounds in a single year (approximately 70 million fish) (Wydoski and Whitney 2003, Gustafson et al. 2010). Between 1994 and 2010, no catch exceeded one million pounds (approximately 12.3 million fish) annually and the median catch was approximately 43,000 pounds (approximately 529,000 fish), which amounts to a 97.7% reduction in catch (WDFW and ODFW 2001, JCRMS 2011). Catch from recreational eulachon fisheries was also high historically (Wydoski and Whitney 2003); and at its height in popularity, the fishery would draw thousands of participants annually. Commercial and recreational fisheries continued through the 2009-2010 season, and then were closed until 2014 (Gustafson et al. 2016). Beginning in 2014, ODFW and WDFW worked with NMFS to reopen their commercial and recreational eulachon fisheries (JCRMS 2014). Based upon their 2001 Eulachon Management Plan, both state agencies now manage their eulachon fisheries using scientific surveys to estimate spawner abundance and set fishery locations, dates, times, and limits by classifying their fisheries into one of three levels from most (level one) to least conservative (three) (WDFW and ODFW 2001). Since 2014, the combined commercial, recreational, and tribal eulachon fisheries have harvested 2.7 (2014), 3.5 (2015), and 1.6 (2016) million eulachon in the Columbia, Cowlitz, and Sandy rivers (Gustafson et al. 2016).

In British Columbia, the Fraser River supports the only commercial eulachon fishery that is within the range of the southern DPS. This fishery has been essentially closed since 1997, only opening briefly in 2002 and 2004 when only minor catches were landed (DFO 2008).

Historically, bycatch of eulachon in the pink shrimp fishery along the U.S. and Canadian coasts has been very high (composing up to 28% of the total catch by weight; Hay and McCarter 2000, DFO 2008). Prior to the mandated use of bycatch-reduction devices (BRDs) in the pink shrimp fishery, 32–61% of the total catch in the pink shrimp fishery consisted of non-shrimp biomass, made up mostly of Pacific hake, various species of smelt including Pacific eulachon, yellowtail rockfish, sablefish, and lingcod (Ophiodon elongatus) (Hannah and Jones 2007). Reducing bycatch in this fishery has long been an active field of research (Hannah et al. 2003, Hannah and Jones 2007, Frimodig 2008) and great progress has been made in reducing bycatch. As of 2005, following required implementation of BRDs, the total bycatch by weight had been reduced to about 7.5% of the total catch and osmerid smelt bycatch was reduced to an estimated average of 0.73% of the total catch across all BRD types (Hannah and Jones 2007). From 2004 through 2011, eulachon bycatch in the California, Oregon, and Washington state shrimp fishery peaked at 1.0 million eulachon in 2010 (Al-Humaidhi et al. 2012). However, from 2012 through 2015, eulachon bycatch greatly increased ranging from 42.6 (2012) to 68.8 (2014) million eulachon annually (Gustafson et al. 2017). Although BRDs were being used, it is believed that they may operate at reduced efficiency when eulachon reach higher densities (Gustafson et al. 2017). Recent experimentation with using green LED lights on the trawl lines of shrimp trawl nets have shown a reduction in eulachon bycatch by 91% ($p=0.0001$) when compared to control nets (Hannah et al. 2015). In 2017, ODFW, in collaboration with the Pacific States Marine Fisheries Commission (PSMFC), will continue to test the use of green LEDs on shrimp trawls nets on reducing fish bycatch (Groth et al. 2017).

Hydroelectric dams block access to historical eulachon spawning grounds and affect the quality of spawning substrates through flow management, altered delivery of coarse sediments, and siltation. Dredging activities during the eulachon spawning run may entrain and kill adult and larval fish and eggs. Eulachon carry high levels of pollutants – arsenic, lead, mercury, DDE, 9H-Fluorene, Phenanthrene (EPA 2002), and although it has not been demonstrated that high contaminant loads in eulachon have increased mortality or reduced reproductive success, such effects have been shown in other fish species (Kime 1995). The negative effects of these factors on the species and its habitat contributed to the determination to list the southern DPS of Pacific eulachon under the ESA.

Status Summary

Adult spawning abundance of the southern DPS of eulachon has clearly increased since the listing occurred in 2010 (Gustafson et al. 2016). The improvement in estimated abundance in the Columbia River, relative to the time of listing, reflects both changes in biological status and improved monitoring. The documentation of eulachon returning to the Naselle, Chehalis, Elwha, and Klamath rivers over the 2011–2015 also likely reflects both changes in biological status and improved monitoring. The Biological Review Team (BRT) concluded that, starting in 1994, the southern DPS of eulachon experienced an abrupt decline in abundance throughout its range (Gustafson et al. 2010). Although eulachon abundance in monitored rivers improved in the 2013–2015 return years, recent conditions in the northeast Pacific Ocean are likely linked to the sharp declines in eulachon abundance in monitored rivers in 2016 and 2017. The likelihood that these poor ocean conditions will persist into the near future suggest that subpopulation declines may again be widespread in the upcoming return years (NMFS 2017).[5] Since the 2014 eulachon spawner peak, eulachon runs have decreased each year with the 2017 Columbia River run being the smallest since the eulachon surveys began in 2011 (pers. comm., R. Gustafson, June 8, 2017).

2.2.2.24 Green Sturgeon

Description and Geographic Range

On April 7, 2006, NMFS listed the southern DPS of North American green sturgeon (hereafter referred to as "green sturgeon") as a threatened species (71 FR 17757). The southern DPS consists of coastal and Central Valley populations south of the Eel River (exclusive), with the only known spawning population in the Sacramento River. Information on their oceanic distribution and behavior indicates that green sturgeon make generally northern migrations—even occurring in numbers off Vancouver Island (NMFS 2005b). A mixed stock assessment assigned about 70% to 90% of the green sturgeon present in the Columbia River estuary and Willapa Bay to the southern DPS. The stock composition in Grays Harbor is about 40% southern DPS (Israel et al. 2009).

Green sturgeon—like all sturgeon—is a long-lived, slow-growing species. Adult green sturgeon typically migrate into fresh water beginning in late February and spawn from March to July. Green sturgeon females produce 60,000-140,000 eggs. Green sturgeon larvae are different from all other sturgeon because they lack a distinct swim-up or post-hatching stage and are distinguished from white sturgeon by their larger size, light pigmentation, and size and shape of the yolk sac. First feeding occurs 10 days after they hatch, and metamorphosis to juveniles is complete at 45 days. The larvae grow fast, reaching a length of 66 mm and a weight of 1.8 grams in three weeks of exogenous feeding. Larvae hatched in the laboratory are photonegative and exhibit hiding behaviors after the onset of exogenous feeding. The larvae and juveniles are

---

[5] National Marine Fisheries Service. September 2017. Recovery Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*). National Marine Fisheries Service, West Coast Region, Protected Resources Division, Portland, OR, 97232.

nocturnal. Juveniles appear to spend one to three years in freshwater before they enter the ocean (NMFS 2005b).

Green sturgeon disperse widely in the ocean between their freshwater life stages. In the Klamath River, Nakamoto et al. (1995) found a lack of females from ages 3 to 13 and males from ages 3 to 9 suggesting an entirely marine existence during those ages. Green sturgeon reach maturity at 14 years for males and 16 years for females (Van Eenennaam et al. 2006) with maximum ages of 60 to 70 years or longer (Moyle 2002). Mature females return every two to four years to spawn (Erickson and Webb 2007). Lindley et al. (2008) found that green sturgeon make rapid, long distance season migrations along the continental shelf of North America from central California to central British Columbia. In the fall, green sturgeon move northward to or past the northern end of Vancouver Island, stay there for the winter, and then return southward during the spring. In an acoustic transmitter study, Moser and Lindley (2007) found that green sturgeon were routinely detected in Willapa Bay during the summer when estuarine water temperatures were greater than the coastal temperatures. However, green sturgeon were not detected in Willapa Bay during the winter when temperatures were below 10° C.

Spatial Structure and Diversity

Green sturgeon are composed of two DPS with two geographically distinct spawning locations. The northern DPS spawn in rivers north of and including the Eel River in Northern California with known spawning occurring in the Eel, Klamath, and Trinity rivers in California and the Rogue and Umpqua rivers in Oregon. The southern DPS spawn in rivers south of the Eel River which is now restricted to the Sacramento River. Historic spawning grounds were blocked by the construction of Shasta Dam (1938-1945) and Keswick Dam (1941-1950) on the Sacramento River and Oroville Dam (1961-1968) on the Feather River. Spawning grounds became limited to an area downstream of Shasta Dam that was impacted by high temperatures until the construction of a temperature control device in Shasta Dam in 1997 (Adams et al. 2007).

The CDFG reported that Oroville Dam limits access to potential spawning habitat, and warm water releases from the Thermalito Afterbay reservoir may increase temperatures to levels unsuitable for green sturgeon spawning and incubation in the Feather River (CDFG 2002). Adult green sturgeons have also been captured in the San Joaquin River delta (Adams et al. 2002). Moyle et al. (1992) suggested that green sturgeon presence in the delta is evidence that green sturgeon are spawning in the San Joaquin River. But, there are no documented observations of green sturgeon in the San Joaquin River upstream of the delta.

Diversity in sturgeon populations can range in scale from genetic differences within and among populations to complex life-history traits. One of the leading factors affecting the diversity of green sturgeon is the loss of habitat due to impassable barriers such as dams. As described above, several tributaries to the Sacramento River have been blocked and have therefore almost certainly reduced the DPS's diversity. Although this DPS migrates over long distances, its spawning locations are small and have been greatly affected by human activities.

Abundance and Productivity

Since 2006, research conducted and published has enhanced the understanding of Southern green sturgeon biology and life history, including reproductive characteristics (NMFS 2015). Southern green sturgeon typically spawn every three to four years (range two to six years) and primarily in the Sacramento River (Brown 2007; Poytress et al. 2012). Adult Southern green sturgeon enter San Francisco Bay in late winter through early spring and spawn from April through early July, with peaks of activity influenced by factors including water flow and temperature (Heublein et al. 2009; Poytress et al. 2011). Spawning primarily occurs in the cool sections of the upper mainstem Sacramento River in deep pools containing small to medium sized gravel, cobble or boulder substrate (NMFS 2015). Eggs incubate for a period of seven to nine days and remain near the hatching area for 18 to 35 days prior to dispersing (Van Eenennaam et al. 2001; Deng et al. 2002; Poytress et al. 2012). Based on length of juvenile sturgeon captured in the San Francisco Bay Delta, Southern green sturgeon migrate downstream toward the estuary between 6 months and 2 years of age (Radtke et al. 1966; NMFS 2015).

Since 2010, Dual Frequency Identification Sonar (DIDSON) surveys of aggregating sites in the upper Sacramento River for Southern green sturgeon have been conducted. Results from these surveys combined with the observed three to four year spawning cycle for Southern green sturgeon resulted in an estimate of 1,348 adults (Table 79; NMFS 2015). There are no estimates for juvenile S green sturgeon.

Table 79. Green sturgeon adult spawner numbers from DIDSON surveys in the upper Sacramento River and ESU estimate (NMFS 2015).

Year	Adult green sturgeon	95% Confidence Interval
2010	164	117 - 211
2011	220	178 - 262
2012	329	272 - 386
2013	338	277 - 399
2014	526	462 - 590
ESU abundance[a]	1,348	824 – 1,872

[a] ESU abundance for Southern green sturgeon numbers calculated from returning spawners in the Sacramento River and the observed spawning three to four year spawning cycle.

Limiting Factors

Many of the principle factors considered when listing Southern DPS green sturgeon as threatened are relatively unchanged (NMFS 2015). Recent studies confirm that the spawning area utilized by Southern green sturgeon is small. Confirmation of Feather River spawning is encouraging and the decommissioning of Red Bluff Diversion Dam and breach of Shanghai Bench makes spawning conditions more favorable, although Southern green sturgeon still encounter impassible barriers in the Sacramento, Feather and other rivers that limit their spawning range. The relationship between altered flows and temperatures in spawning and rearing habitat and Southern green sturgeon population productivity is uncertain. Entrainment as well as stranding in flood diversions during high water events also negatively impact Southern green sturgeon. The prohibition of retention in commercial and recreational fisheries has eliminated a known threat and likely had a very positive effect on the overall population, although recruitment indices are not presently available (NMFS 2015).

Status Summary

The southern DPS of North American green sturgeon remains vulnerable due to having only one small spawning population, potential growth-limiting and lethal temperatures, harvest concerns, loss of spawning habitat, and entrainment by water projects. There will have to be substantial changes in this species' status before it can recover.

2.2.3 Status of the Species' Critical Habitats

2.2.3.1 Salmon ESUs and Steelhead DPSs

We review the status of designated critical habitat affected by the proposed action by examining the condition and trends of essential physical and biological features throughout the designated area. These features are essential to the conservation of the listed species because they support one or more of the species' life stages (e.g., sites with conditions that support spawning, rearing, migration and foraging).

For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each listed species they support[6]; the conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' critical habitat analytical review teams (CHARTs; NOAA Fisheries 2005) evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution of the population it served (e.g., a population at the extreme end of geographic distribution), or the fact that it serves another important role (e.g., obligate area for migration to upstream spawning areas).

The CHARTs identified habitat-related human activities that affect PCE quantity and/or quality. The primary categories of habitat-related activities identified by the CHART are (1) forestry, (2) agriculture, (3) channel modifications/diking, (4) road building/maintenance, (5) urbanization, (6) dams, (7) irrigation impoundments and withdrawals, and (8) wetland loss/removal. All of these activities have PCE-related impacts because they have altered one or more of the following: stream hydrology, flow and water-level modifications, fish passage, geomorphology and sediment transport, temperature, dissolved oxygen, vegetation, soils, nutrients and

---

[6] The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NOAA Fisheries 2005).

chemicals, physical habitat structure, and stream/estuarine/marine biota and forage. And the degrees to which these alterations have affected the region's watersheds are the main factors that lead to the CHART teams' high-, medium-, and low conservation value ratings.

Puget Sound Chinook

We designated critical habitat for PS Chinook salmon on September 2, 2005 (70 FR 52630). There are 61 watersheds and nineteen nearshore marine areas within the range of this ESU. The CHART rated twelve watersheds as having low, nine as having medium, and 40 as having high rating for their conservation value to the ESU (NMFS 2005b). The nearshore marine areas also received a rating of high conservation value. Habitat areas eligible for designation for this ESU included 2,216 miles of stream and 2,376 miles of nearshore marine areas. We excluded some areas that overlap military lands or Indian lands and other areas where the economic impacts outweighed the benefits of designation. We designated approximately 1,683 miles of stream habitats and 2,182 miles of nearshore marine as critical habitat. The designation includes 926 miles of spawning/rearing sites, 215 miles of rearing/migration sites, and 542 miles of migration corridors. The 2,182 miles of designated nearshore marine habitats also contain rearing and migration sites.

Puget Sound Steelhead

We designated critical habitat for PS steelhead on February 24, 2016 (81 FR 9251). Critical habitat for PS steelhead includes approximately 1,879 miles of streams and lakes in 66 watersheds in Washington. There are 759 miles of spawning/rearing sites, 200 miles of rearing/migration sites, and 921 miles of migration corridors. There are 66 watersheds within the PS steelhead DPS. The CHART rated nine watersheds as having low, 16 as having medium, and 41 as having high conservation value to the ESU (NMFS 2015). Of the 66 watershed within the range of the species we excluded three low conservation value watershed in their entirety, as well as many stream segments which intersected tribal lands, military lands, and private forest lands. As a result of the economic and other relevant impacts weighed against the conservation value, approximately 1,600 miles of stream habitats were excluded from the designation.

Hood Canal Summer-run Chum

We designated critical habitat for HCS chum salmon on September 2, 2005 (70 FR 52630). There are 12 watersheds within the range of this ESU. The CHART rated three watersheds as having medium and nine as having high conservation value to the ESU (NMFS, 2005a). Five nearshore marine areas also received a rating of high conservation value. Habitat areas eligible for designation for this ESU include 88 miles of stream and 402 miles of nearshore marine areas. We excluded some areas where the benefits of exclusion outweighed the benefits of designation. There are approximately 79 miles of stream habitats and 377 miles of nearshore marine habitats designated as critical habitat for HCS chum salmon. Of the areas designated as critical habitat, there are 34 miles of spawning/rearing sites, one mile of rearing/migration sites, 36 miles of migration corridors, and eight miles of habitat that is unoccupied but essential to conservation of the ESU. The 377 miles of designated nearshore marine habitats contain rearing and migration sites.

Snake River Fall Chinook

We designated critical habitat for SR fall Chinook salmon on December 28, 1993 (58 FR 68543). It includes river reaches presently or historically accessible (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams). Included are adjacent riparian zones, as well as mainstem river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to the confluence of the Columbia and Snake Rivers; the Snake River including all river reaches from the confluence of the Columbia River upstream to Hells Canyon Dam; the Palouse River from its confluence with the Snake River upstream to Palouse Falls; the Clearwater River from its confluence with the Snake River upstream to its confluence with Lolo Creek; and the North Fork Clearwater River from its confluence with the Clearwater River upstream to Dworshak Dam. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 13,679 square miles in Idaho, Oregon, and Washington. The following counties lie partially or wholly within these basins: Idaho - Adams, Clearwater, Idaho, Latah, Lemhi, Lewis, and Nez Perce; Oregon - Baker, Union, and Wallowa; Washington - Adams, Asotin, Columbia, Franklin, Garfield, Walla Walla, and Whitman.

The critical habitat for this species was designated before we had implemented the CHART team process, so no determination has been made regarding the various conservation values of the habitat areas the fish inhabit. Nonetheless, nearly all the habitat that the SR fall Chinook use overlaps with that of SR steelhead—at least for the mainstems of the Clearwater, Snake, and Columbia Rivers and lower-river tributary habitat. The biggest area of overlap is the lower Snake/ Columbia River rearing/migration corridor, and it is rated as having a high conservation value, but many of the other ratings applied to steelhead critical habitat would apply here as well.

Snake River Spring/summer Chinook

We designated critical habitat for the SR spr/sum Chinook salmon on December 28, 1993 (58 FR 68543) and revised the designation on October 25, 1999 (64 FR 14308). Critical habitat includes river reaches presently or historically accessible (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams). Included are adjacent riparian zones, as well as mainstem river reaches and estuarine areas in the Columbia River from a straight line connecting the west end of the Clatsop jetty (south jetty, Oregon side) and the west end of the Peacock jetty (north jetty, Washington side) upstream to the confluence of the Columbia and Snake Rivers and all Snake River reaches from the confluence of the Columbia River upstream to Hells Canyon Dam. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 22,390 square miles in Idaho, Oregon, and Washington. The following counties lie partially or wholly within these basins: Idaho - Adams, Blaine, Custer, Idaho, Lemhi, Lewis, Nez Perce, and Valley; Oregon - Baker, Umatilla, Union, and Wallowa; Washington - Adams, Asotin, Columbia, Franklin, Garfield, Walla Walla, and Whitman.

The critical habitat for this species was designated before we had implemented the CHART team process, so no determination has been made regarding the various conservation values of the habitat areas the fish inhabit. Nonetheless, the great majority of the habitat that the SR spr/sum Chinook use overlaps with that of SR steelhead. Thus, nearly all of the ratings applied to the steelhead would apply here as well.

Snake River Steelhead

We designated critical habitat for SR steelhead on September 2, 2005 (70 FR 52630). There are 289 watersheds within the range of this ESU. The CHART rated fourteen watersheds as having low, 44 as having medium, and 231 as having high rating of conservation value to the ESU (NMFS, 2005a). The lower Snake/ Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 15 of the 231 identified high-value watersheds. Of the 8,225 miles of habitat areas eligible for designation, approximately 134 miles of stream were excluded because the economic benefits of exclusion outweigh the benefits of designation. Also, we excluded approximately 39 miles of stream because they overlap with Indian lands. In the final critical habitat designation, there are 6,844 miles of spawning/rearing sites, 324 miles of rearing/migration sites, and 884 miles of migration corridors.

Upper Columbia River Steelhead

We designated critical habitat for UCR steelhead on September 2, 2005 (70 FR 52630). There are 42 watersheds within the range of this ESU. The CHART rated three watersheds as having low, 8 as having medium, and 31 as having high conservation value to the ESU (NMFS, 2005a). The Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in 11 of the high value watersheds identified above. Habitat areas for this ESU include 1,332 miles of stream. Of these, approximately 70 stream miles were not designated because they either overlap military or Indian lands, or the economic benefits of exclusion outweigh the benefits of designation. Of the areas designated as critical habitat, there are 360 miles of spawning/rearing sites, 71 miles of rearing/migration sites, and 831 miles of migration corridors.

Middle Columbia River Steelhead

We designated critical habitat for MCR steelhead on September 2, 2005 (70 FR 52630). There are 114 watersheds within the range of this ESU. The CHART rated nine watersheds as having low, 24 as having medium, and 81 as having high conservation value to the ESU (NMFS, 2005a). The lower Columbia River rearing/migration corridor downstream of the spawning range is considered to have a high conservation value and is the only habitat area designated in three of the high value watersheds identified above. Of the 6,529 miles of habitat areas eligible for designation, approximately 714 miles of stream were excluded because the overlap with Indian lands or the economic benefits of exclusion outweigh the benefits of designation. In the areas designated critical habitat, there are 3,732 miles of spawning/rearing sites, 551 miles of rearing/migration sites, and 1,532 miles of migration corridors.

Columbia River Chum

We designated critical habitat for CR chum salmon on September 2, 2005 (70 FR 52630). There are 20 watersheds within the range of this ESU. The CHART rated three watersheds as having medium and 17 as having high conservation value to the ESU. Habitat areas eligible for designation as critical habitat for this ESU included 725 miles of streams. We excluded 7 stream miles of streams where the economic benefits of exclusion outweigh the benefits of designation. Critical habitat for CR chum includes approximately 19 miles of spawning/rearing sites, 55 miles of rearing/migration sites, and 634 miles of migration corridors.

Lower Columbia River Chinook

We designated critical habitat for LCR Chinook salmon on September 2, 2005 (70 FR 52630). Critical habitat for LCR Chinook includes 1,293 miles of streams and lakes in 47 watersheds in Oregon and Washington. There are 440 miles of spawning/rearing sites, 164 miles of rearing/migration sites, and 688 miles of migration corridors. The CHART rated four watersheds as having low, 13 as having medium, and 30 as having high conservation value to the ESU. Of the 47 watersheds considered for designation, we excluded four low-value and five medium-value watersheds in their entirety, and excluded tributary habitat in one medium-value watershed. Also, we excluded approximately 162 miles of stream covered by two habitat conservation plans because the benefits of exclusion outweigh the benefits of designation. As a result of these considerations, 344 miles of stream habitats were excluded from the designation.

Lower Columbia River Coho

We designated critical habitat for LCR coho salmon on February 24, 2016 (81 FR 9251). Critical habitat for LCR Coho includes approximately 2,300 miles of streams in Oregon and Washington. There are 805 miles of spawning/rearing sites, 1,436 miles of rearing/migration sites, and 46 miles of migration corridors. There are 55 watersheds within the range of this ESU. The CHART rated three of the watersheds as having low, eighteen as having medium, and thirty-four as having high conservation value to the ESU (NMFS 2015). As a result of the economic and other relevant impacts weighed against the conservation value, approximately 1,000 miles of stream habitats were excluded from the designation.

Lower Columbia River Steelhead

We designated critical habitat for LCR steelhead on September 2, 2005 (70 FR 52630). Critical habitat for LCR steelhead includes approximately 2,338 square miles of streams in Oregon and Washington. There are 1,114 miles of spawning/rearing sites, 165 miles of rearing/migration sites, and 1,059 miles of migration corridors. The CHART rated two watersheds as having low, 11 as having medium, and 28 as having high rating for their conservation value to the DPS. Of the 41 watersheds considered for designation, we excluded one low conservation value and three medium-value watersheds in their entirety, and the tributary-only portions of one low-value watershed. Also, we are excluding approximately 125 miles of stream covered by two habitat conservation plans because the benefits of exclusion outweigh the benefits of designation. As a result of the considerations, 335 miles of stream habitats were excluded from the designation.

Upper Willamette River Chinook

We designated critical habitat for UWR Chinook salmon on September 2, 2005 (70 FR 52630). Critical habitat for UWR Chinook includes approximately 1,796 miles of streams in Oregon and Washington. There are 644 miles of spawning/rearing sites, 722 miles of rearing/migration sites, and 106 miles of migration corridors. The CHART rated nineteen watersheds as having low, 18 as having medium, and 22 as having high rating for their conservation value to the ESU. Of the 60 watersheds considered for designation, we excluded 11 low conservation value and four medium-value watersheds in their entirety, and the tributary-only portions of eight low-value watersheds. As a result of these considerations, 324 miles of stream habitats were excluded from the designation.

Upper Willamette River Steelhead

We designated critical habitat for UWR steelhead on September 2, 2005 (70 FR 52630). Critical habitat for UWR steelhead includes approximately 1,277 miles of streams in Oregon and Washington. There are 560 miles of spawning/rearing sites, 613 miles of rearing/migration sites, and 104 miles of migration corridors. The CHART rated two watersheds as having low, 11 as having medium, and 28 as having high rating for their conservation value to the DPS. Of the 41 watersheds within the range of this DPS, we excluded nine low conservation value watersheds in their entirety and the tributary-only portions of eight low-value watersheds. Also, we are excluding approximately 11 miles of stream overlapping Indian Land. As a result of these considerations, 335 miles of stream habitats were excluded from the designation.

Oregon Coast Coho

We designated critical habitat for OC coho salmon on February 11, 2008 (73 FR 7816). Critical habitat for OC coho includes approximately 6,565 miles of streams and 15 square miles of lake habitat in Oregon. There are 4,494 miles of spawning/rearing sites, 1,851 miles of rearing/migration sites, and 223 miles of migration corridors. The CHART rated four watersheds as having low, 13 as having medium, and 30 as having high conservation value to the ESU. Of the 80 watersheds considered for designation, we excluded five low conservation value watersheds in their entirety. As a result of these considerations, 84 miles of stream habitats were excluded from the designation.

Southern Oregon/Northern California Coasts Coho

We designated critical habitat for SONCC coho salmon on May 5, 1999 (64 FR 24049). Critical habitat includes all river reaches accessible to listed coho salmon in coastal streams south of Cape Blanco, Oregon, and north of Punta Gorda, California. Critical habitat consists of the water, substrate, and adjacent riparian zone of estuarine and riverine reaches (including off-channel habitats) in the following counties: Klamath, Jackson, Douglas, Josephine, and Curry in Oregon, and Humbolt, Mendocino, Trinity, Glenn, and Del Norte in California. Major rivers, estuaries, and bays known to support SONCC coho salmon include the Rogue River, Smith River, Klamath River, Mad River, Humboldt Bay, Eel River, and Mattole River. Many smaller coastal rivers and streams also provide essential estuarine habitat for coho salmon, but access is often constrained by seasonal fluctuations in hydrologic conditions. Within these areas, essential features of coho salmon critical habitat include adequate; (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions. The critical habitat for this species was designated before we had implemented the CHART team process, so no determination has been made regarding the various conservation values of the habitat areas the fish inhabit.

California Coastal Chinook Salmon

We designated critical habitat for CC Chinook on September 2, 2005 (70 FR 52488); it includes all river reaches and estuarine areas accessible to listed Chinook salmon from Redwood Creek (Humboldt County, California) to the Russian River (Sonoma County, California), inclusive. Excluded are areas above specific dams or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). Ecologically, the majority of the river systems in this ESU are relatively small and heavily influenced by a maritime climate.

Our assessment of the condition of CC Chinook critical habitat shows PCEs for spawning and rearing habitat in the two major rivers within this ESU—the Eel River and the Russian River—to be severely degraded by the persistence of highly turbid flows during the winter and spring, persisting even at low flows. The persistence is considered to be primarily a result of flows released from Scott Dam on the Eel River and Coyote Valley Dam on the Russian River (Beach 1996, USACE 1982, Ritter and Brown 1971). Migration and rearing habitat PCEs in the Eel River (both riverine and estuarine) are degraded by diminished flows resulting from water storage in Lake Pillsbury (Scott Dam) and by interbasin diversions to the Russian River through the Potter Valley Project tunnel. Rearing habitat PCEs of the Russian River, both riverine and estuarine, are considered to be degraded as a result of land use patterns changing the channel configuration limiting available habitat, and a program of keeping the Russian River estuary breached open to the ocean throughout the year. Within the smaller coastal streams of the ESU which support populations of Chinook, the status of critical habitat PCEs for rearing, spawning, and migration are considered degraded to a lesser extent.

Northern California Steelhead

Critical habitat was designated for NC steelhead on September 2, 2005, when NMFS published a final rule in the Federal Register (70 FR 52488). There are approximately 3,028 miles of stream habitats and 25 square miles of estuary habitats designated as critical habitat for NC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS.

In determining the areas eligible for critical habitat designation, the CHART identified the essential primary constituent elements (PCEs) for species conservation. NC steelhead PCEs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 50 watersheds within the range of this DPS. Nine watersheds received a low rating, 14 received a medium rating, and 27 received a high rating of conservation value to the

DPS. Two estuarine habitats, Humboldt Bay and the Eel River estuary, received a high conservation value rating.

NC steelhead inhabit coastal river basins from Redwood Creek south to, and including, the Gualala River. Major watersheds include Redwood Creek, Mad River, Eel River, and several smaller coastal watersheds southward to the Gualala River. Steelhead from both summer and winter run types are found.

Central California Coast Steelhead

Critical habitat was designated for CCC steelhead on September 2, 2005, when NMFS published a final rule in the Federal Register (70 FR 52488). There are approximately 1,465 miles of stream habitats and 386 square miles of estuary habitats designated as critical habitat for CCC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS.

In determining the areas eligible for critical habitat designation, the CHART identified the essential primary constituent elements (PCEs) for species conservation. CCC steelhead PCEs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 46 watersheds within the range of this DPS. Fourteen watersheds received a low rating, 13 received a medium rating, and 19 received a high rating of conservation value to the DPS.

CCC steelhead inhabit coastal river basins from the Russian River southward to, and including, Aptos Creek as well as naturally spawned populations from the San Francisco/San Pablo bays west of the Sacramento/San Joaquin Delta.

Central Valley Spring-run Chinook Salmon

Critical habitat was designated for CVS Chinook salmon on September 2, 2005, when NMFS published a final rule in the Federal Register (70 FR 52488). There are approximately 1,373 miles of stream habitats and 427 square miles of estuary habitats designated as critical habitat for CVS Chinook salmon. NMFS determined that marine areas did not warrant consideration as critical habitat for this ESU.

In determining the areas eligible for critical habitat designation, the CHART identified the essential primary constituent elements (PCEs) for species conservation. CVS Chinook PCEs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 37 watersheds within the range of this ESU. Seven watersheds received a low rating, three received a medium rating, and 27 received a high rating of conservation value to the ESU. Four of these watersheds comprise portions of the San Francisco-San Pablo-Suisun Bay estuarine complex, which provides rearing and migratory habitat for the ESU.

California Central Valley Steelhead

Critical habitat was designated for CV steelhead on September 2, 2005, when NMFS published a final rule in the Federal Register (70 FR 52488). There are approximately 2,308 miles of stream habitats and 254 square miles of estuary habitats designated as critical habitat for CV steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS.

In determining the areas eligible for critical habitat designation, the CHART identified the essential primary constituent elements (PCEs) for species conservation. CV steelhead PCEs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 67 watersheds within the range of this DPS. Twelve watersheds received a low rating, 18 received a medium rating, and 37 received a high rating of conservation value to the DPS.

South-Central California Coast Steelhead

Critical habitat was designated for SCCC steelhead on September 2, 2005, when NMFS published a final rule in the Federal Register (70 FR 52488). There are approximately 1,249 miles of stream habitats and three square miles of estuary habitats designated as critical habitat for SCCC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS.

In determining the areas eligible for critical habitat designation, the CHART identified the essential primary constituent elements (PCEs) for species conservation. SCCC steelhead PCEs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 30 watersheds within the range of this DPS. Six watersheds received a low rating, 11 received a medium rating, and 13 received a high rating of conservation value to the DPS. Morro Bay, an estuarine habitat, is used as rearing and migratory habitat for spawning and rearing steelhead.

SCCC steelhead inhabit coastal river basins from the Pajaro River south to, but not including, the Santa Maria River. Major watersheds include Pajaro River, Salinas River, Carmel River, and numerous smaller rivers and streams along the Big Sur coast and southward. Only winter-run steelhead are found in this DPS. The climate is drier and warmer than in the north that is reflected in vegetation changes from coniferous forests to chaparral and coastal scrub. The mouths of many rivers and streams in this DPS are seasonally closed by sand berms that form during the low stream flows of summer.

2.2.3.2 Eulachon

We designated critical habitat for eulachon on October 20, 2011 (76 FR 65324). Critical habitat for eulachon includes 16 specific areas in California, Oregon, and Washington. The designated areas are a combination of freshwater creeks and rivers and their associated estuaries, comprising approximately 335 miles of habitat. In our biological report, we found that all of the areas considered for critical habitat designation have a high conservation value. The designated critical habitat areas contain at least one of the following physical and biological features essential to conservation of the species: (1) freshwater spawning and incubation sites; (2) freshwater and estuarine migration corridors; and (3) nearshore and offshore marine foraging sites. Freshwater spawning and incubation sites are essential for successful spawning and offspring production; essential environmental components include specific water flow, quality, and temperature conditions; spawning and incubation substrates; and migratory access. Freshwater and estuarine migration corridors, associated with spawning and incubation sites, are essential for allowing adult fish to swim upstream to reach spawning areas and allowing larval fish to proceed downstream and reach the ocean. Essential environment components include waters free of obstruction; specific water flow, quality, and temperature conditions (for supporting larval and adult mobility), and abundant prey items (for supporting larval feeding after the yolk sac depletion). Nearshore and offshore marine foraging habitat are essential for juvenile and adult survival; essential environmental components include water quality and available prey.

We identified a number of activities that may affect the physical and biological features essential to the southern DPS of eulachon such that special management considerations or protection may be required. Major categories of such activities include: (1) Dams and water diversions; (2) dredging and disposal of dredged material; (3) inwater construction or alterations; (4) pollution and runoff from point and non-point sources; (5) tidal, wind, or wave energy projects; (6) port and shipping terminals; and (7) habitat restoration projects. All of these activities may have an effect on one or more of the essential physical and biological features via their alteration of one or more of the following: stream hydrology; water level and flow; water temperature; dissolved oxygen; erosion and sediment input/transport; physical habitat structure; vegetation; soils; nutrients and chemicals; fish passage; and estuarine/marine prey resources.

2.2.3.3 Green Sturgeon

We designated critical habitat for green sturgeon on October 9, 2009 (74 FR 52300). We designated approximately 320 miles of freshwater river habitat, 897 square miles of estuarine habitat, 11,421 square miles of marine habitat, 487 miles of habitat in the Sacramento-San Joaquin Delta, and 135 square miles of habitat within the Yolo and Sutter bypasses (Sacramento River, CA) as critical habitat for the Southern DPS of green sturgeon. Of the areas considered for critical habitat, the Critical Habitat Review Team rated 18 areas as having high, twelve as having medium, and eleven as having low rating for their conservation value to the DPS. Areas designated for critical habitat include coastal U.S. marine waters within 60 fathoms depth from Monterey Bay, California north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its United States boundary; the lower Columbia River estuary; and certain coastal bays and estuaries in Washington (Willapa Bay and Grays Harbor).

Based on the best available scientific information, we identified PCEs for freshwater riverine systems, estuarine areas, and nearshore marine waters (74 FR 52300). For freshwater riverine systems, the specific PCEs for species conservation are (1) food resources, (2) substrate type or size, (3) water flow, (4) water quality, (5) migratory corridor, (6) water depth, and (7) sediment quality. For estuarine areas, the specific PCEs for species conservation are (1) food resources, (2) water flow, (3) water quality, (4) migratory corridor, (5) water depth, and (6) sediment quality. For coastal marine areas, the specific PCEs for species conservation are (1) migratory corridor, (2) water quality, and (3) food resources.

From analyses of the identified PCEs and examination of economic activities, NMFS verified that at least one activity in each specific area may threaten at least one PCE such that special management considerations or protection may be required (NMFS 2009). Major categories of habitat-related activities include: (1) dams, (2) water diversions, (3) dredging and disposal of dredged material, (4) in-water construction or alterations, (5) National Pollutant Discharge Elimination System (NPDES) activities and activities generating non-point source pollution, (6) power plants, (7) commercial shipping, (8) aquaculture, (9) desalination plants, (10) proposed alternative energy hydrokinetic projects, (11) Liquefied Natural Gas (LNG) projects, (12) habitat restoration, and (13) bottom trawl fisheries.

2.3 Environmental Baseline

The “environmental baseline” includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this opinion is therefore the result of the impacts that many activities (summarized below) have had on the various listed species’ survival and recovery. Because the action area for this opinion includes the totality of the listed species’ ranges in Oregon, Washington, and Idaho (see Section 1.4), many of the past and present impacts on the species themselves (effects on abundance, productivity, etc.) are included in the Status of the Species section (see Section 2.2). That is, for many of the past and present impacts being contemplated here, the physical result of activities in the action area are indistinguishable from those effects described in the previous sections on the species’ rangewide status. With respect to the species’ habitat, the environmental baseline is the combination of these effects on the primary constituent elements (PCEs) that are essential to the conservation of the species.

2.3.1 Summary for all Listed Species

Factors Limiting Recovery

The best scientific information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of west coast salmonids. NMFS’ status reviews, Technical Recovery Team publications, and recovery plans for the listed species considered in this opinion identify several factors that have caused them to decline, as well as those that prevent them from recovering (many of which are the same). These include habitat degradation caused by human development and harvest and hatchery practices. Climate change also represents a potentially significant threat to all listed species. Climate change effects in the action area are as described in section 2.2.1 and highlighted in some species individual status sections. Table 80 is a summary of the major factors limiting recovery of the species considered in this opinion; more details can also be found in the individual discussions of the species’ status.

Neither the documents referenced in Table 80 nor any document referenced in previous sections identifies scientific research as either a cause for any species' decline or a factor preventing its recovery.

Table 80. Major Factors Limiting Recovery, Adapted from Species Recovery Plans.

	Estuarine and Nearshore Marine	Floodplain Connectivity and Function	Channel Structure and Complexity	Stream Substrate	Stream Flow	Water Quality	Fish Passage	Harvest-related Adverse Effects	Predation/Competition/ Disease	Hydropower Adverse Effects
PS Chinook	●	●	●	●		●				
PS Steelhead	●	●	●	●		●				
HCS Chum	●	●	●	●	●					
SR fall Chinook		●	●					●		●
SR s/s Chinook		●	●	●	●	●				●
SNR Steelhead		●	●	●	●	●	●		●	●
UCR Steelhead		●		●	●	●	●		●	●
MCR Steelhead		●		●	●	●	●		●	●
CR Chum	●	●	●	●	●		●			
LCR Chinook	●	●	●	●	●		●	●		
LCR Coho		●	●	●	●	●		●		
LCR Steelhead		●	●	●	●	●	●		●	
UWR Steelhead		●	●		●		●			
UWR Chinook		●	●			●	●			
OC Coho		●	●	●	●	●			●	
SONCC Coho	●	●	●	●	●	●	●	●	●	
CC Chin	●	●	●	●	●	●	●	●	●	●
NC Steelhead	●	●	●	●	●	●	●	●	●	●
CCC Steelhead	●	●	●	●	●	●	●	●	●	●
CVS Chinook	●	●	●	●	●	●	●	●	●	●
CCV Steelhead	●	●	●		●	●	●	●	●	●
SCCC Steelhead	●	●	●	●	●	●	●	●	●	●
S. DPS Green Sturgeon	●	●	●	●	●	●	●			
S. DPS Eulachon				●		●	●	●	●	

For detailed information on how various factors have degraded PCEs in the Washington, Idaho, Oregon, and California please see any of the following references Busby et al. (1996), Ford (2011), Good et al. (2005), Gustafson et al. (2010), Jacobs et al. (2002), LCFRB (2004), LCFRB (2010), McElhaney et al. (2004), NMFS (1991), NMFS (1997), NMFS (1998), NMFS (2004), NMFS (2008), NMFS (2011), Nickelson et al. (1992), ODFW (2005b), ODFW (2010a), Stout et al. (2011), Weitkamp et al. (1995), Ford et al. 2010, and WDFW (2010a).

Research Effects

Although not identified as a factor for decline or a threat preventing recovery, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed salmonids. For the year 2018, NMFS has issued numerous section 10(a)(1)(A) scientific research permits and a section 4(d) Tribal Plan Limit authorization allowing lethal and non-lethal take of listed species (Table 81).

Table 81. Total Expected Take of Salmon and Steelhead for Scientific Research and Monitoring in 2018.

DPS/ESU	Origin	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
PS Chinook	Natural	871	33	175,924	5,715
	Listed Hatchery Intact Adipose	875	12	14,625	2,255
	Listed Hatchery Adipose Clip	1,542	119	113,859	10,644
PS Steelhead	Natural	399	9	31,091	555
	Listed Hatchery Intact Adipose	0	0	157	6
	Listed Hatchery Adipose Clip	29	4	1,302	52
HCS Chum	Natural	24	4	34,948	433
	Listed Hatchery Intact Adipose	0	0	80	2
SR fall Chinook	Natural	240	7	949	66
	Listed Hatchery Intact Adipose	200	2	56	12
	Listed Hatchery Adipose Clip	232	6	622	46
SR s/s Chinook	Natural	3,012	19	432,518	4,909
	Listed Hatchery Intact Adipose	788	7	43,809	421
	Listed Hatchery Adipose Clip	2,007	12	16,990	299
SR Steelhead	Natural	6,905	83	147,469	2,060
	Listed Hatchery Intact Adipose	2,050	28	33,650	357
	Listed Hatchery Adipose Clip	2,475	38	25,480	344
UCR Steelhead	Natural	218	2	47,330	975
	Listed Hatchery Intact Adipose	90	2	3,206	86
	Listed Hatchery Adipose Clip	216	4	10,755	250
MCR Steelhead	Natural	41	0	55,882	1,186
	Listed Hatchery Intact Adipose	0	0	100	3
	Listed Hatchery Adipose Clip	25	0	886	34
CR Chum	Natural	35	1	3,530	113
	Listed Hatchery Intact Adipose	0	0	12	12

DPS/ESU	Origin	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
LCR Chinook	Natural	120	2	16,334	516
	Listed Hatchery Intact Adipose	7	0	433	50
	Listed Hatchery Adipose Clip	128	2	3,113	307
LCR Coho	Natural	669	6	12,437	394
	Listed Hatchery Intact Adipose	30	0	387	109
	Listed Hatchery Adipose Clip	503	8	4,580	992
LCR Steelhead	Natural	1,082	11	8,420	289
	Listed Hatchery Adipose Clip	89	2	1,444	66
UWR Chinook	Natural	35	0	3,375	181
	Listed Hatchery Intact Adipose	0	0	16	7
	Listed Hatchery Adipose Clip	36	0	2,712	172
UWR Steelhead	Natural	22	0	1,717	61
OC Coho	Natural	45	0	2,795	207
	Listed Hatchery Adipose Clip	13	0	260	20
SONCC Coho	Natural	92	14	71,753	1,349
	Listed Hatchery Intact Adipose	23	13	9,153	706
	Listed Hatchery Adipose Clip	21	3	121	25
CC Chinook	Natural	590	34	48,986	1,193
NC Steelhead	Natural	508	13	130,564	2,964
CCC Steelhead	Natural	2,353	47	221,927	5,399
	Listed Hatchery Intact Adipose	0	0	6,200	124
CV Chinook	Listed Hatchery Adipose Clip				
	Natural	684	24	402,362	12,015
CCV Steelhead	Listed Hatchery Adipose Clip	755	294	11,792	3,262
	Natural	2,605	77	50,114	1,854
	Listed Hatchery Adipose Clip	1,910	132	24,716	1,940
SCCC Steelhead	Natural	200	6	28,664	988
green sturgeon	Natural	148	6	2,097	119
eulachon	Natural	3,986	2,916	405	356

Actual take levels associated with these activities are almost certain to be a good deal lower than the permitted levels. There are two reasons for this. First, most researchers do not handle or kill the full number of outmigrants (or adults) they are allowed. Our research tracking system reveals that researchers, on average, end up taking only about 28% of the number of fish they request and the actual mortality is only about 15% of what they request. Second, the estimates of mortality for each proposed study are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer fish—especially juveniles—would be killed during any given research project than the researchers are allotted, in some cases many fewer.

2.4 Effects of the Action on the Species and Their Designated

Critical Habitat

“Effects of the action” means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

2.4.1 Effects on Species

As discussed further below, the proposed research activities will have no measurable effects on the listed salmonids' habitat. The actions are therefore not likely to jeopardize any of the listed salmonids by reducing the ability of that habitat to contribute to their survival and recovery.

The primary effect of the proposed research will be on the listed species in the form of capturing and handling the fish. Harassment caused by capturing, handling, and releasing fish generally leads to stress and other sub-lethal effects that are difficult to assess in terms of their impact on individuals, let alone entire species.

The following subsections describe the types of activities being proposed. Each is described in terms broad enough to apply to all the permits. The activities would be carried out by trained professionals using established protocols. The effects of the activities are well documented and discussed in detail below. The state fisheries agencies submittals (CDFW 2017, IDFG 2017, ODFW 2017, and WDFW 2017) include NMFS’ uniform, pre-established set of mitigation measures. These measures are incorporated (where relevant) into every research project approval as part of the conditions to which a researcher must adhere.

Observing/Harassing

For some parts of the proposed studies, listed fish would be observed in-water (e.g., by snorkel surveys or from the banks). Direct observation is the least disruptive method for determining a species’ presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting the fishes’ behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water or behind or under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times the research involves observing adult fish—which are more sensitive to disturbance. During some of the research activities discussed below, redds may be visually inspected, but per NMFS’ pre-established mitigation measures (included in state fisheries agency submittals), would not be walked on. Harassment is the primary form of take associated with these observation activities, and few if any injuries (and no deaths) are expected to occur—particularly in cases where the researchers observe from the stream banks rather than in the water. Because these effects are so small, there is little a researcher can do to mitigate them except to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves, and allow any disturbed fish the time they need to reach cover.

Capturing/handling

Any physical handling or psychological disturbance is known to be stressful to fish (Sharpe et al. 1998). The primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the river and wherever the fish are held), dissolved oxygen conditions, the amount of time that fish are held out of the water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps if the traps are not emptied regularly. Decreased survival of fish can result when stress levels are high because stress can be immediately debilitating and may also increase the potential for vulnerability to subsequent challenges (Sharpe et al. 1998). Debris buildup at traps can also kill or injure fish if the traps are not monitored and cleared regularly. The permit conditions identified earlier in subsection 1.3 contain measures that mitigate the factors that commonly lead to stress and trauma from handling, and thus minimize the harmful effects of capturing and handling fish. When these measures are followed, fish typically recover fairly rapidly from handling.

Electrofishing

Electrofishing is a process by which an electrical current is passed through water containing fish in order to stun them—thus making them easy to capture. It can cause a suite of effects ranging from simply disturbing the fish to actually killing them. The amount of unintentional mortality attributable to electrofishing varies widely depending on the equipment used, the settings on the equipment, and the expertise of the technician.

Most of the studies on the effects of electrofishing on fish have been conducted on adult fish greater than 300 mm in length (Dalbey et al. 1996). Electrofishing can have severe effects on adult salmonids. Spinal injuries in adult salmonids from forced muscle contraction have been documented. Sharber and Carothers (1988) reported that electrofishing killed 50 percent of the adult rainbow trout in their study. The relatively few studies that have been conducted on juvenile salmonids indicate that spinal injury rates are substantially lower than they are for large fish. Smaller fish are subjected to a lower voltage gradient than larger fish (Sharber and Carothers 1988) and may, therefore, be subject to lower injury rates (e.g., Hollender and Carline 1994, Dalbey et al. 1996, Thompson et al. 1997). McMichael et al. (1998) found a 5.1% injury rate for juvenile Middle Columbia River steelhead captured by electrofishing in the Yakima River subbasin. The incidence and severity of electrofishing damage is partly related to the type of equipment used and the waveform produced (Sharber and Carothers 1988, McMichael 1993, Dalbey et al. 1996; Dwyer and White 1997). Continuous direct current (DC) or low-frequency (30 Hz) pulsed DC have been recommended for electrofishing (Fredenberg 1992; Snyder 1992, 1995; Dalbey et al. 1996) because lower spinal injury rates, particularly in salmonids, occur with these waveforms (Fredenberg 1992, McMichael 1993, Sharber et al. 1994, Dalbey et al. 1996). Only a few recent studies have examined the long-term effects of electrofishing on salmonid survival and growth (Dalbey et al. 1996, Ainslie et al. 1998). These studies indicate that although some of the fish suffer spinal injury, few die as a result. However, severely injured fish grow at slower rates and sometimes they show no growth at all (Dalbey et al. 1996).

Permit conditions will require that all researchers follow NMFS' electrofishing guidelines (NMFS 2000). The guidelines require that field crews be trained in observing animals for signs of stress and shown how to adjust electrofishing equipment to minimize that stress. All areas are visually searched for fish before electrofishing may begin. Electrofishing is not done in the vicinity of redds or spawning adults. All electrofishing equipment operators are trained by qualified personnel to be familiar with equipment handling, settings, maintenance, and safety. Operators work in pairs to increase both the number of fish that may be seen and the ability to identify individual fish without having to net them. Working in pairs also allows the researcher to net fish before they are subjected to higher electrical fields. Only DC units are used, and the equipment is regularly maintained to ensure proper operating condition. Voltage, pulse width, and rate are kept at minimal levels and water conductivity is tested at the start of every electrofishing session so those minimal levels can be determined. Due to the low settings used, shocked fish normally revive instantaneously. Fish requiring revivification receive immediate, adequate care. In all cases, electrofishing is used only when other survey methods are not feasible.

The preceding discussion focused on the effects of using a backpack unit for electrofishing and the ways those effects would be mitigated. In larger streams and rivers, electrofishing units are sometimes mounted on boats or rafts. These units often use more current than backpack electrofishing equipment because they need to cover larger (and deeper) areas and, as a result, can have a greater impact on fish. In addition, the environmental conditions in larger, more turbid streams can limit researchers' ability to minimize impacts on fish. That is, in areas of lower visibility it can be difficult for researchers to detect the presence of adults and thereby take steps to avoid them. In any case, the permit conditions requiring the researchers to follow NMFS' electrofishing guidelines apply to researchers intending to use boat electrofishing as well. Furthermore, the permit conditions prohibit the researcher from intentionally targeting adult fish and the researcher must stop electrofishing if they encounter an adult fish.

Screw trapping

Smolt, rotary screw (and other out-migration) traps, are generally used to obtain information on natural population abundance and productivity. On average, they achieve a sample efficiency of four to 20% of the emigrating population from a river or stream--depending on river size. Although under some conditions traps may achieve a higher efficiency for a relatively short period of time (NMFS 2003b). Based on years of sampling at hundreds of locations under hundreds of scientific research authorizations, we would expect the mortality rates for fish captured at rotary screw type traps to be one percent or less.

The trapping, capturing, or collecting and handling of juvenile fish using traps is likely to cause some stress on listed fish. However, fish typically recover rapidly from handling procedures. The primary factors that contribute to stress and mortality from handling are excessive doses of anesthetic, differences in water temperature, dissolved oxygen conditions, the amount of time that fish are held out of water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 64.4 degrees F (18 degrees C) or if dissolved oxygen is below saturation. Additionally, stress can occur if there are more than a few degrees difference in water temperature between the stream/river and the holding tank.

The potential for unexpected injuries or mortalities among listed fish is reduced in a number of ways. These can be found in the individual study protocols and in the permit conditions stated earlier. In general, screw traps are checked at least daily and usually fish are handled in the morning. This ensures that the water temperature is at its daily minimum when fish are handled. Also, fish may not be handled if the water temperature exceeds 69.8 degrees Fahrenheit (21 degrees C). Great care must be taken when transferring fish from the trap to holding areas and the most benign methods available are used—often this means using sanctuary nets when transferring fish to holding containers to avoid potential injuries. The investigators' hands must be wet before and during fish handling. Appropriate anesthetics must be used to calm fish subjected to collection of biological data. Captured fish must be allowed to fully recover before being released back into the stream and will be released only in slow water areas. And often, several other stringent criteria are applied on a case-by case basis: safety protocols vary by river velocity and trap placement, the number of times the traps are checked varies by water and air temperatures, the number of people working at a given site varies by the number of outmigrants expected, etc. All of these protocols and more are used to make sure the mortality rates stay at one percent or lower.

Angling

Fish that are caught with hook and line and released alive may still die as a result of injuries and stress they experience during capture and handling. The likelihood of killing a fish varies widely, based on a number of factors including the type of hook used (barbed vs barbless), the type of bait used (natural vs artificial), the water temperature, anatomical hooking location, the species, and the care with which the fish is released (level of air exposure and length of time for hook removal).

The available information assessing hook and release mortality of adult steelhead suggests that hook and release mortality with barbless hooks and artificial bait is low. Nelson et al (2005) reported an average mortality of 3.6% for adult steelhead that were captured using barbless hooks and radio tagged in the Chilliwack River, BC. The authors also note that there was likely some tag loss and the actual mortality might be lower. Hooton (1987) found catch and release mortality of adult winter steelhead to average 3.4% (127 mortalities of 3,715 steelhead caught) when using barbed and barbless hooks, bait, and artificial lures. Among 336 steelhead captured on various combinations of popular terminal gear in the Keogh River, the mortality of the combined sample was 5.1%. Natural bait had slightly higher mortality (5.6%) than did artificial lures (3.8%), and barbed hooks (7.3%) had higher mortality than barbless hooks (2.9%). Hooton (1987) concluded that catching and releasing adult steelhead was an effective mechanism for maintaining angling opportunity without negatively impacting stock recruitment. Reingold (1975) showed that adult steelhead hooked, played to exhaustion, and then released returned to their target spawning stream at the same rate as steelhead not hooked and played to exhaustion. Pettit (1977) found that egg viability of hatchery steelhead was not negatively affected by catch-and-release of pre-spawning adult female steelhead. Bruesewitz (1995) found, on average, fewer than 13% of harvested summer and winter steelhead in Washington streams were hooked in critical areas (tongue, esophagus, gills, eye). The highest percentage (17.8%) of critical area hookings occurred when using bait and treble hooks in winter steelhead fisheries.

The referenced studies were conducted when water temperatures were relatively cool, and primarily involve winter-run steelhead. Catch and release mortality of steelhead is likely to be higher if the activity occurs during warm water conditions. In a study conducted on the catch and release mortality of steelhead in a California river, Taylor and Barnhart (1999) reported over 80% of the observed mortalities occurred at stream temperatures greater than 21 degrees C. Catch and release mortality during periods of elevated water temperature are likely to result in post-release mortality rates greater than reported by Nelson et al (2005) or (Hooton (1987) because of warmer water and that fact that summer fish have an extended freshwater residence that makes them more likely to be caught. As a result, NOAA Fisheries expects steelhead hook and release mortality to be in the lower range discussed above.

Juvenile steelhead occupy many waters that are also occupied by resident trout species and it is not possible to visually separate juvenile steelhead from similarly-sized, stream-resident, rainbow trout. Because juvenile steelhead and stream-resident rainbow trout are the same species, are similar in size, and have the same food habits and habitat preferences, it is reasonable to assume that catch-and-release mortality studies on stream-resident trout are similar for juvenile steelhead. Where angling for trout is permitted, catch-and-release fishing with prohibition of use of bait reduces juvenile steelhead mortality more than any other angling regulatory change. Artificial lures or flies tend to superficially hook fish, allowing expedited hook removal with minimal opportunity for damage to vital organs or tissue (Muoneke and Childress, 1994). Many studies have shown trout mortality to be higher when using bait than when angling with artificial lures and/or flies (Taylor and White 1992; Schill and Scarpella 1995; Muoneke and Childress 1994; Mongillo 1984; Wydoski 1977; Schisler and Bergersen 1996). Wydoski (1977) showed the average mortality of trout, when using bait, to be more than four times greater than the mortality associated with using artificial lures and flies. Taylor and White (1992) showed average mortality of trout to be 31.4% when using bait versus 4.9 and 3.8% for lures and flies, respectively. Schisler and Bergersen (1996) reported average mortality of trout caught on passively fished bait to be higher (32%) than mortality from actively fished bait (21%). Mortality of fish caught on artificial flies was only 3.9%. In the compendium of studies reviewed by Mongillo (1984), mortality of trout caught and released using artificial lures and single barbless hooks was often reported at less than 2%.

Most studies have found a notable difference in the mortality of fish associated with using barbed versus barbless hooks (Huhn and Arlinghuas 2011; Bartholomew and Bohnsack 2005; Taylor and White 1992; Mongillo 1984; Wydoski 1977). Researchers have generally concluded that barbless hooks result in less tissue damage, they are easier to remove, and because they are easier to remove the handling time is shorter. In summary, catch-and-release mortality of steelhead is generally lowest when researchers are restricted to use of artificial flies and lures. As a result, all steelhead sampling via angling must be carried out using barbless artificial flies and lures.

Only a few reports are available that provide empirical evidence showing what the catch and release mortality is for Chinook salmon in freshwater. The ODFW has conducted studies of hooking mortality incidental to the recreational fishery for Chinook salmon in the Willamette River. A study of the recreational fishery estimates a per-capture hook-and-release mortality for wild spring Chinook in Willamette River fisheries of 8.6% (Schroeder et al. 2000), which is similar to a mortality of 7.6% reported by Bendock and Alexandersdottir (1993) in the Kenai River, Alaska.

A second study on hooking mortality in the Willamette River, Oregon, involved a carefully controlled experimental fishery, and mortality was estimated at 12.2% (Lindsay et al. 2004). In hooking mortality studies, hooking location, gear type, and unhook time is important in determining the mortality of released fish. Fish hooked in the jaw or tongue suffered lower mortality (2.3 and 17.8% in Lindsay et al. (2004)) compared to fish hooked in the gills or esophagus (81.6 and 67.3%). Numerous studies have reported that deep hooking is more likely to result from using bait (e.g. eggs, prawns, or ghost shrimp) than lures (Lindsay et al 2004). One theory is that bait tends to be passively fished and the fish is more likely to swallow bait than a lure. Passive angling techniques (e.g. drift fishing) are often associated with higher hooking mortality rates for salmon while active angling techniques (e.g. trolling) are often associated with lower hooking mortality rates (Rogers et al 1999).

Catch and release fishing does not seem to have an effect on migration. Lindsay et al. (2004) noted that “hooked fish were recaptured at various sites at about the same frequency as control fish”. Bendock and Alex (1993) found that most of their tagged fish later turned up on the spawning grounds. Cowen et al (2007) found little evidence of an adverse effect on spawning success for Chinook.

Not all of the fish that are hooked are subsequently landed. We were unable to find any studies that measured the effect of hooking and losing a fish. However, it is reasonable to assume that nonlanded morality would be negligible, as fish lost off the hook are unlikely to be deeply hooked and would have little or no wound and bleeding (Cowen et al 2007).

Based on the available data, the *U.S. v. Oregon* Technical Advisory Committee has adopted a 10% rate in order to make conservative estimates of incidental mortality in fisheries (TAC 2008). Nonetheless, given the fact that no ESA section 10 permit or 4(d) authorization may “operate to the disadvantage of the species,” we allow no more than a three percent mortality rate for any listed species collected via angling, and all such activities must employ barbless artificial lures and flies.

Gastric Lavage

Knowledge of the food and feeding habits of fish are important in the study of aquatic ecosystems. However, in the past, food habit studies required researchers to kill fish for stomach removal and examination. Consequently, several methods have been developed to remove stomach contents without injuring the fish. Most techniques use a rigid or semi-rigid tube to inject water into the stomach to flush out the contents.

Few assessments have been conducted regarding the mortality rates associated with nonlethal methods of examining fish stomach contents (Kamler and Pope 2001). However, Strange and Kennedy (1981) assessed the survival of salmonids subjected to stomach flushing and found no difference between stomach-flushed fish and control fish that were held for three to five days. In addition, when Light et al. (1983) flushed the stomachs of electrofished and anesthetized brook trout, survival was 100% for the entire observation period. In contrast, Meehan and Miller (1978) determined the survival rate of electrofished, anesthetized, and stomach flushed wild and hatchery coho salmon over a 30-day period to be 87% and 84% respectively.

Tissue Sampling

Tissue sampling techniques such as fin-clipping are common to many scientific research efforts using listed species. All sampling, handling, and clipping procedures have an inherent potential to stress, injure, or even kill the fish. This section discusses tissue sampling processes and its associated risks.

Fin clipping is the process of removing part or all of one or more fins to obtain non-lethal tissue samples and alter a fish’s appearance (and thus make it identifiable). When entire fins are removed, it is expected that they will never grow back. Alternatively, a permanent mark can be made when only a part of the fin is removed or the end of a fin or a few fin rays are clipped. Although researchers have used all fins for marking at one time or another, the current preference is to clip the adipose, pelvic, or pectoral fins. Marks can also be made by punching holes or cutting notches in fins, severing individual fin rays (Welch and Mills 1981), or removing single prominent fin rays (Kohlhorst 1979). Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat varied; however, it can be said that fin clips do not generally alter fish growth. Studies comparing the growth of clipped and unclipped fish generally have shown no differences between them (e.g., Brynildson and Brynildson 1967). Moreover, wounds caused by fin clipping usually heal quickly—especially those caused by partial clips.

Mortality among fin-clipped fish is also variable. Some immediate mortality may occur during the marking process, especially if fish have been handled extensively for other purposes (e.g., stomach sampling). Delayed mortality depends, at least in part, on fish size; small fishes have often been found to be susceptible to it and Coble (1967) suggested that fish shorter than 90 mm are at particular risk. The degree of mortality among individual fishes also depends on which fin is clipped. Studies show that adipose- and pelvic-fin-clipped coho salmon fingerlings have a 100% recovery rate (Stolte 1973). Recovery rates are generally recognized as being higher for adipose- and pelvic-fin-clipped fish in comparison to those that are clipped on the pectoral, dorsal, and anal fins (Nicola and Cordone 1973). Clipping the adipose and pelvic fins probably kills fewer fish because these fins are not as important as other fins for movement or balance (McNeil and Crossman 1979). Mortality is generally higher when the major median and pectoral fins are clipped. Mears and Hatch (1976) showed that clipping more than one fin may increase delayed mortality, but other studies have been less conclusive.

Tagging/Marking

Techniques such as Passive Integrated Transponder (PIT) tagging, coded wire tagging, fin-clipping, and the use of radio transmitters are common to many scientific research efforts using listed species. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish. This section discusses each of the marking processes and its associated risks.

A PIT tag is an electronic device that relays signals to a radio receiver; it allows salmonids to be identified whenever they pass a location containing such a receiver (e.g., any of several dams) without researchers having to handle the fish again. The tag is inserted into the body cavity of the fish just in front of the pelvic girdle. The tagging procedure requires that the fish be captured and extensively handled; therefore any researchers engaged in such activities will follow the conditions listed previously in this Opinion (as well as any permit-specific conditions) to ensure that the operations take place in the safest possible manner. In general, the tagging operations will take place where there is cold water of high quality, a carefully controlled environment for administering anesthesia, sanitary conditions, quality control checking, and a carefully regulated holding environment where the fish can be allowed to recover from the operation.

PIT tags have very little effect on growth, mortality, or behavior. The few reported studies of PIT tags have shown no effect on growth or survival (Prentice et al., 1987; Jenkins and Smith, 1990; Prentice et al., 1990). For example, in a study between the tailraces of Lower Granite and McNary Dams (225 km), Hockersmith et al. (2000) concluded that the performance of yearling chinook salmon was not adversely affected by gastrically- or surgically implanted sham radio tags or PIT-tags. Additional studies have shown that growth rates among PIT-tagged Snake River juvenile fall chinook salmon in 1992 (Rondorf and Miller, 1994) were similar to growth rates for salmon that were not tagged (Conner et al., 2001). Prentice and Park (1984) also found that PIT-tagging did not substantially affect survival in juvenile salmonids.

Coded wire tags (CWTs) are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, hatchery of origin, and so forth (Nielsen, 1992). The tags are intended to remain within the animal indefinitely, consequently making them ideal for long-term, population-level assessments of Pacific Northwest salmon. The tag is injected into the nasal cartilage of a salmon and therefore causes little direct tissue damage (Bergman et al., 1968; Bordner et al., 1990). The conditions under which CWTs may be inserted are similar to those required for applying PIT-tags.

A major advantage to using CWTs is the fact that they have a negligible effect on the biological condition or response of tagged salmon; however, if the tag is placed too deeply in the snout of a fish, it may kill the fish, reduce its growth, or damage olfactory tissue (Fletcher et al. 1987; Peltz and Miller 1990). This latter effect can create problems for species like salmon because they use olfactory clues to guide their spawning migrations (Morrison and Zajac 1987).

In order for researchers to be able to determine later (after the initial tagging) which fish possess CWTs, it is necessary to mark the fish externally—usually by clipping the adipose fin—when the CWT is implanted (see text below for information on fin clipping). One major disadvantage to recovering data from CWTs is that the fish must be killed in order for the tag to be removed. However, this is not a significant problem because researchers generally recover CWTs from salmon that have been taken during the course of commercial and recreational harvest (and are therefore already dead).

The other primary method for tagging fish is to implant them with acoustic tags, radio tags, or archival loggers. There are two main ways to accomplish this and they differ in both their characteristics and consequences. First, a tag can be inserted into a fish's stomach by pushing it past the esophagus with a plunger. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways.

The second method for implanting tags is to place them within the body cavities of (usually juvenile) salmonids. These tags do not interfere with feeding or movement. However, the tagging procedure is difficult, requiring considerable experience and care (Nielsen 1992). Because the tag is placed within the body cavity, it is possible to injure a fish's internal organs. Infections of the sutured incision and the body cavity itself are also possible, especially if the tag and incision are not treated with antibiotics (Chisholm and Hubert 1985; Mellas and Haynes 1985).

Fish with internal tags often die at higher rates than fish tagged by other means because tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982; Matthews and Reavis 1990; Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance. As with the other forms of tagging and marking, researchers will keep the harm caused by tagging to a minimum by following the conditions in the permits as well as any other permit-specific requirements.

Sacrifice

In some instances, it is necessary to kill a captured fish in order to gather whatever data a study is designed to produce. In such cases, determining effect is a very straightforward process: the sacrificed fish, if juveniles, are forever removed from the gene pool; if the fish are adults, the effect depends upon whether they are killed before or after they have a chance to spawn. If they are killed after they spawn, there is very little overall effect. Essentially, it amounts to removing the nutrients their bodies would have provided to the spawning grounds. If they are killed before they spawn, not only are they removed from the population, but so are all their potential progeny. Thus, killing pre-spawning adults has the greatest potential to affect the listed species. Because of this, NMFS rarely allows it to happen. And, in almost every instance where it is allowed, the adults are stripped of sperm and eggs so their progeny can be raised in a controlled environment such as a hatchery—thereby greatly decreasing the potential harm posed by sacrificing the adults.

2.4.2 Species-specific Effects of the Action

In the “Status of the Species” section, we estimated the average annual abundance for adult and juvenile listed salmonids. For most of the listed species, we estimated abundance for adult returning fish and outmigrating smolts. We estimated parr abundance for OC coho. For hatchery propagated juvenile salmonids, we use hatchery production goals. Table 82 (below) displays the estimated annual abundance of hatchery-propagated and naturally produced listed salmonids.

Table 82. Summary of Estimated Annual Abundance of Listed Species.

Species	Life Stage	Origin/Production		
		Natural	Listed Hatchery Intact Adipose*	Listed Hatchery Adipose Clip*
PS Chinook	Adult	18,413	13,227	
	Smolt	2,531,163	7,172,240	36,097,500
PS Steelhead	Adult	18,257		
	Smolt	2,076,734	113,500	110,230
HCS Chum	Adult	25,538	1,935	
	Smolt	4,017,929	150,000	
SR fall Chinook	Adult	11,254	26,558	
	Smolt	585,720	2,878,985	2,707,553
SR spr/sum Chinook	Adult	11,347	5,696	
	Smolt	1,383,142	1,007,592	4,453,059
SR Steelhead	Adult	33,340	300,060	
	Smolt	804,571	749,088	3,345,005
UCR Steelhead	Adult	2,846	6,579	
	Smolt	176,213	159,702	642,307
MCR Steelhead	Adult	23,872	1,842	
	Smolt	417,206	93,680	360,184
CR Chum	Adult	10,644	426	
	Smolt	5,362,740	648,047	6512.2
LCR Chinook	Adult	29,469	38,594	
	Smolt	12,164,845	1,204,984	33,631,872
LCR Coho	Adult	32,986	23,082	
	Smolt	639,015	215,952	7,424,506
LCR Steelhead	Adult	12,920	22,297	
	Smolt	323,607	22,649	1,194,301
UWR Chinook	Adult	11,443	34,454	

	Smolt	1,275,681	16,278	5,543,371
UWR Steelhead	Adult	5,971		
	Smolt	143,898		
OC Coho	Adult	234,203	2,046	
	Parr	16,394,210		60,000
SONCC Coho	Adult	9,056	10,934	
	Parr	1,101,382	575,000	200,000
CC Chinook	Adult	7,034		
	Smolt	1,278,078		
NC Steelhead	Adult	7,221		
	Smolt	821,389		
CCC Steelhead	Adult	2,187	3,866	
	Smolt	248,771		600,000
CVS Chinook	Adult	11,468	8,213	
	Smolt	2,386,000		2,878,601
CCV Steelhead	Adult	1,686	3,856	
	Smolt	630,403		1,600,653
SCCC Steelhead	Adult	695		
	Smolt	79,057		
Green Sturgeon	Adult	1,348		
Eulachon	Adult	81,736,000		

* We do not have separate estimates for adult adipose fin-clipped and intact adipose fin hatchery fish.

2.4.2.1 Puget Sound Chinook Salmon

The specific projects and related take estimates are described in detail in the WDFW submittal (WDFW 2017) and that document is incorporated in full herein. The WDFW would conduct, oversee, or coordinate 16 projects that could take PS Chinook salmon. The majority of planned research (13 out of 16 projects) involves activities that are not intended to kill listed salmon. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 83.

Table 83. Summary of Proposed Take of PS Chinook Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	101,229	590
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	172,885	1,846
	Natural	Intentional (Directed) Mortality	1,085	1,085
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	1,417	14

	Listed Hatchery Intact Adipose	Capture/Mark, Tag, Sample Tissue/Release Live Animal	22,000	330
	Listed Hatchery Intact Adipose	Intentional (Directed) Mortality	140	140
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	21,514	167
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	995	30
	Listed Hatchery Adipose Clip	Intentional (Directed) Mortality	568	568
Adult	Natural	Capture/Handle/Release Fish	47	0
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	20	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	47	0
Spawned Adult/ Carcass	Natural	Capture/Handle/Release Fish	10	0
	Natural	Observe/Sample Tissue Dead Animal	230	0
	Listed Hatchery Intact Adipose	Observe/Sample Tissue Dead Animal	150	0
	Listed Hatchery Adipose Clip	Observe/Sample Tissue Dead Animal	150	0

Researchers, when submitting their applications, estimated the number of juvenile and adult PS Chinook salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed PS Chinook, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would take spawned adult/carcass Chinook salmon are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 84. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of PS Chinook Salmon.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed*
Juvenile	Natural	302,719	12%	3,873	0.2%
	Listed Hatchery Intact Adipose	25,913	0.4%	532	0.007%
	Listed Hatchery Adipose Clip	25,385	0.07%	842	0.002%
Adult	Natural	52	0.3%	0	0%
	Listed Hatchery Intact Adipose	22	0.6%	0	0%

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed*
	Listed Hatchery Adipose Clip	52		0	

*We do not have separate abundance estimates for the two types of adult listed hatchery fish.

Three of WDFW's projects would intentionally kill natural- and hatchery-origin juvenile PS Chinook. The first of these projects has requested to intentionally kill 625 naturally produced juvenile PS Chinook which would be collected from estuarine and nearshore marine habitats throughout the Puget Sound. Thus, no population is likely to experience a disproportionate amount of these losses.

The second project that has requested to intentionally kill juvenile PS Chinook salmon would collect 360 naturally produced juvenile PS Chinook in the Duwamish River basin. The purpose of the research is to determine the proportion of unmarked naturally produced Chinook to unmarked hatchery Chinook. The Duwamish population is estimated to produce roughly 188,698 natural outmigrants annually (Table 6). The WDFW project would therefore kill up to 0.2% of the expected abundance of naturally produced juvenile PS Chinook in the Duwamish population. The research would likely have only a very small impact on the population's abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity at either the population or the species level.

The final project that has requested to intentionally kill juvenile PS Chinook salmon would collect 100 naturally produced juvenile Chinook salmon in the Nisqually River basin. The purpose of the project is to describe the migration timing, diet, habitat preferences, and interactions between hatchery- and natural-origin Chinook and coho. The Nisqually population is estimated to produce roughly 159,971 natural outmigrants annually (Table 6). The WDFW project would therefore kill up to 0.06% of the expected abundance of naturally produced juvenile PS Chinook in the Nisqually population. The research would likely have only a very small impact on the population's abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity at either the population or the species level. For all three of the projects requesting intentional mortalities, the researchers will catch far more fish than they plan to kill. Researchers will concentrate their lethal take on fish that appear to be stressed, likely to die, or are already dead at the time of capture. If possible, the researchers will collect some of the fish from other projects that may have unintentionally killed juvenile PS Chinook.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be killed. When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low: a maximum of 0.2% may be killed from any component of the species. Furthermore, the effects from all of the proposed research would be spread out over most of the major tributaries of the Puget Sound basin. The intentional mortality in the Nisqually and Duwamish projects would account for 11% of the total expected mortality from the proposed research; the rest would affect the species more or less uniformly. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program at the population and ESU level will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 37% of the number of fish they requested and the actual mortality was only 42% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. The largest of WDFW's projects in the Puget Sound basin accounts for 44% of the take of PS Chinook salmon. This project is part of WDFW's IMW program. The premise of the IMW project is that the complex relationships controlling salmon response to habitat conditions can best be understood by concentrating monitoring and research efforts at a few locations. Focusing efforts on a few locations allows enough data on an ecosystem's physical and biological attributes of systems to be collected that becomes possible to evaluate effects of restoration treatments on salmon production and that information, in turn, may be used to design and refine further recovery actions. We expect the research actions to generate lasting benefits to conservation of the listed fish. The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the programs can be found in the state fishery agency submittals.

2.4.2.2 Puget Sound Steelhead

The specific projects and related take estimates are described in detail in WDFW's submittal (WDFW 2017) and that document is incorporated in full herein. The WDFW would conduct, oversee, or coordinate 21 projects that could affect PS steelhead. The majority of planned research (19 out of 21 projects) involves activities that are not intended to kill listed steelhead. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 85.

Table 85. Summary of Proposed Take of PS Steelhead.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	12,174	152
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	16,600	248
	Natural	Intentional (Directed) Mortality	182	182
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	540	5
	Listed Hatchery Intact Adipose	Intentional (Directed) Mortality	14	14
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	2,903	35
	Listed Hatchery Adipose Clip	Intentional (Directed) Mortality	14	14

Adult	Natural	Capture/Handle/Release Fish	27	0
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	945	14
	Listed Hatchery Intact Adipose	Capture/Mark, Tag, Sample Tissue/Release Live Animal	10	0
Spawned Adult/Carcass	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	17	0

Researchers, when submitting their applications, estimated the number of juvenile and adult PS steelhead that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed PS steelhead, the requested take and requested mortality in this evaluation were increased by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would take spawned adult/carcass steelhead are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 86. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of PS Steelhead.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	31,852	2%	640	0.03%
	Listed Hatchery Intact Adipose	609	0.5%	21	0.02%
	Listed Hatchery Adipose Clip	3,209	3%	54	0.05%
Adult	Natural	1,069	6%	15	0.08%
	Listed Hatchery Intact Adipose	11	Unknown	0	0%

Two of WDFW's projects would intentionally kill natural- and hatchery-origin juvenile PS steelhead. The first of these projects has requested to intentionally kill 32 naturally produced juvenile PS steelhead which would be collected from estuarine and nearshore marine habitats throughout the south Puget Sound. Thus, no population is likely to experience a disproportionate amount of these losses. The second project has requested 150 intentional mortalities of naturally produced juvenile steelhead in the Nisqually River basin. We estimate that the Nisqually basin may produce as many as 86,336 steelhead outmigrants (smolts) annually (Table 11). When compared to the abundance of the Nisqually population, the potential mortality levels are very low (a maximum of 0.2% for naturally produced juveniles). The project is designed to determine the contribution of the resident from of *O. mykiss* to the anadromous population segment. The researchers will concentrate their lethal take on fish that appear to be stressed, likely to die, or are already dead at the time of capture.

In total, WDFW may capture, handle, and release up to 28,940 naturally produced juvenile steelhead and kill no more than 0.04% of the expected abundance of naturally produced juvenile steelhead. WDFW may also capture and variously handle, mark, tag, tissue sample, and release up to 1,210 naturally-produced adult PS steelhead throughout the Puget Sound. The majority

(89%) of the adult fish would be captured with hook and line. The researchers expect the mortality to be less than 2% of the requested take and at most 0.1% of the DPS for naturally produced adult steelhead.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the DPS (Percent of DPS), the potential mortality levels are very low. Furthermore, the effects from all of the proposed research would be spread out over various channels and tributaries of the Puget Sound basin. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 26% of the PS steelhead they requested and the actual mortality was only 8% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see above examples). The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the programs can be found in the state fishery agency submittals.

2.4.2.3 Hood Canal Summer-run Chum Salmon

The specific projects and related take estimates are described in detail in WDFW's submittal (WDFW 2017) and those records are incorporated in full herein. The WDFW would conduct, oversee, or coordinate eight projects that could take listed HCS chum salmon. None of planned research involves activities intended to kill listed chum salmon. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 87.

Table 87. Summary of Proposed Take of HCS Chum Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	634,954	1,941
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	20,800	252
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	50	1
Adult	Natural	Capture/Handle/Release Fish	1,308	14
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	500	8

Spawned Adult/ Carcass	Natural	Observe/Sample Tissue Dead Animal	200	0

Researchers, when submitting their applications, estimated the number of juvenile and adult HCS chum salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed HCS chum, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would take spawned adult/carcass chum salmon are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 88. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of HCS Chum Salmon.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	721,329	18%	2,412	0.06%
	Listed Hatchery Intact Adipose	55	0.04%	1	0.0007%
Adult	Natural	1,989	8%	24	0.09%

Two research projects (Salmon/Snow Creeks Summer Chum Population Monitoring and the Big Beef Creek Adult Escapement study) account for 99% of the take of both juvenile and adult chum salmon. The projects may variously capture, handle, mark, tag, tissue sample up to 18% of the expected abundance of adult summer-run chum salmon. The projects would take fish from both HCS chum salmon populations, so neither population is likely to experience a disproportionate amount of the effects. Our understanding of the summer-run chum's status—and hence our ability to manage their conservation—depends to a large degree on the research carried out in these two projects. The HCS chum abundance data collected by these two projects is essential for monitoring the status and trends of the species. A small number of fish (0.09% of the expected number of naturally produced adults and 0.06% of naturally produced juveniles) may die as an unintended result of the research. The impact on this population is therefore small even in the worst case scenario, but it is most likely to be even smaller in actuality. That is, if the past may be used as an indicator, in the last four years, the annual reports from this project indicate that the actual take and mortality are typically 39% and 26% respectively of what is requested for these projects.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low (a maximum of 0.09% for juveniles and adults). Furthermore, the effects from all of the proposed research would be spread out over the entirety of the ESU, so no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 67% of the HCS chum they requested and the actual mortality was only 15% of requested. Furthermore, some of the chum salmon that are captured may belong to the non-listed fall-run chum salmon ESU. The summer and fall run populations overlap and it is often difficult to distinguish them. Hence we are making a very conservative estimate of the effects of the research program on HCS chum salmon.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish. The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. The best example of this would be the two projects discussed above which are essential to our status and trends monitoring, as well as planning for recovery actions. Full details about the projects can be found in the state fishery agency submittals.

2.4.2.4 Snake River Fall Chinook Salmon

The specific projects and related take estimates are described in detail in the Oregon and Washington state fishery agency submittals (IDFG 2017, ODFW 2017, and WDFW 2017) and those records are incorporated in full herein. The three agencies would conduct, oversee, or coordinate eight projects that could take listed SR fall Chinook salmon. Most of the captured juvenile fish would be variously marked, tagged, or tissue sampled and released, whereas most of the adult fish would be briefly handled and released. One of the proposed research activities would intentionally kill 3 juvenile naturally produced SR fall Chinook salmon, but the majority of the proposed work would involve activities that are not intended to harm listed fish. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 89.

Table 89. Summary of Proposed Take of SR Fall Chinook Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	1,600	40
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	150	6
		Intentional (Directed) Mortality	3	3
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	370	9
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	95	4
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	420	10
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	95	4
Adult	Natural	Capture/Handle/Release Fish	30	0

	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	10	1
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	10	0
Spawned Adult/ Carcass	Natural	Capture/Handle/Release Fish	5	0

Researchers, when submitting their applications, estimated the number of juvenile and adult SR fall Chinook salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed SR fall Chinook, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% buffer would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance.

Table 90. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of SR Fall Chinook Salmon.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed*
Juvenile	Natural	1,928	0.3%	54	0.009%
	Listed Hatchery Intact Adipose	512	0.02%	14	0.0005%
	Listed Hatchery Adipose Clip	567	0.02%	15	0.0006%
Adult	Natural	33	0.3%	0	0%
	Listed Hatchery Intact Adipose	11	0.08%	1	0.004%
	Listed Hatchery Adipose Clip	11		0	

*We do not have separate abundance estimates for the two types of adult listed hatchery fish.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low in all cases, with the maximum mortality for any category being a few hundredths of a percent. And because SR fall Chinook are considered to have only one population, the mortalities would affect that population just as displayed above and would not therefore have variable effects across the species' geography. Thus, the research would have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 9% of the number of fish they requested and the actual mortality was only 3% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish. The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. For example, in the Stock Assessment in the Snake Basin project WDFW collects information about the status and trends of Snake River salmon and steelhead. The information is needed for management and recovery plans for the species. Full details about the programs can be found in the state fishery agency submittals.

2.4.2.5 Snake River Spring/Summer Chinook Salmon

The specific projects and related take estimates are described in detail in the state fishery agency submittals (IDFG 2017, ODFW 2017, and WDFW 2017) and those records are incorporated in full herein. The three agencies would conduct, oversee, or coordinate 24 projects that could take listed SR spr/sum Chinook salmon. Most of the captured juvenile fish would be handled briefly and released, whereas most of the adult fish would be variously marked, tagged, or tissue sampled and released. One of the proposed research activities would intentionally kill 4 juvenile naturally produced SR spr/sum Chinook, but the vast majority of the proposed work involves activities that are not intended to harm listed fish at all. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 91.

Table 91. Summary of Proposed Take of SR spr/sum Chinook Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	393,133	3,220
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	83,795	900
		Intentional (Directed) Mortality	4	4
		Observe/Harass	1,430	0
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	1,520	18
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	235	6
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	9,738	147
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	310	8
		Observe/Harass	10	0
Adult	Natural	Capture/Handle/Release Fish	66	5
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	15	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	47	0
Spawned Adult/Carcass	Natural	Observe/Sample Tissue Dead Animal	4,265	0
	Listed Hatchery Intact Adipose	Observe/Sample Tissue Dead Animal	845	0
	Listed Hatchery Adipose Clip	Observe/Sample Tissue Dead Animal	900	0

Researchers, when submitting their applications, estimated the number of juvenile and adult SR spr/sum Chinook salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed SR spr/sum Chinook salmon, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would take spawned adult/carcass Chinook salmon are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 92. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of SR spr/sum Chinook Salmon.

Life Stage	Origin	Total Requested Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed*
Juvenile	Natural	524,625	38%	4,536	0.3%
	Listed Hatchery Intact Adipose	1,931	0.2%	26	0.003%
	Listed Hatchery Adipose Clip	11,053	0.2%	171	0.004%
Adult	Natural	73	0.6%	6	0.05%
	Listed Hatchery Intact Adipose	17	1%	0	0%
	Listed Hatchery Adipose Clip	52		0	

*We do not have separate abundance estimates for the two types of adult listed hatchery fish.

With ten percent added to the requested take, the state fisheries agencies programs may variously capture, handle, mark, tag, tissue sample, and release up to 524,625 naturally produced juveniles, the great majority of which (93%) would be captured in rotary screw traps. Researchers deploy screw traps from late winter through early summer and use them to capture outmigrating juvenile salmon and steelhead. Researchers use the data collected from screw traps to derive estimates of outmigration abundance. Our records from the past nine years indicate that mortality rates for screw traps are typically less than 1%.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low: a maximum of 0.3% may be killed from any component of the species. Furthermore, the effects from all of the proposed research would be spread out over most of the major tributaries in the Snake River basin. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 57% of the number of adult fish they requested and the actual mortality was only 4% of requested. For juvenile fish, researchers have only taken 52% of the number of fish they requested and the actual mortality was only 13% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish. The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Many of the projects are also essential for monitoring the status and trends of the species. For example, two projects together account for nearly 93% of the total take of naturally produced juvenile SR spr/sum Chinook. These two projects monitor the status and trends of SR spr/sum Chinook and help to direct management and recovery actions for the species. Full details about the projects can be found in the state fishery agency submittals.

2.4.2.6 Snake River Steelhead

The specific projects and related take estimates are described in detail in each of the state fishery agency submittals (IDFG 2017, ODFW 2017, and WDFW 2017) and those records are incorporated in full herein. The three agencies would conduct, oversee, or coordinate 28 projects that could take listed SR steelhead. Most of the captured juvenile fish would be handled briefly and released, whereas most of the adult fish would be variously marked, tagged, or tissue sampled and released. One of the proposed research activities would intentionally kill 4 juvenile naturally produced SR steelhead, but the vast majority of the proposed work involves activities that are not intended to harm listed fish at all. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 93.

Table 93. Summary of Proposed Take of SR Steelhead.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	81,642	1,891
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	77,185	818
	Natural	Intentional (Directed) Mortality	4	4
	Natural	Observe/Harass	1,015	0
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	545	16
	Listed Hatchery Intact Adipose	Capture/Mark, Tag, Sample Tissue/Release Live Animal	300	6
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	3,190	68
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	400	8
	Listed Hatchery Adipose Clip	Observe/Harass	75	0

Adult	Natural	Capture/Handle/Release Fish	80	4
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	1,525	20
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	10	0
	Listed Hatchery Intact Adipose	Capture/Mark, Tag, Sample Tissue/Release Live Animal	75	5
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	160	2
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	300	10
Spawned Adult/ Carcass	Natural	Capture/Handle/Release Fish	65	2
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	660	7
	Natural	Observe/Sample Tissue Dead Animal	115	0

Researchers, when submitting their applications, estimated the number of juvenile and adult SR steelhead that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed SR steelhead, the requested take and requested mortality in this evaluation were increased by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass steelhead or take spawned adult/carcass steelhead are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 94. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of SR Steelhead.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed*
Juvenile	Natural	174,714	22%	2,984	0.4%
	Listed Hatchery Intact Adipose	930	0.1%	24	0.003%
	Listed Hatchery Adipose Clip	3,949	0.1%	84	0.002%
Adult	Natural	1,766	5%	26	0.08%
	Listed Hatchery Intact Adipose	94	0.2%	6	0.006%
	Listed Hatchery Adipose Clip	506		13	

*We do not have separate abundance estimates for the two types of adult listed hatchery fish.

With ten percent added to the requested take, the state fisheries agencies programs may variously capture, handle, mark, tag, tissue sample and release up to 174,714 naturally produced juveniles, about 99% of which would be captured in rotary screw traps. Researchers deploy screw traps from late winter through early summer to capture juvenile salmon and steelhead during their annual outmigration. Researchers use the data collected from screw traps to derive estimates of outmigration abundance. Our records from the past nine years indicate that mortality rates for screw traps are typically less than 1% of the fish captured.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be
When compared to the abundance of the DPS (Percent of DPS), the potential mortality levels are low (a maximum of 0.4% for juveniles and 0.08% for adults). These effects would be spread out over various channels and tributaries of the Snake River basin. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 34% of the SR steelhead they requested and the actual mortality was only 14% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. For example, the Idaho Steelhead Monitoring and Evaluation project and the Idaho Chinook Supplementation Study are designed to estimate freshwater production of naturally-produced salmonids, estimate survival rates of hatchery-reared salmonids from release to emigration, and determine emigration timing of wild and hatchery salmonids. These data are vital to assessing the health of naturally-produced stocks and their freshwater habitat. We expect the research actions to generate lasting benefits to conservation of the listed fish. The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the projects can be found in the state fishery agency submittals.

2.4.2.7 Upper Columbia River Steelhead

The one project (Aquatic Monitoring to Assess Flow Restoration Impacts) that may take UCR steelhead is described in detail in the WDFW’s submittal (WDFW 2017) and that document is incorporated in full herein. The planned research is not intended to kill listed steelhead. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 95.

Table 95. Summary of Proposed Take of UCR Steelhead.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	1,350	16

Researchers, when submitting their applications, estimated the number of juvenile UCR steelhead that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed UCR steelhead, the requested take and requested mortality in this evaluation were increased by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance.

Table 96. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of UCR Steelhead.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	1,485	0.8%	18	0.01%

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the DPS (Percent of DPS), the potential mortality level of 0.01% is very low. Furthermore, the effects from the proposed research would be spread out over various channels and tributaries of the upper Columbia River basin. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. WDFW's Aquatic Monitoring to Assess Flow Restoration Impacts project monitors the effectiveness of the Washington Department of Ecology's water-rights purchases and leases. WDFW has designed survey methodologies to monitor the effects of on fish, amphibians, and invertebrates. We expect the research actions to generate lasting benefits to conservation of the listed fish. Full details about the project can be found in the state fishery agency submittal.

2.4.2.8 Middle Columbia River Steelhead

The specific projects and related take estimates are described in detail in two of the state fishery agency submittals (ODFW 2017 and WDFW 2017) and those documents are incorporated in full herein. The two agencies would conduct, oversee, or coordinate 17 projects that could take listed MCR steelhead. The majority of planned research (15 out of 17 projects) involves activities that are not intended to kill listed steelhead. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 97.

Table 97. Summary of Proposed Take of MCR Steelhead.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	18,110	295
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	64,925	900

	Natural	Intentional (Directed) Mortality	209	209
	Natural	Observe/Harass	2,500	0
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	6,040	62
	Listed Hatchery Intact Adipose	Capture/Mark, Tag, Sample Tissue/Release Live Animal	1,250	35
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	5,050	53
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	250	5
Adult	Natural	Capture/Handle/Release Fish	2	0
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	2,315	23
	Natural	Observe/Harass	285	0
	Listed Hatchery Intact Adipose	Capture/Mark, Tag, Sample Tissue/Release Live Animal	35	1
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	825	9
Spawned Adult/ Carcass	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	605	13
	Natural	Observe/Sample Tissue Dead Animal	450	0
	Listed Hatchery Intact Adipose	Capture/Mark, Tag, Sample Tissue/Release Live Animal	20	2
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	12	1

Researchers, when submitting their applications, estimated the number of juvenile and adult MCR steelhead that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed MCR steelhead, the requested take and requested mortality in this evaluation were increased by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass steelhead or take spawned adult/carcass steelhead are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 98. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of MCR Steelhead.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	91,568	22%	1,544	0.4%
	Listed Hatchery Intact Adipose	8,019	9%	107	0.1%
	Listed Hatchery Adipose Clip	5,830	2%	64	0.02%
Adult	Natural	2,549	11%	25	0.1%

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed
	Listed Hatchery Intact Adipose	39	51%	1	0.6%
	Listed Hatchery Adipose Clip	908		10	

*We do not have separate abundance estimates for the two types of adult listed hatchery fish.

Two projects have asked to intentionally kill juvenile naturally produced MCR steelhead. The first of these projects has requested to kill a total of 9 juvenile steelhead from six different populations. Thus, no population is likely to experience a disproportionate amount of these losses. The second project has requested to intentionally kill 180 juvenile steelhead from the Deschutes River basin and 20 from Fifteenmile Creek. Juvenile MCR steelhead abundance estimates can be calculated from the escapement data. The average escapement of adult steelhead (2010-2014) is 2,796 in the Deschutes River basin (Table 34). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (1,398 females), 4.9 million eggs are expected to be produced annually. With an estimated survival rate of 6.5% (Ward and Slaney 1993), the Deschutes River basin should produce roughly 318,000 natural-origin outmigrants annually. When compared to the abundance of juvenile steelhead in the Deschutes River population, the requested intentional mortality levels are very low (a maximum of 0.05%). For Fifteenmile Creek, the average escapement of adult steelhead (2010-2014) is 490 (Table 34). By applying the same conservative fecundity estimate of 3,500 eggs and the estimated survival rate of 6.5%, Fifteenmile Creek should produce roughly 55,000 natural-origin outmigrants annually. When compared to the abundance of juvenile steelhead in Fifteenmile Creek, the requested intentional mortality of 20 naturally produced juvenile steelhead is very low (a maximum of 0.04%). Furthermore, the researchers will concentrate their lethal take on fish that appear to be stressed, likely to die, or are already dead at the time of capture. If possible, the researchers may also collect the fish from other projects that may have unintentionally killed juvenile MCR steelhead.

In total, researchers may variously capture, handle, mark, tag, tissue sample and release up to 97,521 naturally produced juvenile steelhead and kill up to 1,678 (a 1.7% mortality rate). The majority of the requested nonlethal take of juvenile steelhead (74%) would be captured with screw traps and fyke nets/traps. Our records from the past nine years indicate that mortality rates for screw and fyke traps are typically less than 1%. Researchers deploy screw traps and fyke traps from late winter through early summer to capture juvenile salmon and steelhead during their annual outmigration. Managers use the data collected from screw traps to derive estimates of outmigration abundance.

Researchers may also variously capture, handle, mark, tag, tissue sample and release up to 2,554 naturally produced adults. WDFW and ODFW submitted six projects that would take adult steelhead. The research projects are designed to monitor the status and trends of steelhead, study the effects of hatchery fish spawning in the wild, and monitor habitat restoration and the effects it may have on abundance and productivity. All of these projects are important for the survival and recovery of the species. We use trends in abundance and productivity to measure the status of the species and the effects of various recovery efforts. The research would take place in seven different subbasins and the effects would therefore be spread out over all the DPS's populations. Researchers intend to release all naturally produced adult steelhead alive. However, a small number of the naturally produced adult fish (0.1%) may die as an unintended result of the research. These same projects may unintentionally kill up to 0.6% of the abundance of adult listed hatchery steelhead. Some of the adipose clipped steelhead are likely to be from non-listed hatchery programs, but unidentifiable as such.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the DPS (Percent of DPS), the potential mortality levels are low (a maximum of 0.4% for naturally produced juveniles and adults). These effects would be spread out over various channels and tributaries of the middle Columbia River basin. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 34% of the MCR steelhead they requested and the actual mortality was only 16% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see above example). The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the programs can be found in the state fishery agency submittals.

2.4.2.9 Columbia River Chum Salmon

The specific projects and related take estimates are described in detail in two of the state fishery agency submittals (ODFW 2017 and WDFW 2017) and those records are incorporated in full herein. The two agencies would conduct, oversee, or coordinate ten projects that could take listed CR chum salmon. The majority of planned research (9 out of 10 projects) involves activities that are not intended to kill listed chum salmon. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 99.

Table 99. Summary of Proposed Take of CR Chum Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	13,315	162
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	20,000	200
	Natural	Intentional (Directed) Mortality	11	11

	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	500	5

Researchers, when submitting their applications, estimated the number of juvenile and adult CR chum salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed CR Chum, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance.

Table 100. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of CR Chum Salmon.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	36,659	0.7%	410	0.008%
	Listed Hatchery Intact Adipose	550	0.08%	6	0.0008%

One project has asked to intentionally kill juvenile naturally produced CR chum salmon. Researchers would collect up to eleven juvenile chum salmon from tributaries to the Lower Columbia River, the Sandy River basin, and the Hood River basin. Thus, no population is likely to experience a disproportionate amount of these losses.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low: a maximum of 0.008% may be killed from any component of the species. Furthermore, the effects from all of the proposed research would be spread out over nearly all the tributaries to the Columbia River that contain chum salmon. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance (a maximum loss of 0.008%), a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 33% of the CR chum they requested and the actual mortality was only 14% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. For example, the two largest projects are designed to estimate freshwater production of naturally-produced salmonids, estimate survival rates of hatchery-reared salmonids from release to emigration, and determine emigration timing of wild and hatchery salmonids. These data are vital to assessing the health of naturally-produced stocks and their freshwater habitat. We expect the research actions to generate lasting benefits to conservation of the listed fish. The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the projects can be found in the state fishery agency submittals.

2.4.2.10 Lower Columbia River Chinook Salmon

The specific projects and related take estimates are described in detail in the state fishery agency submittals (ODFW 2017 and WDFW 2017) and those records are incorporated in full herein. The two agencies would conduct, oversee, or coordinate 21 projects that could take listed LCR Chinook salmon. The majority of the proposed research (18 out of 21 projects) would involve activities that are not intended to harm listed fish. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 101.

Table 101. Summary of Proposed Take of LCR Chinook Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	462,937	3,603
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	636,210	9,915
		Intentional (Directed) Mortality	74	74
		Observe/Harass	950	0
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	100	3
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	325	7
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	77,220	1,473
Adult	Natural	Capture/Handle/Release Fish	81	2
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	150	2
		Observe/Harass	200	0
	Listed Hatchery Intact Adipose	Observe/Harass	5	0
	Listed Hatchery Adipose Clip	Observe/Harass	400	0
Spawned Adult/ Carcass	Natural	Capture/Handle/Release Fish	20	1

Researchers, when submitting their applications, estimated the number of juvenile and adult LCR Chinook salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed LCR Chinook salmon, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass LCR Chinook salmon or take spawned adult/carcass LCR

Chinook salmon are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 102. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of LCR Chinook Salmon.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	1,209,143	10%	14,951	0.1%
	Listed Hatchery Intact Adipose	110	0.009%	3	0.0003%
	Listed Hatchery Adipose Clip	85,300	0.3%	1,628	0.005%
Adult	Natural	254	0.9%	4	0.01%

*We do not have separate abundance estimates for the two types of adult listed hatchery fish.

Three projects have requested intentional mortalities of naturally produced juveniles from six LCR Chinook salmon populations. One of the projects would collect voucher samples of otolith marked juveniles. The voucher specimens would be compared to samples collected from the same brood year of spawned adult fish. Another project requesting intentional mortalities of juvenile Chinook is designed to test wild fish populations for whirling disease and other fish pathogens. To complete a full and comprehensive disease/parasitic analysis, researchers need to examine various tissues. The final project is collecting voucher specimens for the Oregon Biodiversity Genome Project. The purpose of the project is to build a reference library for environmental DNA sampling. The researchers will concentrate their lethal take on fish that appear to be stressed, likely to die, or are already dead at the time of capture. If possible, the researchers will collect the fish from other projects that may have unintentionally killed juvenile LCR Chinook.

The majority (99%) of the naturally produced juvenile LCR Chinook would be captured with screw traps and beach seines. Our records from the past ten years indicate that mortality rates for screw traps are typically less than 1% and beach seines less than 2%. Researchers deploy screw traps from late winter through early summer to capture juvenile salmon and steelhead during their annual outmigration. Beach seines are used throughout the year and are more effective in deep water habitats. Managers use the data collected from screw traps and beach seines to derive estimates of outmigration abundance.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be

When compared to the abundance at the population and ESU scales (Percent of Population/ESU), the potential mortality levels are very low: a maximum of 0.1% may be killed from any component of the species. Therefore, the research would likely amount to only a very small impact on the species' abundance and productivity. In addition, because the take is concentrated in two populations there could be some very small (and currently unmeasurable) effects on spatial structure and diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 30% of the LCR Chinook they requested and the actual mortality was only 23% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish. The majority of the projects in the Programs are essential for monitoring the status and trends of the species. Other projects focus on monitoring and evaluating actions recommended for the conservation of the listed species. For example, for one project WDFW is studying the influence of hatchery fish on naturally produced fish and the effectiveness of restoration actions in the Mill/Abernathy/Germany population of LCR Chinook. The project is a joint effort of the Washington Departments of Fish and Wildlife and Ecology, NOAA Fisheries, the Environmental Protection Agency, Lower Elwha Klallam Tribe and Weyerhaeuser Company and is financially supported by the Washington Salmon Recovery Funding Board. The premise of the project is that the complex relationships controlling salmon response to habitat conditions can best be understood by concentrating monitoring and research efforts at a few locations. Focusing efforts on a few locations allows enough data on an ecosystem's physical and biological attributes of systems to be collected that becomes possible to evaluate effects of restoration treatments on salmon production and that information, in turn, may be used to design and refine further recovery actions. Full details about the programs can be found in the state fishery agency submittals.

2.4.2.11 Lower Columbia River Coho Salmon

The specific projects and related take estimates are described in detail in two of the state fishery agency submittals (ODFW 2017 and WDFW 2017) and those documents are incorporated in full herein. The two agencies would conduct, oversee, or coordinate 23 projects that could take listed LCR coho salmon. The majority of planned research (21 out of 23 projects) involves activities that are not intended to kill listed coho salmon. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 103.

Table 103. Summary of Proposed Take of LCR Coho Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	87,682	1,019
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	69,074	952
		Intentional (Directed) Mortality	44	44
		Observe/Harass	8,900	0
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	350	4
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	10,550	109
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	49,180	984

Adult	Natural	Capture/Handle/Release Fish	250	2
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	235	5
		Observe/Harass	100	0
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	75	1
		Observe/Harass	200	0
Spawned Adult/ Carcass	Natural	Capture/Handle/Release Fish	15	2

Researchers, when submitting their applications, estimated the number of juvenile and adult LCR coho salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed LCR coho, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass coho salmon or take spawned adult/carcass coho salmon are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 104. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of LCR Coho Salmon.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed*
Juvenile	Natural	172,370	27%	2,213	0.3%
	Listed hatchery intact adipose	385	0.2%	4	0.002%
	Listed hatchery adipose clipped	65,703	0.9%	1,202	0.02%
Adult	Natural	534	2%	8	0.02%
	Listed hatchery adipose clipped	83	0.4%	1	0.005%

* We do not have separate abundance estimates for adipose clipped and intact adipose adult hatchery salmonids.

One project has requested to intentionally kill 40 juvenile naturally produced coho from the Clackamas River watershed. The project is designed to test wild fish populations for whirling disease and other fish pathogens. To complete a full and comprehensive disease/parasitic analysis, researchers need to examine various tissues. The other project has requested to intentionally kill one juvenile naturally produced coho from each of four populations. The researchers in both projects will concentrate their lethal take on fish that appear to be stressed, likely to die, or are already dead at the time of capture. If possible, the researchers will collect the fish from other projects that may have unintentionally killed juvenile LCR coho salmon.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are low (a maximum of 0.3% for naturally produced juveniles and 0.02% for naturally produced adults). Furthermore, the effects from all of the proposed research would be spread out over most of the tributaries of the Columbia River that contain coho. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year-to-year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 28% of the LCR coho they requested and the actual mortality was only 11% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. One of the larger projects, the Cedar Creek Juvenile Salmonid Trapping, is designed to estimate juvenile salmonid production in the Cedar Creek watershed using mark and recapture methods. Co-managers use the information in the annual coho population estimates for the Washington portion of the Lower Columbia River ESU. We expect this and other research actions to generate lasting benefits to conservation of the listed fish. The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the projects can be found in the state fishery agency submittals.

2.4.2.12 Lower Columbia River Steelhead

The specific projects and related take estimates are described in detail in two of the state fishery agency submittals (ODFW 2017 and WDFW 2017) and those documents are incorporated in full herein. The two agencies would conduct, oversee, or coordinate 15 projects that could take listed LCR steelhead. The majority of planned research (13 out of 15 projects) involves activities that are not intended to kill listed steelhead. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 105.

Table 105. Summary of Proposed Take of LCR Steelhead.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	18,180	237
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	34,920	385
		Intentional (Directed) Mortality	134	134
		Observe/Harass	1,450	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	2,050	21

		Capture/Mark, Tag, Sample Tissue/Release Live Animal	48,510	767
Adult	Natural	Capture/Handle/Release Fish	30	0
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	2,100	22
		Observe/Harass	100	0
Spawned Adult/ Carcass	Natural	Capture/Handle/Release Fish	45	4
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	35	4

Researchers, when submitting their applications, estimated the number of juvenile and adult LCR steelhead that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed LCR steelhead, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass steelhead or take spawned adult/carcass steelhead are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 106. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of LCR Steelhead.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	58,557	18%	832	0.3%
	Listed Hatchery Intact Adipose	55,616	5%	867	0.07%
Adult	Natural	2,343	18%	24	0.2%

One project has requested intentional mortalities of juvenile steelhead from populations in the Upper and Lower Columbia River Gorge and Clackamas River basin. The project is designed to test wild fish populations for whirling disease and other fish pathogens. To complete a full and comprehensive disease/parasitic analysis, researchers need to examine various tissues. The other project has requested to intentionally kill one juvenile naturally produced steelhead from each of four populations. The researchers will concentrate their lethal take on fish that appear to be stressed, likely to die, or are already dead at the time of capture. If possible, the researchers will collect the fish from other projects that may have unintentionally killed juvenile LCR steelhead.

Researchers may variously capture, handle, mark, tag, tissue sample and release up to 58,454 naturally produced smolts and kill no more than 2% of them (including the intentional mortalities). The majority (92%) of the requested nonlethal take of juvenile steelhead would be captured with screw traps and beach seines. Our records from the past ten years indicate that mortality rates for screw traps are typically less than 1% and beach seines less than 2%. Researchers deploy screw traps from late winter through early summer to capture juvenile salmon and steelhead during their annual outmigration. Beach seines are used throughout the year and are more effective in deep water habitats. Managers use the data collected from screw traps and beach seines to derive estimates of outmigration abundance.

Researchers may variously capture, handle, mark, tag, tissue sample and release up to 2,343 naturally produced adults. Researchers would use hook and line, beach seines, fish ladders, and weirs to capture adult steelhead from nine populations. WDFW and ODFW submitted five projects that would take adult steelhead. These five projects are designed to monitor steelhead status and trends. The projects would count returning adults, take tissue samples to determine the origin of the fish, and tag a portion of the fish. Researchers would use tags to monitor the movements of fish and validate the population estimates. All of these projects are important for the survival and recovery of the species. We use trends in abundance and productivity to measure the status of the species and the effects of various recovery efforts. Researchers intend to release all naturally produced adult steelhead alive. However, a small number of fish (1% of the requested numbers, 0.3% of the DPS) may die as an unintended result of the research.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the DPS (Percent of DPS), the potential mortality levels are very low (as stated above). These effects would be spread out over various channels and tributaries of the lower Columbia River basin. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, there would be a very small impact on abundance, no measureable impact on productivity, spatial structure, or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 26% of the LCR steelhead they requested and the actual mortality was only 11% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see the examples above). The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the programs can be found in the state fishery agency submittals.

2.4.2.13 Upper Willamette River Chinook Salmon

The specific projects and related take estimates are described in detail in the ODFW submittal (ODFW 2017) and those records are incorporated in full herein. The ODFW would conduct, oversee, or coordinate 24 projects that could take listed UWR Chinook salmon. The majority of planned research (22 out of 24 projects) involves activities that are not intended to kill listed steelhead. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 107.

Table 107. Summary of Proposed Take of UWR Chinook Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	16,097	249
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	27,200	426
		Collect, Sample, and Transport Live Animal	200	2
		Intentional (Directed) Mortality	26	26
		Observe/Harass	300	0
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	20	1
		Observe/Harass	40	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	7,210	102
		Observe/Harass	210	0
Adult	Natural	Capture/Handle/Release Fish	205	6
		Observe/Harass	30	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	191	9
		Observe/Harass	110	0
Spawned Adult/ Carcass	Natural	Capture/Handle/Release Fish	10	1
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	50	1

Researchers, when submitting their applications, estimated the number of juvenile and adult UWR Chinook salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed SR fall Chinook, we increased the requested take and requested mortality by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass UWR Chinook salmon or take spawned adult/carcass UWR Chinook salmon are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 108. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of UWR Chinook Salmon.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	47,875	4%	773	0.06%
	LHIA	22	0.1%	1	0.007%
	LHAC	7,931	0.1%	112	0.002%
Adult	Natural	226	2%	7	0.06%
	LHAC	210	0.6%	10	0.03%

Notes: LHAC=Listed Hatchery Adipose Clipped, LHIA=Listed Hatchery Intact Adipose (Abundance estimates for adult hatchery salmonids are LHAC and LHIA combined).

One project has requested to intentionally kill 20 naturally produced UWR Chinook smolts in the Clackamas River basin. The project is designed to test wild fish populations for whirling disease and other fish pathogens. To complete a full and comprehensive disease/parasitic analysis, researchers need to examine various tissues. Another project has requested to intentionally kill a total of six juvenile naturally produced Chinook salmon. The design of the project is such that the fish would be taken from randomly sampled streams throughout the species' range and therefore no population would be disproportionately affected by the research. In both projects, the researchers will concentrate their lethal take on fish that appear to be stressed, likely to die, or are already dead at the time of capture. If possible, the researchers will collect the fish from other projects that may have unintentionally killed juvenile UWR Chinook.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low: a maximum of 0.06% may be killed from any component of the species. Furthermore, the effects from all of the proposed research would be spread out over most of the tributaries to the Willamette River basin. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 41% of the number of fish they requested and the actual mortality was only 13% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. More than half of the requested take of UWR Chinook salmon are from ODFW's Spring Chinook Salmon in the Willamette River project. The purpose of ODFW's project is to study temporal and spatial use patterns by life stage and identify the habitat/environmental attributes of high use areas. Study results will be used to help identify priority recovery actions and will provide a basis for implementing the Upper Willamette spring Chinook Recovery Plan. We expect these and other research actions to generate lasting benefits to conservation of the listed fish. The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the programs can be found in the state fishery agency submittals.

2.4.2.14 Upper Willamette River Steelhead

The specific projects and related take estimates are described in detail in the ODFW's submittal (ODFW 2017) and that document is incorporated in full herein. The ODFW would conduct, oversee, or coordinate 14 projects that could take listed UWR steelhead. One of the research projects would intentionally kill juvenile UWR steelhead, but the great majority of the proposed work would involve activities that do not intend to harm listed fish. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 109.

Table 109. Summary of Proposed Take of UWR Steelhead.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	4,307	103
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	2,670	35
		Intentional (Directed) Mortality	4	4
		Observe/Harass	1,505	0
Adult	Natural	Capture/Handle/Release Fish	107	3
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	130	1
		Observe/Harass	5	0

Researchers, when submitting their applications, estimated the number of juvenile and adult UWR steelhead that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed UWR steelhead, the requested take and requested mortality in this evaluation were increased by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass steelhead are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 110. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of UWR Steelhead.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	7,679	5%	156	0.1%
Adult	Natural	261	4%	4	0.07%

One project has requested to intentionally kill a total of four juvenile naturally produced UWR steelhead. The design of the project is such that the fish would be taken from randomly sampled streams throughout the species' range and therefore no population would be disproportionately affected by the research. The researchers will concentrate their lethal take on fish that appear to be stressed, likely to die, or are already dead at the time of capture. If possible, the researchers will collect the fish from other projects that may have unintentionally killed juvenile UWR steelhead.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the DPS (Percent of DPS), the potential mortality levels are very low (a maximum of 0.1% for naturally produced juveniles and adults). These effects would be spread out over various channels and tributaries of the Upper Willamette River basin. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 14% of the UWR steelhead they requested and the actual mortality was only 1% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. More than half of the requested take is from three projects. The first two projects are evaluating the distribution and population status of fish species in two of ODFW's districts (one project per district). The third project is the Willamette National Forest Identification of Fish Distribution and Population Monitoring. We expect these research projects (and the others submitted by ODFW) to generate lasting benefits to conservation of the listed fish. The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the projects can be found in the state fishery agency submittals.

2.4.2.15 Oregon Coast Coho Salmon

The specific projects and related take estimates are described in detail in ODFW's submittal (ODFW 2017) and that document is incorporated in full herein. The ODFW would conduct, oversee, or coordinate 36 projects that could take OC coho salmon. The research in ODFW's submittal involves activities that are not intended to kill listed coho salmon. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 111.

Table 111. Summary of Proposed Take of OC Coho Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	375,218	8,847
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	137,584	2,416
		Intentional (Directed) Mortality	13	13
		Observe/Harass	135,470	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	90	3
Adult	Natural	Capture/Handle/Release Fish	12	1
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	5,400	53
		Observe/Harass	15,250	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	5	0
	Listed Hatchery Adipose Clip	Observe/Harass	200	0

Spawned Adult/ Carcass	Natural	Observe/Sample Tissue Dead Animal	50	0

Researchers, when submitting their applications, estimated the number of juvenile and adult OC coho salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed OC coho, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass coho or take spawned adult/carcass coho salmon are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 112. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of OC Coho Salmon.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	564,097	3%	12,404	0.08%
	Listed hatchery adipose clipped	99	0.2%	3	0.006%
Adult	Natural	5,953	3%	59	0.03%
	Listed hatchery adipose clipped	6	0.3%	0	0%

One project has requested to intentionally kill a total of 13 juvenile naturally produced OC coho salmon. The design of the project is such that the fish would be taken from randomly sampled streams throughout the species' range and therefore no population would be disproportionately affected by the research. The researchers will concentrate their lethal take on fish that appear to be stressed, likely to die, or are already dead at the time of capture. If possible, the researchers will collect the fish from other projects that may have unintentionally killed juvenile OC coho salmon.

One of the research projects in ODFW's research program accounts for more than half of the take of smolts and adults. In 1997, as part of the Oregon Plan for Salmon and Watersheds, ODFW began monitoring survival and downstream migration of salmonids in coastal basins. The purpose of the Oregon Plan is to restore native fish populations and the aquatic systems that support them to productive and sustainable levels that will provide substantial environmental, cultural, and economic benefits. For nearly 20 years, the project has been capturing and variously handling, tagging, and tissue sampling coho from six OC coho populations. The information gathered from the project has been critical to our understanding of the species' survival and abundance.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low (a maximum of 0.08% for naturally produced juveniles and adults). Furthermore, the effects from all of the proposed research would be spread out over most of the streams that contain coho on the Oregon Coast. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 28% of the number of fish they requested and the actual mortality was only 13% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see the examples above). The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the programs can be found in the state fishery agency submittals.

2.4.2.16 Southern Oregon/Northern California Coasts Coho Salmon

The specific projects and related take estimates are described in detail in two of the state agencies' submittals (ODFW 2017 and CDFW 2017) and those documents are incorporated in full herein. The state agencies would conduct, oversee, or coordinate 37 projects that could take SONCC coho salmon. None of the planned research would intentionally kill listed coho salmon. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 113.

Table 113. Summary of Proposed Take of SONCC Coho Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	47,476	496
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	45,965	466
		Intentional (Directed) Mortality	10	10
		Observe/Harass	52,765	0
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	52	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	1,250	17
Adult	Natural	Capture/Handle/Release Fish	578	6
		Capture/Mark, Tag, Sample Tissue/Release Live Animal	659	3
		Observe/Harass	10,649	0
	Listed Hatchery Intact Adipose	Capture/Handle/Release Fish	3	0

		Capture/Mark, Tag, Sample Tissue/Release Live Animal	1,358	3
		Observe/Harass	14,835	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	520	6
Spawned Adult/ Carcass	Natural	Observe/Sample Tissue Dead Animal	2,019	0
	Listed Hatchery Intact Adipose	Observe/Sample Tissue Dead Animal	205	0

Researchers, when submitting their applications, estimated the number of juvenile and adult SONCC coho salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed SONCC coho, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass coho salmon are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 114. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of SONCC Coho Salmon.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled*	Requested Mortality plus 10%	Percent of ESU killed*
Juvenile	Natural	102,796	9%	1,069	0.1%
	Listed Hatchery Intact Adipose	57	0.01%	0	0%
	Listed hatchery adipose clipped	1,375	0.7%	19	0.009%
Adult	Natural	1,361	15%	10	0.1%
	Listed Hatchery Intact Adipose	1,497	19%	3	0.09%
	Listed hatchery adipose clipped	572		7	

* We do not have separate abundance estimates for adipose clipped and intact adipose adult hatchery salmonids.

One project has requested to intentionally kill a total of ten juvenile naturally produced SONCC coho salmon. The design of the project is such that the fish would be taken from randomly sampled streams throughout the species' range and therefore no population would be disproportionately affected by the research. The researchers will concentrate their lethal take on fish that appear to be stressed, likely to die, or are already dead at the time of capture. If possible, the researchers will collect the fish from other projects that may have unintentionally killed juvenile SONCC coho salmon.

The proposed research projects may capture, handle, and release up to 15% of the expected abundance of naturally produced adult coho. The majority (79%) of the adult coho take is for two projects. The first project is the Huntley Park beach seine project on the Rogue River in

Oregon. The second project is the Trinity River run-size and escapement estimate in California. These two projects are the primary sources of abundance information; the data derived from the projects is used to inform many management decisions throughout the species range. Mortality is expected to be no more than 0.7% of the number of naturally produced adult coho captured, handled, and released.

The state agencies may also capture, handle, and release up to 19% of the expected abundance of listed hatchery adult coho salmon. However, many of these fish are likely to be unlisted hatchery coho. There are both listed and unlisted coho hatchery stocks with more fish produced in the unlisted hatchery stock programs. The state agencies do not identify the origin of the hatchery fish. Regardless, we consider the adipose fin-clipped listed hatchery fish to be surplus to conservation and recovery needs and therefore there are no take prohibitions for these fish (70 FR 37160).

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low (a maximum of 0.1% for naturally produced juveniles and adults). Effects on juvenile fish would be spread out over various channels and tributaries the ESU inhabits in Oregon and California. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year-to-year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 6% of the SONCC coho they requested and the actual mortality was only 3% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see above example). The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the programs can be found in the state fishery agency submittals.

2.4.2.17 California Coastal Chinook Salmon

The specific projects and related take estimates are described in detail in CDFW's submittal (CDFW 2017) and that document is incorporated in full herein. The CDFW would conduct, oversee, or coordinate 15 projects that could take CC Chinook salmon. The proposed research involves activities that are not intended to harm or kill listed fish at all. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 115.

Table 115. Summary of Proposed Take of CC Chinook Salmon.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	204,985	2,036
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	20,863	232
	Natural	Observe/Harass	6,070	0
Adult	Natural	Capture/Handle/Release Fish	265	0
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	44	1
	Natural	Observe/Harass	8,084	0
Spawned Adult/Carcass	Natural	Observe/Sample Tissue Dead Animal	1,619	0

Researchers, when submitting their applications, estimated the number of juvenile and adult CC Chinook salmon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed CC Chinook, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass Chinook salmon, or sample dead fish, are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 116. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of CC Chinook Salmon.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	248,433	19%	2,495	0.2%
Adult	Natural	340	5%	1	0.02%

The research projects proposed by CDFW may variously capture, handle, mark, tag, tissue sample, and release up to 19% of the expected abundance of naturally produced juvenile Chinook salmon. The majority (86%) of the take of juvenile Chinook is from two screw traps in the Redwood Creek Watershed. The research is designed to determine abundance of downstream migrating juvenile Chinook salmon, coho salmon, steelhead trout, and cutthroat trout using mark/recapture techniques. Researchers recapture fish in the second screw trap and use the numbers of recaptured fish to determine abundance. Although a portion of the juvenile Chinook salmon in this project would be marked and tissue sampled, the vast majority (97%) of the fish would only be handled and released. Of all the capture methods employed by researchers, screw traps are one of the most efficient and have some of the lowest mortality rates. The average mortality rate reported by researchers using screw traps to capture juvenile CC Chinook is 0.2% (2011-2015).

Researchers may also capture and variously handle, mark, tag, tissue sample and release 340 adult steelhead with only one anticipated mortality. Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low (a maximum of 0.2% for naturally produced juveniles and 0.02% for adults). Furthermore, the effects from all of the proposed research would be spread out over most of the major tributaries of the ESU. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 42% of the CC Chinook they requested and the actual mortality was only 27% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see above example). The majority of the projects in CDFW's Program focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the program can be found in the state fishery agency submittal.

2.4.2.18 Northern California Steelhead

The specific projects and related take estimates are described in detail in CDFW's submittal (CDFW 2017) and that document is incorporated in full herein. The CDFW would conduct, oversee, or coordinate 15 projects that could take NC steelhead. The proposed research involves activities that are not intended to harm or kill listed fish at all. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 117.

Table 117. Summary of Proposed Take of NC Steelhead.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	101,260	913
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	22,841	328
	Natural	Observe/Harass	13,150	0
Adult	Natural	Capture/Handle/Release Fish	75	1
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	2,220	0
	Natural	Observe/Harass	5,489	0
Spawned Adult/Carcass	Natural	Observe/Sample Tissue Dead Animal	549	0

Researchers, when submitting their applications, estimated the number of juvenile and adult NC steelhead that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed NC steelhead, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass steelhead, or sample dead fish, are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 118. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of NC steelhead.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	136,511	17%	1,365	0.2%
Adult	Natural	2,525	35%	1	0.02%

The research projects proposed by CDFW may variously capture, handle, mark, tag, tissue sample, and release up to 17% of the expected abundance of naturally produced juvenile steelhead. The majority (84%) of the take of juvenile steelhead is from two screw traps in the Redwood Creek Watershed. The research is designed to determine abundance of downstream migrating juvenile Chinook salmon, coho salmon, steelhead trout, and cutthroat trout using mark/recapture techniques. Researchers recapture fish in the second screw trap and use the numbers of recaptured fish to determine abundance. Although a portion of the juvenile steelhead in this project would be marked and tissue sampled, the vast majority (95%) of the fish would only be handled and released. Of all the capture methods employed by researchers, screw traps are one of the most efficient and have some of the lowest mortality rates. The average mortality rate reported by researchers using screw traps to capture juvenile NC steelhead is 0.4% (2011-2015).

The research projects may capture and variously handle, mark, tag, tissue sample, and release up to 35% of the expected abundance of naturally produced adult steelhead. The majority (87%) of the take of adult steelhead is from a fish ladder on the Eel River. The researchers expect to take up to 2,000 adult steelhead with no mortalities.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low (a maximum of 0.2% for naturally produced juveniles and 0.02% for adults). Furthermore, the effects from all of the proposed research would be spread out over most of the major tributaries of the ESU. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year to year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 47% of the NC steelhead they requested and the actual mortality was only 15% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see above example). The majority of the projects in CDFW's Program focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the program can be found in the state fishery agency submittal.

2.4.2.19 Central California Coast Steelhead

The specific projects and related take estimates are described in detail in CDFW's submittal (CDFW 2017) and that document is incorporated in full herein. The CDFW would conduct, oversee, or coordinate 11 projects that could take CCC steelhead. The proposed research involves activities that are not intended to harm or kill listed fish at all. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 119.

Table 119. Summary of Proposed Take of CCC Steelhead.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	9,565	163
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	5,670	88
	Natural	Observe/Harass	2,630	0
Adult	Natural	Capture/Handle/Release Fish	30	0
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	2	0
	Natural	Observe/Harass	915	0
Spawned Adult/Carcass	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	14	0
	Natural	Observe/Sample Tissue Dead Animal	88	0

Researchers, when submitting their applications, estimated the number of juvenile and adult CCC steelhead that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed CCC steelhead, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass steelhead, or sample dead fish, are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 120. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of CCC steelhead.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	16,759	7%	276	0.1%
Adult	Natural	33	2%	0	0%

Researchers may variously capture, handle, mark, tag, tissue sample, and release up to 16,759 juvenile steelhead and kill, at most, 2% of those fish. Researchers may also capture and variously handle, mark, tag, tissue sample and release 33 adult steelhead with no anticipated mortalities. Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the DPS (Percent of DPS), the potential mortality levels are very low (a maximum of 0.1% for naturally produced juveniles). Furthermore, the effects from all of the proposed research would be spread out over most of the major tributaries of the DPS. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year-to-year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 15% of the CCC steelhead they requested and the actual mortality was only 7% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see above example). The majority of the projects in CDFW’s Program focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the program can be found in the state fishery agency submittal.

2.4.2.20 Central Valley Spring-run Chinook Salmon

The specific projects and related take estimates are described in detail in CDFW’s submittal (CDFW 2017) and that document is incorporated in full herein. The CDFW would conduct, oversee, or coordinate 28 projects that could take CVS Chinook. The majority of planned research (26 out of 28 projects) involves activities that are not intended to kill listed Chinook. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 121.

Table 121. Summary of Proposed Take of CVS Chinook.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	421,704	4,330
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	1,060	15
	Natural	Observe/Harass	29,225	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	8,201	83
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	240	1
	Listed Hatchery Adipose Clip	Intentional (Directed) Mortality	160	160
	Listed Hatchery Adipose Clip	Observe/Harass	1,675	0
Adult	Natural	Capture/Handle/Release Fish	54	0
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	10	0
	Natural	Observe/Harass	54,275	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	28	0
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	10	0
	Listed Hatchery Adipose Clip	Observe/Harass	7,095	0
Spawned Adult/Carcass	Natural	Observe/Sample Tissue Dead Animal	4,680	0
	Natural	Observe/Harass	19,250	0
	Listed Hatchery Adipose Clip	Observe/Sample Tissue Dead Animal	7,175	0

Researchers, when submitting their applications, estimated the number of juvenile and adult CVS Chinook that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed CVS Chinook, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass Chinook, or sample dead fish, are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 122. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of CVS Chinook.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	465,040	19%	4,780	0.2%

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Listed Hatchery Adipose Clip	9,461	0.3%	268	0.009%
Adult	Natural	70	0.6%	0	0%
Adult	Listed Hatchery Adipose Clip	42	0.5%	0	0%

Two projects have proposed to intentionally kill 160 juvenile adipose clipped listed hatchery Chinook. We consider adipose clipped listed hatchery CVS Chinook to be excess to recovery needs. Therefore, we do not expect the loss of 160 juvenile adipose clipped listed hatchery Chinook to effect the abundance, productivity, spatial structure, or diversity of the ESU.

The research projects proposed by CDFW may variously capture, handle, mark, tag, tissue sample, and release up to 19% of the expected abundance of naturally produced juvenile Chinook salmon. The majority (98%) of the take of juvenile steelhead is from screw traps in seven different locations throughout five basins of the Central California Valley. The research projects are designed to determine abundance of downstream migrating juvenile salmonids using mark/recapture techniques. Researchers recapture fish in the second screw trap and use the numbers of recaptured fish to determine abundance. Although a portion of the juvenile Chinook salmon in these projects would be marked and tissue sampled, the vast majority (99%) of the fish would only be handled and released. Of all the capture methods employed by researchers, screw traps are one of the most efficient and have some of the lowest mortality rates. The average mortality rate reported by researchers using screw traps to capture juvenile CVS Chinook salmon is 0.8% (2012-2016).

Researchers may also capture and variously handle, mark, tag, tissue sample and release 70 naturally produced and 42 adipose clipped hatchery adult Chinook salmon with no anticipated mortalities.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the ESU (Percent of ESU), the potential mortality levels are very low (a maximum of 0.2% for naturally produced juveniles). Furthermore, the effects from all of the proposed research would be spread out over most of the major tributaries of the ESU. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year-to-year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 23% of the naturally produced CVS Chinook they requested and the actual mortality was only 17% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see above example). The majority of the projects in CDFW's Program focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the program can be found in the state fishery agency submittal.

2.4.2.21 California Central Valley Steelhead

The specific projects and related take estimates are described in detail in CDFW's submittal (CDFW 2017) and that document is incorporated in full herein. The CDFW would conduct, oversee, or coordinate 33 projects that could take CCV steelhead. The proposed research involves activities that are not intended to harm or kill listed fish at all. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 123.

Table 123. Summary of Proposed Take of CCV Steelhead.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	8,120	125
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	4,970	87
	Natural	Observe/Harass	70,670	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	833	9
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	196	6
	Listed Hatchery Adipose Clip	Observe/Harass	1,130	0
Adult	Natural	Capture/Handle/Release Fish	151	4
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	575	10
	Natural	Observe/Harass	6,882	0
	Listed Hatchery Adipose Clip	Capture/Handle/Release Fish	21	0
	Listed Hatchery Adipose Clip	Capture/Mark, Tag, Sample Tissue/Release Live Animal	356	9
	Listed Hatchery Adipose Clip	Observe/Harass	1,980	0
Spawned Adult/Carcass	Natural	Observe/Sample Tissue Dead Animal	347	0
	Listed Hatchery Adipose Clip	Observe/Sample Tissue Dead Animal	57	0

Researchers, when submitting their applications, estimated the number of juvenile and adult CCV steelhead that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed CCV steelhead, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass steelhead, or sample dead fish, are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 124. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of CCV steelhead.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	14,399	2%	233	0.04%
	Listed Hatchery Adipose Clip	1,132	0.07%	17	0.001%
Adult	Natural	799	47%	15	0.9%
	Listed Hatchery Adipose Clip	415	11%	10	0.3%

Researchers may variously capture, handle, mark, tag, tissue sample, and release up to 14,399 naturally produced juvenile steelhead and kill, at most, 2% of those fish. Researchers may also capture and variously handle, mark, tag, tissue sample and release up to 799 naturally produced adult steelhead and kill, at most, 2% of those fish. The effects of this research would be dispersed throughout the DPS; researcher targeting adult steelhead would take place in seven different basins of the California central valley.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the DPS (Percent of DPS), the potential mortality levels are very low (a maximum of 0.04% for naturally produced juveniles and 0.9% for adults). Furthermore, the effects from all of the proposed research would be spread out over most of the major tributaries of the DPS. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year-to-year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 9% of the naturally produced juvenile CCV steelhead they requested and the actual mortality was only 7% of requested. Our research tracking system also reveals that for the same time period researchers, on average, ended up taking 14% of the naturally produced adult CCV steelhead they requested and the actual mortality was only 0.4% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see above example). The majority of the projects in CDFW's Program focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the program can be found in the state fishery agency submittal.

2.4.2.22 South-Central California Coast Steelhead

The specific projects and related take estimates are described in detail in CDFW's submittal (CDFW 2017) and that document is incorporated in full herein. The CDFW would conduct, oversee, or coordinate seven projects that could take SCCC steelhead. The proposed research involves activities that are not intended to harm or kill listed fish at all. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 125.

Table 125. Summary of Proposed Take of SCCC Steelhead.

Life Stage	Origin	Take Action	Requested Take	Requested Mortality
Juvenile	Natural	Capture/Handle/Release Fish	6,620	75
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	7,800	137
	Natural	Observe/Harass	2,745	0
	Natural	Recondition and release	12,000	120
Adult	Natural	Capture/Handle/Release Fish	15	0
	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	200	0
	Natural	Observe/Harass	2,556	0
Spawned Adult/Carcass	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	7	0
	Natural	Observe/Sample Tissue Dead Animal	70	0
	Natural	Collect, Sample, and Transport Live Animal	5	0

Researchers, when submitting their applications, estimated the number of juvenile and adult SCCC steelhead that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed SCCC steelhead, we increased the requested take and requested mortality in this evaluation by 10%. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10% would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass steelhead, or sample dead fish, are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 126. Total Requested Take, Plus the 10% Buffer, Compared to the Estimated Abundance of SCCC steelhead.

Life Stage	Origin	Total Take plus 10%	Percent of ESU Handled	Requested Mortality plus 10%	Percent of ESU killed
Juvenile	Natural	29,062	37%	365	0.5%
Adult	Natural	237	34%	0	0%

Researchers may variously capture, handle, mark, tag, tissue sample, and release up to 29,062 juvenile steelhead and kill, at most, 1.3% of those fish. The majority of these fish (45%) would be captured from the Carmel River during summer-time low flows and held temporarily in an artificial stream channel adjacent to the river. Efforts are underway to restore stream flows in the Carmel River, and in the interim this program will help to insure that adequate numbers of juvenile steelhead survive through the summer. Researchers may also capture and variously handle, mark, tag, tissue sample and release up to 237 adult steelhead with no anticipated mortalities.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to the abundance of the DPS (Percent of DPS), the potential mortality levels are very low (a maximum of 0.5% for naturally produced juveniles). Furthermore, the effects from all of the proposed research would be spread out over most of the major tributaries of the DPS. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

It is very likely that the effects of the program will be much lower than what we have evaluated. To account for year-to-year variation in species abundance, researchers factor in a modest overestimate of take. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 8% of the SCCC steelhead they requested and the actual mortality was only 3% of requested.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish (see above example). The majority of the projects in CDFW's Program focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the program can be found in the state fishery agency submittal.

2.4.2.23 Green Sturgeon

The specific projects and related take estimates are described in detail in the CDFW and ODFW submittals (CDFW 2017 and ODFW 2017) and in individual project applications; those records are incorporated in full herein. The agencies would conduct, oversee, or coordinate 19 projects that could take listed green sturgeon. The proposed research involves activities that are not intended to harm juveniles or adults, except for a small amount of intentional mortality of eggs.

Any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. We have summarized the total proposed take in Table 127.

Table 127. Summary of Requested Take of Green Sturgeon by Take Action for the 2018 Program.

Life Stage	Take Action	Requested Take	Requested Mortality
Egg	Intentional (Directed) Mortality	160	160
Larvae	Capture/Handle/Release Fish	97	21
Juvenile	Capture/Handle/Release Fish	33	0
	Observe/Harass	20	0
Adult	Capture/Handle/Release Fish	26	0
	Capture/Mark, Tag, Sample Tissue/Release Fish	24	0
	Observe/Harass	206	0

Researchers, when submitting their applications, estimated the number of green sturgeon that may be handled and killed during the year. Additionally, to account for the dynamic and potentially increasing scope of research that may annually affect listed green sturgeon, we increased the requested take and requested mortality in this evaluation by 10 percent. Although it is difficult to anticipate how much more research may be requested, NMFS believes this 10 percent buffer would be sufficient to include any changes or additions. The table below compares the total requested take, plus the 10% buffer, to the species' estimated abundance. Activities that would observe/harass sturgeon are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in the table below.

Table 128. Summary of Total Proposed Take of Green Sturgeon for the 2018 Program.

Life Stage	Requested Take plus 10%	Percent of DPS Handled	Requested Mortality plus 10%	Percent of ESU Killed
Egg	176	See Discussion	176	See Discussion
Larvae	107	See Discussion	23	See Discussion
Juvenile	36	See Discussion	0	0%
Adult	55	4%	0	0%

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be The 2018 Program may kill up to 176 eggs and 17 larvae. The annual abundance of green sturgeon eggs and larvae is currently unknown due to a lack of knowledge of the survival rate of early life history stages of green sturgeon. However, given an annual spawning run estimate of 292 individuals, and a mean green sturgeon fecundity of 142,000 (Van Eenennaam et al. 2001), it can be safely assumed that 175 egg mortalities and 17 larval mortalities would represent a very small fraction of the annual abundance of those life stages for the DPS. Researchers would capture juvenile and adult green sturgeon and variously mark, tag, or tissue sample the fish before releasing them (Table 50).

Researchers do not expect to kill any juvenile or adult green sturgeon. Therefore, the research would have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. We expect the research actions to generate lasting benefits to conservation of the listed fish. The majority of the projects in the 2018 Program focus on monitoring and evaluating actions recommended for the conservation of the listed species, and some projects are beginning to monitor population abundance and trends.

2.4.2.24 Eulachon

The specific projects and their effects on eulachon are described in detail in three of the state fishery agency submittals (CDFW 2017, ODFW 2017, and WDFW 2017) and those documents are incorporated in full herein. The three agencies would conduct twenty-three projects that could take eulachon. None of the planned research involves activities that are intended to kill eulachon. However, any fish handling carries an inherent potential for causing or promoting stress, disease, injury, or death of the specimen. For 2018, the research programs may take up to 2,017 adult eulachon and kill no more than 83. The projects may also take 2,000 post spawn adult eulachon. Activities that would take post spawn eulachon are not expected to affect the species' abundance, productivity, distribution, or diversity, therefore, we do not include them in our analysis of effects.

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, or reproductive effects, the effects of the proposed action considered herein are best seen in the context of the fish that will be When compared to a DPS abundance of roughly 81 million eulachon, the death of 98 adult eulachon represents a negligible loss (0.0001%) of that total. That's about one out of every one million fish. Furthermore, the effects from all of the proposed research would be spread out over various river systems in California, Oregon, and Washington. Thus, no population is likely to experience a disproportionate amount of these losses. Therefore, the research would likely have only a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity.

An effect of the research that cannot be quantified is how it would help benefit and conserve the species. Several of the projects that may take eulachon are assessing habitat conditions and monitoring restoration activities. We expect the research actions to generate lasting benefits to conservation of all listed fish species. The majority of the projects in the Programs focus on monitoring and evaluating actions recommended for the conservation of the listed species. Full details about the programs can be found in the state fishery agency submittals.

2.4.3 Effects on Critical Habitat

Full descriptions of effects of the proposed activities are found in the state submittals (CDFW 2017, IDFG 2017, ODFW 2017, and WDFW 2017). In general, the activities would be capturing fish with traps, nets, hook and line, backpack electrofishing, and sampling them at fishways, diversion screens, and weirs. These techniques are minimally intrusive in terms of their effect on habitat because they would involve very little, if any, disturbance of streambeds or adjacent riparian zones. None of the activities will measurably affect any habitat PCE listed earlier. Moreover, the proposed activities are all of short duration. Therefore, NMFS concludes that the proposed activities are not likely to have an adverse impact on any designated critical habitat.

2.5 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the Act.

Future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could impact listed species or their habitat. Government actions are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area which encompasses numerous government entities exercising various authorities and the many private landholdings, make any analysis of cumulative effects difficult and speculative. However, we can reasonably state that the vast majority of such actions in the region will eventually have to undergo section 7 consultation. In almost all potential instances, the actors will need government funding or authorization to carry out a project that may affect salmon, and therefore the effects such a project may have on salmon and steelhead will be analyzed when the need arises.

Non-Federal actions are likely to continue affecting listed species. The cumulative effects in the action area are difficult to analyze because of this Opinion's large geographic scope, the different resource authorities in the action area, the uncertainties associated with government and private actions, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation; however, given the trends in the region, the adverse cumulative effects are likely to increase. The primary cumulative effects will arise from those water quality and quantity impacts that occur as human population growth and development shift patterns of water and land use, thereby creating more intense pressure on streams and rivers within this geography in terms of volume, velocities, pollutants, baseflows, and peak flows. But the specifics of these effects, too, are impossible to predict at this time. In addition, there are the aforementioned effects of climate change—many of those will arise from or be exacerbated by actions taking place in the action area and elsewhere that will not undergo ESA consultation. One thing to note is that the actions considered in this opinion would only continue for one year. We are unaware of any non-Federal actions likely to take place in the action area over the next year that would have measurable effects on the species or their habitat.

2.6 Integration and Synthesis

2.6.1 Salmon and Steelhead

The Integration and Synthesis section is the final step of NMFS' assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the cumulative effects (Section 2.5) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) result in appreciable reductions in the likelihood of both survival and recovery of the species in the wild by reducing its numbers, reproduction, or distribution or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. We make these assessments in full consideration of the status of the species and critical habitat (Section 2.2) and the environmental baseline of each species and its critical habitat (Section 2.3). The assessments are also made in consideration of the other research that has been authorized and that may affect the various listed species (Table 81). The following sections therefore add the take proposed by CDFW, IDFG, ODFW, and WDFW to the research take that has already been authorized in the region and then compare those totals to the estimated annual abundance of each species under consideration.

2.6.1.1 Puget Sound Chinook Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total authorized take would be as much as 16% of the estimated abundance of naturally produced juvenile PS Chinook salmon and 4% for naturally produced adult PS Chinook salmon (Table 129).

Table 129. Total expected take of PS Chinook salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 84).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance*	Requested mortality plus the baseline	Percent of abundance*
Juvenile	Natural	411,301	16%	7,456	0.3%
	Listed Hatchery Intact Adipose	39,484	0.6%	1,570	0.02%
	Listed hatchery adipose clipped	75,861	0.2%	5,109	0.01%
Adult	Natural	727	4%	19	0.1%
	Listed Hatchery Intact Adipose	647	24%	5	0.6%
	Listed hatchery adipose clipped	2,560		72	
Spawned Adult/ Carcass	Natural	11		0	

* We do not have separate abundance estimates for adipose clipped and intact adipose adult hatchery salmonids.

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 3% of the total requested take of Chinook is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises 44 projects), the potential mortality would equal no more than one-tenths of a percent of the abundance for naturally produced adults and three-tenths of a percent for juveniles. Thus the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance. And the activities contemplated in this opinion represent less than half of that already small number.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system for the 4(d) Limit 7 program reveals that on average researches only take about 37% of the naturally produced PS Chinook they request and the actual (reported) mortality is only 42% of requested mortality.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

Researchers may also handle naturally produced post-spawn adults. Spawned adults or carcasses are often swept downstream into traps. As many as 11 naturally produced post-spawn adults may be taken in 2018. Chinook salmon die after spawning. Therefore, any deaths of post-spawn fish during handling are not considered to be a result of the research, nor, is the research targeting the post-spawn fish expected to have any effect on the species' abundance, productivity, diversity, or spatial structure.

2.6.1.2 Puget Sound Steelhead

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total authorized take would be as much as three percent of the estimated abundance of naturally produced juvenile PS steelhead and seven percent for naturally produced adult PS steelhead (Table 130).

Table 130. Total expected take of PS steelhead for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 86).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	55,269	3%	1,259	0.06%
	Listed Hatchery Intact Adipose	667	0.6%	23	0.02%
	Listed hatchery adipose clipped	4,328	4%	101	0.09%
Adult	Natural	1,309	7%	22	0.1%
	Listed Hatchery Intact Adipose	11	Unknown	0	
Spawned Adult/ Carcass	Natural	19		0	

Notes: LHAC=Listed Hatchery Adipose Clipped, LHIA=Listed Hatchery Intact Adipose.

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 2% of the total requested take of steelhead is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises 41 projects), the potential mortality would be no more than one-tenth of a percent of the abundance for naturally produced adults or juveniles. Thus the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system for the 4(d) Limit 7 program reveals that on average researches only take about 26% of the naturally produced PS steelhead they request and the actual (reported) mortality is only 8% of requested mortality.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

Researchers may also handle both naturally produced and listed hatchery post-spawn adults. As many as 19 naturally produced post-spawn adults may be taken in 2018. Although steelhead may spawn more than once, repeat spawning is relatively uncommon and repeat spawners are predominately female (Busby et al. 1996). For those spawned adults that are still alive survival is relatively low and these fish have already contributed to the next generation. Therefore, any deaths of post-spawn fish during handling are not considered to be a result of the research, nor, is the research targeting the post-spawn fish expected to have any effect on the species' abundance, productivity, diversity, or spatial structure.

2.6.1.3 Hood Canal Summer-run Chum Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total authorized take would be as much as 19% of the estimated abundance of naturally produced juvenile HCS chum salmon and 8% for naturally produced adult HCS chum salmon (Table 131).

Table 131. Total expected take of HCS chum salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 88).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	759,500	19%	3,095	0.08%
Juvenile	Listed Hatchery Intact Adipose	135	0.09%	3	0.002%
Adult	Natural	2,133	8%	32	0.1%
Spawned Adult/Carcass	Natural	220		0	

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 0.4% of the total requested take of chum is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 15 projects), the potential mortality would equal no more than one-tenth of a percent of the abundance for naturally produced adults or juveniles. Thus the projected total lethal take for all research and monitoring activities represents only fractions of a percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system for the 4(d) Limit 7 program reveals that on average researches only take about 67% of the naturally produced HCS chum salmon they request and the actual (reported) mortality is only 15% of requested mortality. Therefore, we derived the percentages by overestimating the number of adult and juvenile fish likely to be taken and conservatively estimating the actual number of juveniles and adults. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

Researchers may also handle both naturally produced and listed hatchery post-spawn adults. Spawned adults or carcasses are often swept downstream into traps. As many as 220 naturally produced post-spawn adults may be taken in 2018. Chum salmon die after spawning. Therefore, any deaths of post-spawn fish during handling are not considered to be a result of the research, nor, is the research targeting the post-spawn fish expected to have any effect on the species' abundance, productivity, diversity, or spatial structure.

2.6.1.4 SR Fall Chinook Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total authorized take would be as much as half a percent of the estimated abundance of naturally produced juvenile SR fall Chinook salmon and four percent for naturally produced adult SR fall Chinook salmon (Table 132).

Table 132. Total expected take of SR fall Chinook salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 90).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance*	Requested mortality plus the baseline	Percent of abundance*
Juvenile	Natural	2,852	0.5%	119	0.02%
	Listed Hatchery Intact Adipose	568	0.02%	26	0.0009%
	Listed hatchery adipose clipped	1,159	0.04%	60	0.002%
Adult	Natural	273	2%	7	0.06%
	Listed Hatchery Intact Adipose	211	2%	3	0.03%
	Listed hatchery adipose clipped	243		6	

* We do not have separate abundance estimates for adipose clipped and intact adipose adult hatchery salmonids.

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 4% of the total requested take of Chinook is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 15 projects), the potential mortality would equal no more than one-tenth of a percent of the abundance for any life stage or origin. Thus the projected total lethal take for all research and monitoring activities represents only fractions of a percent of the species' total abundance, and the activities contemplated in this opinion represent only fractions of those already small numbers.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system for the 4(d) Limit 7 program reveals that on average researches only take about 9% of the naturally produced SR fall Chinook they request and the actual (reported) mortality is only 3% of requested mortality. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Third, many of the juvenile fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be parr or fry: life stages represented by many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the already small percentages by (a) conservatively estimating the actual number of juveniles, (b) overestimating the number of fish likely to be killed (both juvenile and adult), and (c) treating each dead juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, they would be restricted to reductions in abundance and productivity (because the species has only one population), and to some degree they would be offset by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead or promote their recovery.

2.6.1.5 SR spr/sum Chinook Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total authorized take would be as much as 45% of the estimated abundance of naturally produced juvenile SR spr/sum Chinook salmon and 8 percent for naturally produced adult SR spr/sum Chinook salmon (Table 133).

Table 133. Total expected take of SR spr/sum Chinook salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 92).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance*	Requested mortality plus the baseline	Percent of abundance*
Juvenile	Natural	626,653	45%	6,926	0.5%
	Listed Hatchery Intact Adipose	12,760	1%	160	0.02%
	Listed hatchery adipose clipped	26,513	0.6%	434	0.01%
Adult	Natural	945	8%	16	0.1%

	Listed Hatchery Intact Adipose	517	25%	5	0.3%
	Listed hatchery adipose clipped	919		10	

* We do not have separate abundance estimates for adipose clipped and intact adipose adult hatchery salmonids.

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (only 1% of the total requested take of Chinook is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 20 projects), the potential mortality would equal a maximum of half a percent of the abundance for naturally produced fish. Thus the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 57% of the number of adult fish they requested and the actual mortality was only 4% of requested. For juvenile fish, researchers have only taken 52% of the number of fish they requested and the actual mortality was only 13% of requested.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.1.6 Snake River Steelhead

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total authorized take would be as much as 28% of the estimated abundance of naturally produced juvenile SR steelhead and 22% for naturally produced adult SR steelhead (Table 134).

Table 134. Total expected take of SR steelhead for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 94).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance*	Requested mortality plus the baseline	Percent of abundance*
Juvenile	Natural	226,308	28%	3,767	0.5%
	Listed Hatchery Intact Adipose	22,330	3%	254	0.03%
	Listed hatchery adipose clipped	28,704	0.9%	419	0.01%
Adult	Natural	7,221	22%	92	0.3%
	Listed Hatchery Intact Adipose	1,144	1%	24	0.02%
	Listed hatchery adipose clipped	1,981		41	
Spawned Adult/ Carcass	Natural	781		10	

* We do not have separate abundance estimates for adipose clipped and intact adipose adult hatchery salmonids.

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 2% of the total requested take of steelhead is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 20 projects), the potential mortality would equal no more than half of a percent of the abundance for naturally produced adults or juveniles. Thus the projected total lethal take for all research and monitoring activities represent only a small fraction of the species' total abundance. And the activities contemplated in this opinion represent less than half of that already small number.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 34% of the SR steelhead they requested and the actual mortality was only 14% of requested.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

Researchers may also handle both naturally produced and listed hatchery post-spawn adults. As many as 781 naturally produced post-spawn adults may be taken in 2018. Although steelhead may spawn more than once, repeat spawning is relatively uncommon and repeat spawners are predominately female (Busby et al. 1996). For those spawned adults that are still alive survival is relatively low and these fish have already contributed to the next generation. Therefore, any deaths of post-spawn fish during handling are not considered to be a result of the research, nor, is the research targeting the post-spawn fish expected to have any effect on the species' abundance, productivity, diversity, or spatial structure.

2.6.1.7 Upper Columbia River Steelhead

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total authorized take would be 11 percent of the estimated abundance of naturally produced juvenile UCR steelhead (Table 135).

Table 135. Total expected take of UCR steelhead for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 96).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	18,785	11%	391	0.2%

The majority of fish handled subsequently recover shortly after handling with no long-term ill effects. So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 16 projects), the potential mortality would equal no more than two-tenths of a percent of the abundance for juveniles. Thus the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance. And the activities contemplated in this opinion represent only fractions of those already small numbers.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system for the 4(d) Limit 7 program reveals that the actual (reported) mortality for juvenile UCR steelhead is only 1% of requested mortality. Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles, and (c) treating each juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.1.8 Middle Columbia River Steelhead

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total authorized take would be as much as 35 percent for naturally produced juvenile MCR steelhead and 53 percent for adults. (Table 136).

Table 136. Total expected take of MCR steelhead for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 98).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance*	Requested mortality plus the baseline	Percent of abundance*
Juvenile	Natural	147,385	35%	2,727	0.7%
	Listed Hatchery Intact Adipose	8,119	9%	110	0.1%
	Listed hatchery adipose clipped	6,666	2%	96	0.03%
Adult	Natural	2,581	11%	25	0.1%
	Listed Hatchery Intact Adipose	39	53%	1	0.6%
	Listed hatchery adipose clipped	930		10	
Spawned Adult/ Carcass	Natural	666		14	
	Listed Hatchery Intact Adipose	22		2	
	Listed hatchery adipose clipped	13		1	

* We do not have separate abundance estimates for adipose clipped and intact adipose adult hatchery salmonids.

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 2% of the total requested take of naturally produced fish is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 21 projects), the potential mortality would be no more than seven-tenths of a percent of the abundance of naturally produced adult and juvenile steelhead. The potential mortality for listed hatchery fish would equal no more than six-tenths of a percent for adults or juveniles. Intact adipose fin listed hatchery fish are produced for conservation purposes, however adipose clipped hatchery fish are considered to be surplus to recovery needs. Thus the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance. And the activities contemplated in this opinion represent only fractions of those already small numbers.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system for the 4(d) Limit 7 program reveals that on average researches only take about 29% of the naturally produced juvenile MCR steelhead they request and the actual (reported) mortality is only 13% of requested mortality. For naturally produced adult MCR steelhead, researchers only take about 29% of the fish they request and the actual (reported) mortality is only 13% of requested mortality.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

Researchers may also handle both naturally produced and listed hatchery post-spawn adults. As many as 666 naturally produced post-spawn adults may be taken in 2018. Although steelhead may spawn more than once, repeat spawning is relatively uncommon and repeat spawners are predominately female (Busby et al. 1996). For those spawned adults that are still alive survival is relatively low and these fish have already contributed to the next generation. Therefore, any deaths of post-spawn fish during handling are not considered to be a result of the research, nor, is the research targeting the post-spawn fish expected to have any effect on the species' abundance, productivity, diversity, or spatial structure.

2.6.1.9 Columbia River Chum Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total take would be as much as seven-tenths of a percent of the estimated abundance of juvenile naturally produced CR chum salmon and one-tenth for adults (Table 137).

Table 137. Total expected take of CR chum salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 100).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	40,099	0.7%	519	0.01%
	Listed Hatchery Intact Adipose	562	0.09%	18	0.003%
Adult	Natural	15	0.1%	0	0%

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 1% of the total requested take is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 13 projects), the potential mortality would equal no more than one-hundredth of a percent of the abundance for any life stage or origin. Thus the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance. And the activities contemplated in this opinion represent less than half of that already small number.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 33% of the CR chum they requested and the actual mortality was only 14% of requested. Therefore, we derived the percentages by overestimating the number of adult and juvenile fish likely to be taken and conservatively estimating the actual number of juveniles and adults. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.1.10 Lower Columbia River Chinook Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total authorized take would be ten percent of the estimated abundance of naturally produced juvenile LCR Chinook salmon and one percent of adults. (Table 138).

Table 138. Total expected take of LCR Chinook salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 102).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance*	Requested mortality plus the baseline	Percent of abundance*
Juvenile	Natural	1,224,782	10%	15,448	0.1%
	List Hatchery Intact Adipose	423	0.04%	47	0.004%
	Listed Hatchery Adipose Clipped	87,983	0.3%	1,920	0.006%
Adult	Natural	321	1%	4	0.01%
Spawned Adult/ Carcass	Natural	22		1	

* We do not have separate abundance estimates for adipose clipped and intact adipose adult hatchery salmonids.

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (only 1% of the total requested take of naturally produced fish is lethal). So, the effect of all actions we consider here is the potential mortality, and when the requested take is combined with the baseline (which comprises approximately 22 projects), the potential mortality would equal no more than one-tenth of a percent of the abundance of any life stage or origin. Thus, the projected total lethal take for all research and monitoring activities represents only fractions of a percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 30% of the LCR Chinook they requested and the actual mortality was only 23% of requested.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

Researchers may also handle naturally produced post-spawn adults. Spawned adults or carcasses are often swept downstream into traps. As many as 22 naturally produced post-spawn adults may be taken in 2018. Chinook salmon die after spawning. Therefore, any deaths of post-spawn fish during handling are not considered to be a result of the research, nor, is the research targeting the post-spawn fish expected to have any effect on the species' abundance, productivity, diversity, or spatial structure.

2.6.1.11 Lower Columbia River Coho Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total take would range from three-tenths to twenty-nine percent of estimated species abundance (Table 139).

Table 139. Total expected take of LCR coho salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 104).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance*	Requested mortality plus the baseline	Percent of abundance*
Juvenile	Natural	184,367	29%	2,592	0.4%
	List Hatchery Intact Adipose	727	0.3%	111	0.05%
	Listed Hatchery Adipose Clipped	69,618	0.9%	2,168	0.03%
Adult	Natural	600	2%	8	0.02%
	Listed Hatchery Adipose Clipped	583		9	
Spawned Adult/ Carcass	Natural	17			

* We do not have separate abundance estimates for adipose clipped and intact adipose adult hatchery salmonids.

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 2% of the total requested take is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 21 projects), the potential mortality would equal no more than four-tenths of a percent of the abundance for adults or juveniles. Thus, the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 28% of the LCR coho they requested and the actual mortality was only 11% of requested.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus, the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

Researchers may also handle both naturally produced and listed hatchery post-spawn adults. Spawned adults or carcasses are often swept downstream into traps. As many as 17 naturally produced post-spawn adults may be taken in 2018. Coho salmon die after spawning. Therefore, any deaths of post-spawn fish during handling are not considered to be a result of the research, nor, is the research targeting the post-spawn fish expected to have any effect on the species' abundance, productivity, diversity, or spatial structure.

2.6.1.12 Lower Columbia River Steelhead

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total take would range from eighteen to twenty-one percent of estimated species abundance (Table 140).

Table 140. Total expected take of LCR steelhead for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 106).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	66,656	21%	1,099	0.3%
	Listed Hatchery Adipose Clipped	56,695	5%	921	0.08%

Adult	Natural	2,382	18%	24	0.2%
Spawned Adult/ Carcass	Natural	136		6	
	Listed Hatchery Adipose Clipped	39		4	

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 2% of the total requested take of naturally produced fish is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 20 projects), the potential mortality would equal no more than three-tenths of a percent of the abundance for adults or juveniles. Thus, the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 26% of the LCR steelhead they requested and the actual mortality was only 11% of requested.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

Researchers may also handle both naturally produced and listed hatchery post-spawn adults. As many as 136 naturally produced post-spawn adults may be taken in 2018. Although steelhead may spawn more than once, repeat spawning is relatively uncommon and repeat spawners are predominately female (Busby et al. 1996). For those spawned adults that are still alive survival is relatively low and these fish have already contributed to the next generation. Therefore, any deaths of post-spawn fish during handling are not considered to be a result of the research, nor, is the research targeting the post-spawn fish expected to have any effect on the species' abundance, productivity, diversity, or spatial structure.

2.6.1.13 Upper Willamette River Chinook Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total take would range from two-tenths of a percent to four percent of estimated species abundance (Table 141).

Table 141. Total expected take of UWR Chinook salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 108).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	50,480	4%	927	0.07%
	Listed Hatchery Intact Adipose	38	0.2%	8	0.05%
	Listed Hatchery Adipose Clipped	10,203	0.2%	267	0.005%
Adult	Natural	254	2%	7	0.06%
	Listed Hatchery Adipose Clipped	243	0.7%	10	0.03%
Spawned Adult/ Carcass	Natural	11			
	Listed Hatchery Adipose Clipped	55			

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (2% of the total requested take of naturally produced fish is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 12 projects), the potential mortality would equal no more than seven-hundredths of a percent of the abundance for any life stage or origin. Thus, the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 14% of the UWR steelhead they requested and the actual mortality was only 1% of requested.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus, the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

Researchers may also handle both naturally produced and listed hatchery post-spawn adults. Spawned adults or carcasses are often swept downstream into traps. As many as 11 naturally produced and 55 hatchery produced post-spawn adults may be taken in 2018. Chinook salmon die after spawning. Therefore, any deaths of post-spawn fish during handling are not considered to be a result of the research, nor, is the research targeting the post-spawn fish expected to have any effect on the species' abundance, productivity, diversity, or spatial structure.

2.6.1.14 Upper Willamette Steelhead

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total take would be no more than six percent of estimated species abundance (Table 142).

Table 142. Total expected take of UWR steelhead for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 110).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	8,797	6%	208	0.1%
Adult	Natural	276	5%	4	0.07%

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 3% of the total requested take of naturally produced fish is lethal). So, the effect of all actions we consider here is potential mortality, and when requested take is combined with the baseline (which comprises approximately 11 projects), the potential mortality would be no more than one-tenth of a percent of the abundance for adults or juveniles. Thus, the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 14% of the UWR steelhead they requested and the actual mortality was only 1% of requested.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus, the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.1.15 Oregon Coast Coho Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total take would range from nine-tenths of a percent to three percent of estimated species abundance (Table 143).

Table 143. Total expected take of OC coho salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 112).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	566,392	3%	12,586	0.08%
	Listed Hatchery Adipose Clipped	359	0.6%	23	0.04%
Adult	Natural	5,998	3%	59	0.03%
	Listed Hatchery Adipose Clipped	19	0.9%	0	0%
Spawned Adult/ Carcass	Natural	55			

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (only 2% of the total requested take is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 7 projects), the potential mortality would equal no more than eight-hundredths of a percent of the abundance for adults or juveniles. Thus, the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 28% of the number of fish they requested and the actual mortality was only 13% of requested.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

Researchers may also handle both naturally produced and listed hatchery post-spawn adults. Spawned adults or carcasses are often swept downstream into traps. As many as 55 post-spawn adults may be taken in 2018. Coho salmon die after spawning. Therefore, any deaths of post-spawn fish during handling are not considered to be a result of the research, nor, is the research targeting the post-spawn fish expected to have any effect on the species' abundance, productivity, diversity, or spatial structure.

2.6.1.16 Southern Oregon/Northern California Coasts Coho Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total take could be as much as sixteen percent of the abundance of naturally produced adult and juvenile SONCC coho salmon (Table 144).

Table 144. Total expected take of SONCC coho salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this Biological Opinion (Table 114).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance*	Requested mortality plus the baseline	Percent of abundance*
Juvenile	Natural	174,149	16%	2,414	0.2%
	Listed Hatchery Intact Adipose	7,850	1%	706	0.1%
	Listed Hatchery Adipose Clipped	1,496	0.7%	44	0.02%
Adult	Natural	1,453	16%	24	0.3%
	Listed Hatchery Intact Adipose	1,520		16	
	Listed Hatchery Adipose Clipped	593	19%	10	0.2%

* We do not have separate abundance estimates for adipose clipped and intact adipose adult hatchery salmonids.

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 2% of the total requested take is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 19 projects), the potential mortality would equal no more than three-tenths of a percent of the abundance for naturally produced adults or juveniles. Thus, the projected total lethal take for all research and monitoring activities represent only fractions of a percent of the species' total abundance of naturally produced fish. The potential mortality for listed hatchery fish would equal no more than two-tenths of a percent. Adipose clipped hatchery fish are considered to be surplus to recovery needs.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past ten years researchers, on average, ended up taking 6% of the SONCC coho they requested and the actual mortality was only 3% of requested.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus, the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.1.17 California Coastal Chinook Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total capture take would range from 13 percent to 23 percent of estimated species abundance—depending on the age class (Table 145).

Table 145. Total expected take of CC Chinook salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this biological opinion (Table 116).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	289,064	23%	3,440	0.3%
Adult	Natural	930	13%	35	0.5%

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (less than two percent of the total requested take is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 17 projects), the potential mortality would equal only three-tenths of a percent of the estimated abundance of natural-origin juveniles and half a percent of natural-origin adult estimated abundance. Thus, the projected total lethal take for all research and monitoring activities represents only fractions of a percent of the species' total abundance, and the activities contemplated in this opinion represent only fractions of those already small numbers.

In addition, the true numbers of fish that would actually be taken would most likely be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a 10 percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 42% of the CC Chinook they requested and the actual mortality was only 27% of requested. This would mean that the actual effect is likely to be lower than the numbers stated in the table above.

Third, many of the fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the percentages by (a) overestimating the number of adult and juvenile fish likely to be taken, (b) conservatively estimating the actual number of juveniles and adults, and (c) treating each juvenile fish as part of the same year class. Thus, the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.1.18 Northern California Steelhead

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total capture take would be no more than 42% percent of estimated species abundance (Table 146).

Table 146. Total expected take of NC Steelhead for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this biological opinion (Table 118).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	267,075	33%	4,329	0.5%
Adult	Natural	3,033	42%	14	0.2%

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than two percent of the total requested take is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 14 projects), the potential mortality would equal half a percent of the estimated abundance of natural-origin juveniles and only two-tenths of a percent of natural-origin adult estimated abundance. Thus, the projected total lethal take for all research and monitoring activities represents only a small percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a 10 percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 47% of the NC steelhead they requested and the actual mortality was only 15% of requested. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Third, many of the juvenile fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be parr or fry: life stages represented by many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the already small percentages by (a) conservatively estimating the actual number of juveniles, (b) overestimating the number of fish likely to be killed (both juvenile and adult), and (c) treating each dead juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.1.19 Central California Coast Steelhead

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total capture take would range from 78 percent to 107 percent of estimated species abundance—depending on the component and age class (Table 147).

Table 147. Total expected take of CCC Steelhead for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this biological opinion (Table 120).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	193,111	78%	4,445	2%
Adult	Natural	2,343	107%	36	2%
Spawned Adult/ Carcass	Natural	239			

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than two percent of the total requested take of steelhead is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 19 projects), the potential mortality would be no more than two percent of the estimated abundance of natural-origin juveniles and adults. The abundance estimate is not inclusive of all populations in the DPS and is therefore lower than the actual DPS abundance. Thus, the projected total lethal take for all research and monitoring activities represents only a small percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a 10 percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 15% of the CCC steelhead they requested and the actual mortality was only 7% of requested. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Third, many of the juvenile fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be parr or fry: life stages represented by many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the already small percentages by (a) conservatively estimating the actual number of juveniles, (b) overestimating the number of fish likely to be killed (both juvenile and adult), and (c) treating each dead juvenile fish as part of the same year class. Thus, the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.1.20 Central Valley Spring-run Chinook Salmon

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), for the Sacramento River basin the total capture take would range from seven to thirty-six percent of the estimated abundance of naturally produced juvenile and adult CVSR Chinook salmon (Table 148).

Table 148. Total expected take of CVSR Chinook salmon for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this biological opinion (Table 122).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	865,277	36%	16,740	0.7%
	Listed Hatchery Adipose Clipped	17,028	0.6%	2,906	0.1%
Adult	Natural	679	6%	22	0.2%
	Listed Hatchery Adipose Clipped	682	8%	252	3%

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (less than two percent of the total requested take is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 17 projects), the potential mortality would equal no more than seven-tenths of a percent of the estimated abundance of natural-origin juveniles and adults. When the effect of the Programs is added to the baseline for adipose clipped listed hatchery CVSR Chinook salmon, the potential mortality would equal one-tenth of a percent for juveniles and four percent for adults. We consider adipose clipped listed hatchery fish to be surplus to recovery needs. Thus, the projected total lethal take for all research and monitoring activities represents only a small percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a 10 percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 23% of the naturally produced CVS Chinook they requested and the actual mortality was only 17% of requested. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Third, many of the juvenile fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be parr or fry: life stages represented by many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the already small percentages by (a) conservatively estimating the actual number of juveniles, (b) overestimating the number of fish likely to be killed (both juvenile and adult), and (c) treating each dead juvenile fish as part of the same year class. Thus, the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.1.21 California Central Valley Steelhead

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total capture take would range from 10 percent to 190 percent of estimated abundance of naturally produced CCV steelhead—depending on the age class (Table 149). The number of adult steelhead that may be captured is much higher than the estimated abundance for the species. However, our estimated abundance is likely to be much lower than actual abundance and the effects of research would likewise be lower than what we have calculated. Current abundance data for CCV steelhead is limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data is the most reliable, as redd surveys for steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period. However, the hatchery data represents only a partial count. For example, the Feather River abundance estimate only includes those steelhead that entered the hatchery fish ladder at the upstream end of anadromous distribution. Many more adult steelhead spawn in the river and never enter the fish ladder.

Table 149. Total expected take of CCV steelhead for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this biological opinion (Table 124).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	60,743	10%	1,980	0.3%
	Listed Hatchery Adipose Clipped	11,998	0.7%	836	0.05%
Adult	Natural	3,196	190%	87	5%
	Listed Hatchery Adipose Clipped	2,185	57%	100	3%

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than four percent of the total requested take is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately 18 projects), the potential mortality would equal three-tenths of a percent of the estimated abundance of natural-origin juveniles and 5 percent of natural-origin adult estimated abundance. However, as stated above, we believe our abundance estimates are much lower than the actual abundance of the species. Thus, the projected total lethal take for all research and monitoring activities represents only a small percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a 10 percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 9% of the naturally produced juvenile CCV steelhead they requested and the actual mortality was only 7% of requested. Our research tracking system also reveals that for the same time period researchers, on average, ended up taking 14% of the naturally produced adult CCV steelhead they requested and the actual mortality was only 0.4% of requested. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Third, many of the juvenile fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be parr or fry: life stages represented by many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the already small percentages by (a) conservatively estimating the actual number of juveniles, (b) overestimating the number of fish likely to be killed (both juvenile and adult), and (c) treating each dead juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.1.22 South-Central California Coast Steelhead

When combined with scientific research and monitoring permits already approved (see section 2.3 Environmental Baseline), the total capture take would range from 58 percent to 73 percent of estimated species abundance—depending on the component and age class (Table 150). The number of fish that may be captured is high relative to the estimated abundance of the species. However, our estimated abundance is likely to be much lower than actual abundance and the effects of research would likewise be lower than what we have calculated. Our knowledge of current SCCC steelhead abundance is based largely on multiple short-term studies some of which are more than ten years old (Table 76).

Table 150. Total expected take of SCCC steelhead for scientific research and monitoring already approved for 2018 (Table 81) plus the actions covered in this biological opinion (Table 126).

Life Stage	Origin	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Juvenile	Natural	57,726	73%	1,353	2%
Adult	Natural	407	58%	5	0.7%
Spawned Adult/ Carcass	Natural	33			

The majority of fish handled subsequently recover shortly after handling with no adverse physiological, behavioral, or reproductive effects (no more than 3% of the total requested take is lethal). So, the effect of all actions we consider here is the potential mortality, and when requested take is combined with the baseline (which comprises approximately five projects), the potential mortality would equal only 2% of the estimated abundance of natural-origin juveniles and only 0.7% of natural-origin adult estimated abundance. The abundance estimate is not inclusive of all populations in the DPS and is therefore lower than the actual DPS abundance. Thus, the projected total lethal take for all research and monitoring activities represents only a very small percent of the species' total abundance.

In addition, the true numbers of fish that would actually be taken would almost certainly be smaller than the amounts authorized. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a 10 percent buffer. It is therefore very likely that researchers will take fewer fish than estimated. Our research tracking system reveals that for the past five years researchers, on average, ended up taking 8% of the SCCC steelhead they requested and the actual mortality was only 3% of requested. This would mean that the actual effect is likely to be fractions of the numbers stated in the table above.

Third, many of the juvenile fish that may be affected will be in the smolt stage, but others definitely will not be. These latter would simply be described as "juveniles," which means they may actually be parr or fry: life stages represented by many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the already small percentages by (a) conservatively estimating the actual number of juveniles, (b) overestimating the number of fish likely to be killed (both juvenile and adult), and (c) treating each dead juvenile fish as part of the same year class. Thus the actual numbers of fish likely to be killed represent fractions of the numbers stated above. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, and because they would be spread out over the species' entire range, they would be restricted to reductions in the species' total abundance and productivity (that is, the effects on structure and diversity would be unmeasurably small and not assignable to any individual population). Moreover, to some degree, the small reductions in abundance and productivity would be offset to some degree by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead and promote their recovery.

2.6.2 Summary for Salmon and Steelhead

The majority (at least 99%) of the naturally produced and listed hatchery juvenile fish that would be captured, handled, tissue sampled, etc., during the course of the proposed research are expected to survive with no long-term ill effects. Eight projects, out of a total of 215, have requested to intentionally kill naturally produced and listed hatchery juvenile salmonids. These projects combined would intentionally kill fish from fifteen of the twenty-two listed salmon and steelhead included in this evaluation. There are no requests to intentionally kill HCS chum salmon, UCR steelhead, CC Chinook salmon, NC steelhead, CCC steelhead, CCV steelhead, or SCCC steelhead.

The proposed amount of juvenile salmon and steelhead that may be killed is very small in comparison to the expected outmigration of each species. In no case would it be more than two percent of the estimated outmigration of naturally produced fish. Such losses would have little effect on abundance, a similarly small effect on productivity, and effectively unmeasurably small effects on diversity and distribution. Nonetheless, actual takes are almost certainly smaller than the amounts in the tables 129 through 150. First, we develop conservative estimates of juvenile abundance, as described in Section 2.2 above. Second, as noted repeatedly in the effects section, the researchers generally request more take than they estimate will actually occur and, to that requested amount of take, we add a ten percent buffer. It is therefore very likely that researchers will kill fewer fish than estimated. Third, many of the fish we have counted as smolts would actually be pre-smolts. These pre-smolts may be yearlings, parr, or fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, we derived the already small percentages by (a) conservatively estimating the actual number of juveniles and adults, (b) overestimating the number of fish likely to be killed, and (c) treating each dead juvenile fish as part of the same year class. Thus, the actual numbers of juvenile and adult salmonids the research is likely to kill are nearly certain to be smaller than the stated figures. Still, if even the worst case were to occur and the researchers were to take the maximum estimated number of fish, the effects of the losses would be very small, they would be restricted to reductions in abundance and productivity and, to some degree, they would be offset by the information to be gained—information that in most cases would be directly used to protect salmon and steelhead or promote their recovery.

The majority (at least 99%) of the naturally produced and hatchery propagated adult fish that would be captured, handled, tissue sampled, etc., during the course of the proposed research are expected to survive with no long-term physiological, behavioral, or reproductive effects. The proposed amount of naturally produced and listed hatchery adult salmon and steelhead that may be killed is a very small fraction of the expected returns. In all but two cases (CCC and CCV steelhead), the expected mortality plus the baseline would it be no more than several tenths of a percent of the average or forecasted annual return of naturally produced fish. And as we stated above, we believe the actual effect on CCC and CCV steelhead to much lower than what we calculated. Such losses to threatened salmon and steelhead would have little effect on abundance, a similarly small effect on productivity, and effectively unmeasurably small effects on diversity and distribution. Moreover, 64 out of the 107 projects that may take adult salmon or steelhead generally don't actually expect to kill any adults at all. Thus the estimates for lethal take are very conservative: the request for lethal take is often made simply to ensure that the research can go forward should something go awry and an adult is killed. Over the past five years, the actual take of adult salmon and steelhead (both nonlethal and lethal) reported for the states' research programs was always less than requested. Our research tracking system reveals that on average for the past five years researchers take about 27% of the numbers of naturally produced adult salmonids they request and only kill about 5% of requested. Furthermore, the effects on all species would be distributed throughout each listed unit as a whole, and much of the information generated from the research would be used to improve listed salmonid survival in the future.

2.6.3 Sturgeon and Eulachon

The effects on sturgeon and eulachon are detailed in the previous pages and those effects have individually been shown to be minimal. When that minimal effect is added to the previously allotted research take (see section 2.3 Environmental Baseline) the end result is still a very small degree of effect (Table 151).

Table 151. Total expected take of sturgeon and eulachon for scientific research and monitoring in projects that have already been permitted/authorized (Table 81) plus the actions covered in this Biological Opinion (Table 128 and Section 2.4.2.24).

Species	Life Stage	Requested take plus the baseline	Percent of abundance	Requested mortality plus the baseline	Percent of abundance
Sturgeon	Egg	1,526	See Discussion	1,526	See Discussion
	Larvae	7,122	See Discussion	1,038	See Discussion
	Juvenile	2,083	See Discussion	118	See Discussion
	Adult	197	15%	5	0.4%
Eulachon	Adult	5,473	0.007%	2,922	0.004%
	Spawned Adult/ Carcass	2,200		0	

The majority of juvenile and adult sturgeon handled subsequently recover shortly after handling with no long-term physiological, behavioral, or reproductive effects (no more than 5% of the total take is lethal). Therefore, the effects of the proposed action considered herein are best seen in the context of the fish that may be killed. When combined with the baseline, research authorizations may kill up to 1,526 eggs, 1,038 larvae, and 118 juvenile sturgeon. The annual abundance of green sturgeon eggs and larvae is currently unknown due to a lack of knowledge of the survival rate of early life history stages of green sturgeon. However, given an annual spawning run estimate of 292 individuals, and a mean green sturgeon fecundity of 142,000 (Van Eenennaam et al. 2001), it can be safely assumed that the egg, larvae, and juvenile mortalities would represent a small fraction of the annual abundance of those life stages for the DPS.

When requested take of adult sturgeon is combined with the baseline (which comprises 14 projects), the potential mortality would equal only 0.4% of the estimated abundance of adult sturgeon. Thus, the projected total lethal take for all research and monitoring activities represents only a very small percent of the species' total abundance.

Some of the eulachon captured by the proposed research activities are expected to recover shortly after handling with no long-term physiological, behavioral, or reproductive effects. Therefore, effects of the proposed action considered herein are best seen in the context of the fish that will be killed. When requested mortality is combined with the baseline, the loss of these fish is three-thousandths of a percent of abundance. Thus the projected total loss for all research and monitoring activities represent only fractions of a percent of the species' total abundance. And the activities contemplated in this opinion represent only fractions of those already small numbers. Still, if even the worst case were to occur and the researchers were to kill the maximum estimated number of fish, the effects of the losses would be very small, they would restricted to reductions in abundance and productivity and, to some degree, they would be offset by the information to be gained—information that in most cases would be directly used to protect sturgeon and eulachon or promote their recovery.

2.6.4 Critical Habitat

As noted earlier, we do not expect the individual research programs to have any appreciable effect on any listed species' critical habitat. This is true for all the actions in combination with the previously proposed research as well: the actions' short durations, minimal intrusion, and overall lack of measureable effect signify that even when taken together they would have no discernible impact on critical habitat.

2.6.5 Summary

As noted in the sections on species status, no listed species currently has all its biological requirements being met. Their status is such that there must be a substantial improvement in the environmental conditions of their habitat and other factors affecting their survival if they are to begin to approach recovery. In addition, while the future impacts of cumulative effects are uncertain at this time, they are likely to continue to be negative. In addition, while the future impacts of cumulative effects are uncertain at this time, they are likely to continue to be negative. Nonetheless, in no case would the proposed actions exacerbate any of the negative cumulative effects discussed (habitat alterations, etc.) and in all cases the research may eventually help to limit adverse effects by increasing our knowledge about the species' requirements, habitat use, and abundance. The effects of climate change are also likely to continue to be negative. However, given the proposed actions' short time frames and limited areas, those negative effects, while somewhat unpredictable, are too small to be effectively gauged as an additional increment of harm over the time span considered in this analysis. Moreover, the actions would in no way contribute to climate change (even locally), and in any case the proposed actions would actually help monitor the effects of climate change by noting stream temperatures, flows, etc. So while we can expect both cumulative effects and climate change to continue their negative trends, it is unlikely that the proposed actions would have any additive impact to the pathways by which those effects are realized (e.g., a slight reduction in fish abundance would have no effect on increasing stream temperatures or continuing land development).

To this picture, it is necessary to add the increment of effect represented by the proposed actions. In doing this, we have shown that while the proposed research activities will in fact have a small negative effect on each of the species' abundance and productivity, the actions, even in total, are unlikely to have more than a negligible effect on the species' other biological requirements. In all cases, even the effect on abundance will be minimal, the activity has not been identified as a threat, and the research is designed to benefit the species' survival in the long term.

The majority of the research proposed for 2018 in the Programs involves fish handling that is not intended to kill listed fish. However, handling does have the potential to cause stress, disease, injury or other sub-lethal effects, and even mortality in some instances. Agency researchers will use techniques generally accepted in their profession (e.g., anesthetics), when handling and sampling fish. To reduce risks to listed fish, all researchers are required to follow established state and Federal guidelines such as NMFS Electrofishing Guidelines (NMFS 2000b). Based on extensive prior experience with the techniques the agencies will use—and past reviews of similar activities by these agencies and their stated minimization and mitigation measures—only a very small percentage of the listed fish proposed to be handled are likely to be killed. Some of the research activities (10 out of 215 projects) do call for sacrificing some listed fish, but those fish will make up a small fraction of the overall research take.

It is not possible to know the exact adult and juvenile abundance for the various species during the coming year. For some of the species abundance estimates are updated each year, but for other species abundance data may be somewhat older. Each year's estimates are based on updated, revised information; they are produced with the best data available. Although these numbers are often very accurate, they must be considered estimates. Researchers also estimate the numbers of fish they expect to take during the coming year (displayed above and detailed in the agency's submittals). Further, researchers are required to submit reports at the end of the year detailing how many fish were actually taken. In nearly all cases in the 17 years this program has been running, the actual numbers of adult and juvenile fish taken have been much less than the requested numbers. If this trend continues, and we believe from experience that it will, it is very likely that the numbers of adults and juveniles taken in 2018 will be much smaller than the amounts proposed.

Also, the projects will not be concentrated in one stream, watershed, or marine area—or even a few—but rather will be distributed throughout each of the listed species' ranges. The number of mortalities for any single population will therefore be very small. The mortalities will only cause minor reductions in abundance and productivity and will not affect any species' spatial structure or diversity. In no case will the activities affect any species to the point of appreciably reducing its ability to survive and recover in the wild. Furthermore, the effects of the research on listed species, to some degree, would be offset by the information to be gained—information that in most cases would be directly used to protect listed species or promote their recovery.

In addition, NMFS' 4(d) rules are designed to encourage activities and programs that will conserve listed species. If programs are consistent with the rules' limits, ESA take prohibitions do not apply to those programs. As discussed in the Evaluation/Determination Document, the states' Programs are consistent with the 4(d) rules and will sufficiently conserve the listed species. Thus, the ESA take prohibitions do not apply to the Programs, nor do they apply to any Federal Action associated with the Programs.

One further consideration is that a great number of the activities contained in the section 10 and 4(d) research programs are expressly designed for the purpose of monitoring various species' statuses—an activity that the ESA specifically requires. According to ESA section 4(c)(2), we must review a species' status every five years after it is listed; the majority of the take associated with the research program goes directly toward fulfilling that goal. Therefore, though no individual activity is specifically mandated, much of the program's overall effect is actually to further purpose and intent of the ESA.

2.7 Conclusion

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of PS Chinook salmon, PS steelhead, HCS chum salmon, SR fall Chinook salmon, SR spr/sum Chinook salmon, SR steelhead, UCR steelhead, MCR steelhead, CR chum salmon, LCR Chinook salmon, LCR coho salmon, LCR steelhead, UWR Chinook salmon, UWR steelhead, OC coho salmon, SONCC coho salmon, CC Chinook salmon, NC steelhead, CCC steelhead, CVS Chinook salmon, CCV steelhead, SCCC steelhead, southern DPS eulachon, southern DPS green sturgeon, or to destroy or adversely modify any designated critical habitat.

2.8 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harass" is further defined by interim guidance as any act which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

In this instance, and for the actions considered in this opinion, there is no incidental take at all. The reason for this is that all the take contemplated in this document would be carried out under permits that allow the permit holders to directly take the animals in question. The actions are considered to be direct take rather than incidental take because in every case their actual purpose is to take the animals while carrying out a lawfully permitted activity. Thus, the take cannot considered "incidental" under the definition give above. Nonetheless, one of the purposes of an incidental take statement is to lay out the amount or extent of take beyond which individuals carrying out an action cannot go without being in possible violation of section 9 of the ESA. That purpose is fulfilled here by the amounts of direct take laid out in the effects section above (2.4). Those amounts—displayed in the various permits’ effects analyses—constitute hard limits on both the amount and extent of take the permit holders would be allowed in a given year. This concept is also reflected in the reinitiation clause just below.

The NMFS has not promulgated protective regulations via § 4(d) of the ESA for eulachon. Promulgation of 4(d) take prohibitions for eulachon shall result in a reinitiation of this opinion if the effects of the research program considered in this opinion results in take that is prohibited by the 4(d) rule.

2.9 Reinitiation of Consultation

As provided in 50 CFR 402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the agency action on listed species or designated critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat not considered in this opinion, or 4) a new species is listed or critical habitat designated that may be affected by the action.

In the context of this opinion, there is no incidental take anticipated and the reinitiation trigger set out in (1) is not applicable. If any of the direct take amounts specified in this opinion's effects analysis section (2.4) are exceeded, reinitiation of formal consultation will be required because the regulatory reinitiation triggers set out in (2) and/or (3) will have been met.

2.9 "Not Likely to Adversely Affect" Determinations

NMFS's concurrence with a determination that an action “is not likely to adversely affect” listed species or critical habitat is based on our finding that the effects are expected to be discountable, insignificant, or completely beneficial. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs; discountable effects are those that are extremely unlikely to occur; and beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat.

2.9.1 Southern Resident Whales Determination

The Southern Resident (SR) whale DPS composed of J, K, and L pods was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). The final rule listing killer whales as endangered identified several potential factors that may have caused their decline or may be limiting recovery. These are: quantity and quality of prey, toxic chemicals which accumulate in top predators, and disturbance from sound and vessel traffic. The rule also identified oil spills as a potential risk factor for this species. The final recovery plan includes more information on these potential threats to killer whales (NMFS 2008b).

NMFS published the final rule designating critical habitat for SR killer whales on November 29, 2006 (71 FR 69054). Critical habitat includes approximately 2,560 square miles of inland waters including Puget Sound, but does not include areas with water less than 20 feet deep relative to extreme high water. The physical or biological features (PBFs) of SR killer whale critical habitat are: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

SR killer whales spend considerable time in the Georgia Basin from late spring to early autumn, with concentrated activity in the inland waters of Washington State around the San Juan Islands, and then move south into Puget Sound in early autumn. Pods make frequent trips to the outer coast during this season. In the winter and early spring, SR killer whales move into the coastal waters along the outer coast from Southeast Alaska south to central California (NMFS 2008a, Hilborn et al. 2012). Half of the research activities included in the proposed actions would occur in freshwater areas where SR killer whales do not occur; and therefore, the proposed action may only indirectly affect SR killer whales by reducing their prey. The remainder of the research would occur in the critical habitat of SR killer whales (i.e. Puget Sound, Pacific Ocean) but direct interactions among the vessels and their capture equipment would be of an extremely low likelihood, therefore the potential for effects is discountable. This opinion would not authorize marine mammal take, nor has such take ever been observed in the past when similar activities were conducted in the action area. As a whole, the proposed action would only have discountable effects on marine mammals.

SR killer whales consume a variety of fish and one species of squid, but salmon, and Chinook salmon in particular, are their primary prey (review in NMFS 2008a). Ongoing and past diet studies of SR killer whales conduct sampling during spring, summer and fall months in inland waters of Washington State and British Columbia (i.e., Ford and Ellis 2006; Hanson et al. 2010; ongoing research by NWFSC). Genetic analysis of these samples indicate that when SR killer whales are in inland waters from May to September, they consume Chinook salmon stocks that originate from regions including the Fraser River (including Upper Fraser, Mid Fraser, Lower

Fraser, N. Thompson, S. Thompson and Lower Thompson), Puget Sound (N. and S. Puget Sound), the Central BC Coast, W. and E. Vancouver Island, and Central Valley California (Hanson et al. 2010). Other research and analysis provides additional information on the age of prey consumed (Hanson unpubl. data, as summarized in Ward et al. unpubl. report), confirming that SR killer whales predominantly consume larger (i.e. older) Chinook salmon when in inland waters (May through September).

The proposed actions may affect SR killer whales indirectly by reducing availability of their primary prey, Chinook salmon. As described in the effects analysis for salmonids, approximately 58,609 juvenile and 277 adult salmonids, including 31,887 juvenile and 32 adult Chinook may be killed during proposed research activities. Still, as the effects analysis illustrated, the proposed research as a whole is expected to have only very small effects on salmonid abundance and productivity and no appreciable effect on diversity or distribution (Table 118). Further, the adult salmonids that may be killed during the course of the research activities would not affect the whales' prey base because they would be taken after they have returned to freshwater and would therefore no longer be available as prey for the whales.

Table 152. Summary of Proposed Incidental and Intentional Mortality of Salmon and Steelhead from Scientific Research Projects in the 2018 State Research Programs.

Species	ESU/DPS	Adult	Juvenile
Chinook salmon	Puget Sound	0	4,770
	Snake River fall-run	7	76
	Snake River spring/summer-run	5	4,303
	Lower Columbia River	4	15,075
	Upper Willamette River	15	806
	California Coastal	1	2,268
	Central Valley spring-run	0	4,589
Chinook salmon Total		32	31,887
Chum salmon	Hood Canal summer-run	22	2,194
	Columbia River		378
Chum salmon Total		22	2,572
Coho salmon	Lower Columbia River	8	3,109
	Oregon Coast	54	11,279
	Southern Oregon/Northern California Coast	18	989
Coho salmon Total		80	15,377
Steelhead	Puget Sound	14	650
	Snake River Basin	46	2,811
	Upper Columbia River		16
	Middle Columbia River	33	1,559
	Lower Columbia River	22	1,544
	Upper Willamette River	4	142
	Northern California	1	1,241
	Central California Coast	0	251

	California Central Valley	23	227
	South-Central California Coast	0	332
Steelhead Total		143	8,773

Take of juvenile salmonids could affect prey availability to the whales in future years throughout their range, including designated critical habitat in inland waters of Washington. The average smolt to adult ratio from coded wire tag returns is no more than 0.5% for hatchery Chinook in the Columbia Basin (http://www.cbr.washington.edu/cwtSAR/). Average smolt to adult survival of naturally produced Chinook in the Columbia Basin is 1% (Schaller et al. 2007). For Puget Sound, average survival of both naturally produced and hatchery Chinook is also 1%. If one percent of the 31,887 juvenile Chinook salmon taken by research activities were to survive to adulthood this would translate to the effective loss of no more than 319 adult Chinook salmon from a variety of runs across a 3-5 year period after the research activities occurred (i.e., by the time these juveniles would have grown to be adults and available prey of killer whales).

In addition, the estimated mortality of Chinook is likely to be much smaller than stated. Our estimates of lethal take for most of the proposed studies are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer fish will be killed by the research than stated. In fact, our research tracking system reveals that on average researchers have only killed 23% of the allotted lethal take of Chinook salmon. Therefore, we derived the already small number of adults by overestimating the number of fish likely to be killed. Thus the actual reduction in prey available to the whales is undoubtedly smaller than the stated figures.

Given the total quantity of prey available to killer whales throughout their range, this reduction in prey is extremely small, and although measurable is not anticipated to be different than zero by multiple decimal places (based on NMFS previous analysis of the effects of salmon harvest on Southern Residents; e.g., NMFS 2008c). Because the reduction is so small, there is also a very low probability that any of the juvenile Chinook salmon killed by the research activities would have later (in 3-5 years' time) been intercepted by the killer whales across their vast range in the absence of the research activities. Therefore, the anticipated take of salmonids associated with the proposed actions would result in an insignificant reduction in adult equivalent prey resources for killer whales.

Given these circumstances, and the fact that we anticipate no direct interaction between the researchers and the killer whales, NMFS finds that potential adverse effects of the proposed research on SR killer whales are insignificant and determines that the proposed action may affect, but is not likely to adversely affect killer whales.

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on our EFH assessment and the descriptions of EFH for Pacific coast salmon (PFMC 1999) contained in the fishery management plans developed by the Pacific Fishery Management Council and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km) offshore of Washington, Oregon, and California north of Point Conception. Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically, accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers (as identified by the PFMC) and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years).

3.2 Adverse Effects on Essential Fish Habitat

As the Biological Opinion above describes, the proposed research actions are not likely, singly or in combination, to adversely affect the habitat upon which Pacific salmon, groundfish, and coastal pelagic species depend upon. All the actions are of limited duration, minimally intrusive, and are entirely discountable in terms of their effects, short-or long-term, on any habitat parameter important to the fish.

3.3 Essential Fish Habitat Conservation Recommendations

No conservation recommendations are necessary.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the Federal agency must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation from NMFS. Given that there are no conservation recommendations, there is no statutory response requirement.

3.5 Supplemental Consultation

The action agency must reinitiate EFH consultation with if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for the EFH conservation recommendations [50 CFR 600.920(l)].

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this consultation are the applicants and funding/action agencies listed on the first page. Individual copies were made available to the applicants. This consultation will be posted on the NMFS West Coast Region website (www.westcoast.fisheries.noaa.gov). The format and naming adheres to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, ‘Security of Automated Information Resources,’ Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation, if applicable contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, if applicable, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5. REFERENCES

5.1 State Fishery Agency Submittals

California Department of Fish and Wildlife (CDFW). 2017. Letter from Russ Bellmer, California Department of Fish and Wildlife conveying the state's research Program for consideration under the NMFS 4(d) research limit, to Gary Rule, NMFS, December 15, 2017.

Idaho Department of Fish and Game (IDFG). 2017. Letter from Lance Hebdon, Anadromous Fishery Manager, Idaho Department of Fish and Game conveying the state's research Program for consideration under the NMFS 4(d) research limit, to Gary Rule, NMFS, December 4, 2017.

Oregon Department of Fish and Wildlife (ODFW). 2017. Letter from Ed Bowles, Fish Division Administrator, Oregon Department of Fish and Wildlife conveying the state's research Program for consideration under the NMFS 4(d) rules, to Gary Rule, NMFS, December 13, 2017.

Washington Department of Fish and Wildlife (WDFW). 2017. Letter from Val Tribble, ESA Response Unit, Washington Department of Fish and Wildlife conveying the state's research Program for consideration under the NMFS 4(d) research limit, to Gary Rule, NMFS, December 4, 2017.

5.2 Federal Register Notices

November 20, 1991 (56 FR 58612). Notice of Policy: Policy on Applying the Definition of Species Under the Endangered Species Act to Pacific Salmon.

December 28, 1993 (58 FR 68543). Final Rule. Endangered and Threatened Species: Designated Critical Habitat for Snake River Sockeye Salmon, Snake River Spring/summer Chinook Salmon, and Snake River Fall Chinook Salmon.

July 18, 1997 (62 FR 38479). Interim Rule: Endangered and Threatened Species; Final Rule Governing Take of the Threatened Southern Oregon/Northern California Coast Evolutionarily Significant Unit (ESU) of Coho Salmon.

August 18, 1997 (62 FR 43937). Final Rule: Endangered and Threatened Species: Listing of Several Evolutionarily Significant Units (ESUs) of West Coast Steelhead.

March 25, 1999 (64 FR 14508). Final Rule: Endangered and Threatened Species; Threatened Status for Two ESUs of Chum Salmon in Washington and Oregon.

May 5, 1999 (64 FR 24049). Final Rule: Designated Critical Habitat: Critical Habitat for 19 Evolutionarily Significant Units of Salmon and Steelhead in Washington, Oregon, Idaho, and California.

October 25, 1999 (64 FR 57399). Final Rule: Designated Critical Habitat: Revision of Critical Habitat for Snake River Spring/Summer Chinook Salmon.

February 16, 2000 (65 FR 7764). Final Rule: Designated Critical Habitat: Central California Coast and Southern Oregon/Northern California Coasts Coho Salmon.

July 10, 2000 (65 FR 42422). Final Rule: Endangered and Threatened Species; Final Rule Governing Take of 14 Threatened Salmon and Steelhead Evolutionarily Significant Units (ESUs).

April 6, 2005 (70 FR 17386). Proposed Rule: Proposed Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon.

June 28, 2005 (70 FR 37160). Final Rule: Endangered and Threatened Species; Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs.

September 2, 2005 (70 FR 52630). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho.

November 18, 2005 (70 FR 69903). Final Rule: Endangered Status for Southern Resident Killer Whales.

January 5, 2006 (71 FR 834). Final Rule: Endangered and Threatened Species; Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead.

April 7, 2006 (71 FR 17757). Final Rule: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon.

November 29, 2006 (71 FR 69054). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for Southern Resident Killer Whale.

May 11, 2007 (72 FR 26722). Final Rule: Endangered and Threatened Species; Final Listing Determination for Puget Sound Steelhead.

February 11, 2008 (73 FR 7816). Final Rule: Endangered and Threatened Species; Final Threatened Listing Determination, Final Protective Regulations, and Final Designation of Critical Habitat for the Oregon Coast Evolutionarily Significant Unit of Coho Salmon.

September 25, 2008 (73 FR 55451). Final Rule: Endangered and Threatened Species; Final Protective Regulations for Threatened Puget Sound Steelhead.

October 9, 2009 (74 FR 52300). Final Rulemaking to Designate Critical Habitat for the Threatened Southern Distinct Population Segment of North American Green Sturgeon.

March 18, 2010 (75 FR 13012). Final Rule: Threatened Status for Southern Distinct Population Segment of Eulachon.

June 2, 2010 (75 FR 30714). Final Rule: Endangered and Threatened Wildlife and Plants: Final Rulemaking To Establish Take Prohibitions for the Threatened Southern Distinct Population Segment of North American Green Sturgeon.

August 15, 2011 (76 FR 50448). Notice of Availability of 5-year Reviews. Endangered and Threatened Species; 5-Year Reviews for 17 Evolutionarily Significant Units and Distinct Population Segments of Pacific Salmon and Steelhead.

April 14, 2014 (79 FR 20802). Final Rule to Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service

February 24, 2016 (81 FR 9252). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for Lower Columbia River Coho Salmon and Puget Sound Steelhead.

5.3 Literature Cited

Adams, P. B., C. B. Grimes, S. T. Lindley, and M. L. Moser. 2002. Status review for North American green sturgeon, Acipenser medirostris. NOAA, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA. 50 p.

Adams, P. B., C. Grimes, J. E. Hightower, S. T. Lindley, M. L. Moser, and M. J. Parsley. 2007. Population status of North American green sturgeon Acipenser medirostris. Environmental Biology of Fishes 79:339–356.

Ainslie, B.J., J.R. Post, and A.J. Paul. 1998. Effects of Pulsed and Continuous DC Electrofishing on Juvenile Rainbow Trout. North American Journal of Fisheries Management:Vol. 18, No. 4, pp. 905–918.

Allen, R.L., and T.K. Meekin. 1973. An evaluation of the Priest Rapids Chinook salmon spawning channel, 1963-1971. Washington Department of Fisheries, Technical Report 11: 1-52, Olympia, Washington.

Al-Humaidhi, A. W., M. A. Bellman , J. Jannot, and J. Majewski. 2012. Observed and estimated total bycatch of green sturgeon and Pacific eulachon in 2002-2010 U.S. west coast fisheries. West Coast Groundfish Observer Program. National Marine Fisheries Service, NWFSC, 2725 Montlake Blvd E., Seattle, WA 98112.

Anlauf, K.J., K.K. Jones, C.H. Stein. 2009. The status and trend of physical habitat and rearing potential in coho bearing streams in the Oregon Coastal Coho Evolutionary Significant Unit. OPSW-ODFW-2009-5, Oregon Department of Fish and Wildlife, Salem.

Beacham, T. D., D. E. Hay, and K. D. Le. 2005. Population structure and stock identification of eulachon (Thaleichthys pacificus), an anadromous smelt, in the Pacific Northwest. Mar. Biotechnol. 7:363–372.

Beamer, E.M., B.A. Hayman, and S. Hinton. 2005. Linking Watershed Conditions to Egg-to-Fry Survival of Skagit Chinook Salmon. An appendix to the Skagit River System Cooperative Chinook Recovery Plan. Draft Version 2.0.

Beamer, E.M., R.E. McClure, and B.A. Hayman. 2000. Fiscal Year 1999 Skagit River Chinook Restoration Research. Skagit System Cooperative.

Beamesderfer, R., M. Simpson, G. Kopp, J. Inman, A. Fuller, and D. Demko. 2004. Historical and current information on green sturgeon occurrence in the Sacramento and San Joaquin rivers and tributaries. S.P. Cramer & Associates, Inc. 44 p.

Becker, D.C. 1970. Temperature, timing, and seaward migration of juvenile Chinook salmon from the central Columbia River. Battelle Northwest Laboratories, AEC Research and Development Report, Richland, Washington.

Bendock, T. and M. Alexandersdottir. 1993. Hooking mortality of Chinook salmon released in the Kenai River, Alaska. North American Journal of Fisheries Management 13:540-549.
Berejikian, B.A., E.P. Tezak, and S.L. Schroder. 2001. Reproductive Behavior and Breeding Success of Captively Reared Chinook Salmon. North American Journal of Fisheries Management. 21:255-260.

Bergman, P.K., K.B. Jefferts, H.F. Fiscus, and R.C. Hager. 1968. A preliminary evaluation of an implanted, coded wire fish tag. Washington Department of Fisheries, Fisheries Research Papers 3(1):63-84.

Bishop, S. and A. Morgan (eds). 1996. Critical habitat issues by basin for natural Chinook salmon stocks in the coastal and Puget Sound areas of Washington State. Northwest Indian Fisheries Commission, Olympia, WA, 105 p.

Bledsoe, L.J., D.A. Somerton, and C.M. Lynde. 1989. The Puget Sound runs of salmon: An examination of the changes in run size since 1896. In C.D. Levings, L.B. Holtby, and M.A. Henderson (editors), Proceedings of the National Workshop on Effects of Habitat Alteration on

Salmonid Stocks, May 6-8, 1987, Nanaimo, B.C., p. 50-61. Can. Spec. Publ. Fish. Aquat. Sci. 105.

Bordner, C.E., S.I. Doroshov, D.E. Hinton, R.E. Pipkin, R.B. Fridley, and F. Haw. 1990. Evaluation of marking techniques for juvenile and adult white sturgeons reared in captivity. American Fisheries Society Symposium 7:293-303.

Bradford, M.J. 1995. Comparative review of Pacific salmon survival rates. Can. J. Fish. Aquat. Sci. 52:1327-1338.

Bruesewitz, S.L. 1995. Hook placement in steelhead. Technical Report No. AF95-01. Washington Department of Fish and Wildlife, Olympia.

Brynildson, O.M. and C.L. Brynildson. 1967. The effect of pectoral and ventral fin removal on survival and growth of wild brown trout in a Wisconsin stream. Transactions of the American Fisheries Society 96:353-355.

Bugert, R., P. LaRiviere, D. Marbach, S. Martin, L. Ross, and D. Geist. 1990. Lower Snake River compensation plan salmon hatchery evaluation program. 1989 Annual Report to U.S. Fish and Wildlife Service (Cooperative Agreement 14-16-0001-89525).

Bugert, R.M., and W. Hopley. 1989. The Snake River fall Chinook egg bank program: The final chapter. Unpublished report. (Available from Washington Department of Fish and Wildlife, Fish Division, 600 Capitol Way N., Olympia, WA 98501.)

Bugert, R.M., C.W. Hopley, C.A. Busack, and G.W. Mendel. 1995. Maintenance of stock integrity in Snake River fall Chinook salmon. In H.L. Schramm, Jr., and R.G. Piper (eds.), Uses and effects of cultured fishes in aquatic ecosystems, p. 267–276. American Fisheries Society Symposium 15 (AFS), Bethesda, MD.

Busack, C., and D. Rawding. 2003. HPVA results for salmon and steelhead production in Washington Lower Columbia basins. In McElhany P., T. Backman, C. Busack, S. Heppell, S. Kolmes, A. Maule, J. Myers, D. Rawding, D. Shively, A. Steel, and C. Steward, Appendix J: Interim report on viability criteria for Willamette and Lower Columbia basin Pacific salmonids. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.)

Busby, P.J., T.C. Wainwright, G.J. Bryant, L.J. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-27.

Cannamela, D.A. 1992. Potential impacts of releases of hatchery steelhead trout “smolts” on wild and natural juvenile Chinook and sockeye salmon. Idaho Department of Fish and Game, White Paper, Boise.

California Hatchery Scientific Review Group (California HSRG). 2012. California Hatchery Review Report. Prepared for the US Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. 100 pgs.

CDFG (California Department of Fish and Game). 2002. California Department of Fish and Game Comments to NMFS Regarding Green Sturgeon Listing. 129 p

California Depart of fish and Wildlife (CDFW). 2012. Recovery Strategy of California Coho Salmon Progress Report 2004-2012.

Chapman, D., C. Peven, T. Hillman, A. Giorgi, and F. Utter. 1994. Status of steelhead in the mid-Columbia River. Don Chapman Consultants, Inc., Boise, ID. 318 p. plus appendices.

Chapman, D.W. 1986. Salmon and steelhead abundance in the Columbia River in the nineteenth century. Trans. Am. Fish. Soc. 115:662–670.

Chilcote, M.W. 2001. Conservation assessment of steelhead populations in Oregon. Unpublished report. (Available from Oregon Department of Fish and Wildlife, Fish Division, 3406 Cherry Drive NE, Salem, OR 97303.)

Chisholm, I.M. and W.A. Hubert. 1985. Expulsion of dummy transmitters by rainbow trout. Transactions of the American fisheries Society 114:766-767.

Cichosz, T., D. Saul, A. Davidson, W. Warren, D. Rollins, J. Willey, T. Tate, T. Papanicolaou, and S. Juul. 2001. Clearwater subbasin summary. Draft submitted to the Northwest Power Planning Council. Online at http://www.nwcouncil.org/fw/subbasinplanning/ clearwater/plan/Default.htm [accessed November 2001].

Coble, D.W. 1967. Effects of fin-clipping on mortality and growth of yellow perch with a review of similar investigations. Journal of Wildlife Management 31:173-180.

Conner, W.P., H.L. Burge, and R. Waitt. 2001. Snake River fall Chinook salmon early life history, condition, and growth as affected by dams. Unpublished report prepared by the U.S. Fish and Wildlife Service and University of Idaho, Moscow, ID. 4 p.

COSEWIC (Committee On The Status Of Endangered Wildlife In Canada). 2009. Guidelines for Recognizing Designatable Units. Approved by COSEWIC in November 2009. Available at: http://www.cosewic.gc.ca/eng/sct2/sct2_5_e.cfm

COSEWIC. 2011a. COSEWIC assessment and status report on the Eulachon, Cass/Skeena Rivers population, Central Pacific Coast population and the Fraser River population Thaleichthys pacificus in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 88 pp.

COSEWIC. 2011b. Eulachon Species at Risk Act (SARA) Process Backgrounder. Available at: http://fnfisheriescouncil.ca/index.php/more-info/search-documents/doc_download/875-eulachonsarabackgrounderannex

Cramer, S.P., C.F. Willis, S.C. Vigg, J.T. Hawksworth, R. Montagne, D. Cramer, F. Shrier, C. Phillips, J. Welty, and K. Reininga. 1997. Synthesis and analysis of the Lower Columbia River Steelhead Initiative. Special Report. S.P. Cramer and Associates, Gresham, Oregon.

Dalbey, S.R., T.E. McMahon, and W. Fredenberg. 1996. Effect of electrofishing pulse shape and electrofishing induced spinal injury to long term growth and survival of wild rainbow trout. North American Journal of Fisheries Management 16:560-569.

Dalbey, S.R., T.E. McMahon, and W. Fredenberg. 1996. Effect of electrofishing pulse shape and electrofishing-induced spinal injury to long-term growth and survival of wild rainbow trout. North American Journal of Fisheries Management 16:560-569.

DFO (Dept. Fisheries and Oceans Canada). 2008. Fraser River eulachon (Thaleichthys pacificus): 2007 population assessment and harvest recommendations for 2008. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2007/048.

Dimick, R.E., and F. Merryfield. 1945. The fishes of the Willamette River system in relation to pollution. Oregon State College, Engineering Experiment Station, Corvallis.

Drake, J., R. Emmett, K. Fresh, R. Gustafson, M. Rowse, D. Teel, M. Wilson, P. Adams, E. Spangler, and R. Spangler. 2010. Status Review Update for Eulachon in Washington, Oregon, and California. January 20, 2010.

Dwyer, W.P. and R.G. White. 1997. Effect of Electroshock on Juvenile Arctic Grayling and Yellowstone Cutthroat Trout Growth 100 Days after Treatment. North American Journal of Fisheries Management 17:174-177.

EPA (Environmental Protection Agency). 2002. Columbia River Basin fish contaminant survey. EPA 910-R-02-006, Environmental Protection Agency, Region 10, Seattle, WA. Available at http://yosemite.epa.gov/r10/oea.nsf/Reports/Reports

Erickson, D. L., and M. A. H. Webb. 2007. Spawning periodicity, spawning migration, and size at maturity of green sturgeon, Acipenser medirostris, in the Rogue River, Oregon. Environmental Biology of Fishes 79:255–268.

Ferguson, J.W. 2010. Memorandum to James H. Lecky: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2010. Northwest Fisheries Science Center. November 9, 2010.

Fish Passage Center (FPC). 2002. Adult salmon passage counts. FPC Internet Website. http://www.fpc.org/adult.html (accessed June 13, 2002).

Fish Passage Center (FPC). 2005. Weekly Report #05-30. FPC Internet Website. http://www.fpc.org/ (accessed January 20, 2006).

Fish Passage Center (FPC). 2010. Adult salmon passage counts. FPC Internet Website. http://www.fpc.org/adult.html (accessed February 4, 2010).

Fletcher, D.H., F. Haw, and P.K. Bergman. 1987. Retention of coded-wire tags implanted into cheek musculature of largemouth bass. North American Journal of Fisheries Management 7:436-439.

Ford, M., P. Budy, C. Busack, D. Chapman, T. Cooney, T. Fisher, J. Geiselman, T. Hillman, J. Lukas, C. Peven, C. Toole, E. Weber, and P. Wilson. 2001. Final Report of the Upper Columbia River Steelhead and Spring Chinook Salmon Biological Requirements Committee, March 2001. (Available from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.)

Ford, J.K.B. and G.M. Ellis. 2006. Selective foraging by fish-eating killer whales Orcinus orca in British Columbia. Marine Ecology Progress Series. Vol. 316:185-199.

Ford, M.J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-113, 281 p.

Ford MJ, Hempelmann J, Hanson MB, Ayres KL, Baird RW, Emmons CK, et al. (2016) Estimation of a Killer Whale (Orcinus orca) Population's Diet Using Sequencing Analysis of DNA from Feces. PLoS ONE 11(1): e0144956. doi:10.1371/journal.pone.0144956

Fredenberg, W.A. 1992. Evaluation of electrofishing‑induced spinal injuries resulting from field electrofishing surveys in Montana. Montana Department of Fish, Wildlife and Parks, Helena.

Fresh, K.L., E. Casillas, L.L. Johnson, and D.L. Bottom. 2005. 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. NOAA technical memorandum, Northwest Fisheries Science Center, National Marine Fisheries Service. Seattle, WA. 136 pp.

Frimodig, A. 2008. Informational report: Bycatch reduction devices used in the pink shrimp trawl fishery. Rep. to California Fish and Game Commission. California Dept. Fish and Game, Marine Region, State Fisheries Evaluation Project.

Fry, D. H., Jr. 1979. Anadromous fishes of California., Calif. Dept. Fish & Game, Sacramento, CA.

Fulton, L.A. 1968. Spawning areas and abundance of Chinook salmon, Oncorhynchus tshawytscha, in the Columbia River basin—past and present. U.S. Fish and Wildlife Service Spec. Sci. Rep., Fish. 571.

Fulton, L.A. 1970. Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River basin past and present. U.S. Fish and Wildlife Service, Special Scientific Report, Fisheries 618.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-66. 598 p.

Griffith, J., M. Alexandersdottir, R. Rogers, J. Drotts, P. Stevenson. 2004. 2003 Annual Stillaguamish Smolt Report. Stillaguamish Tribe of Indians.

Gustafson, R. G., M. J. Ford, D. Teel, and J. S. Drake. 2010. Status review of eulachon (Thaleichthys pacificus) in Washington, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-105, 360 pp.

Hamilton, J. B., G. L. Curtis, S. M. Snedaker, and D. K. White. 2005. Distribution of anadromous fishes in the Upper Klamath River watershed prior to hydropower dams – A synthesis of the historical evidence. Fisheries 30(4):10-20.

Hannah, R. W., and S. A. Jones. 2007. Effectiveness of bycatch reduction devices (BRDs) in the ocean shrimp (Pandalus jordani) trawl fishery. Fish. Res. 85:217–225.

Hannah, R. W., S. A. Jones, and K. M. Matteson. 2003. Observations of fish and shrimp behavior in ocean shrimp (Pandalus jordani) trawls. ODFW Information Rep. 2003-03. Oregon Dept. fish and Wildlife, Marine Resources Program, Newport.

Hanson, B., R.W. Baird, J.K.B. Ford, J. Hempelmann-Halos, D.M. Van Doornik, J.R. Candy, C. K. Emmons, G.S. Schorr, B. Gisborne, K.L. Ayres, S.K. Wasser, K.C. Balcomb, K. Balcomb-Bartok, J.G. Sneva and M.J. Ford. 2010. Species and stock identification of prey consumed by southern resident killer whales in their summer range. Endangered Species Research 11:69-82.

Hard, J.J., J.M. Myers, M.J. Ford, R.G. Cope, G.R. Pess, R.S. Waples, G.A. Winans, B.A. Berejikian, F.W. Waknitz, P.B. Adams. P.A. Bisson, D.E. Campton, and R.R. Reisenbichler. 2007. Status review of Puget Sound steelhead (Oncorhynchus mykiss). U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-81, 117 p.

Hartt, A.C. and M.B. Dell. 1986. Early oceanic migrations and growth of juvenile Pacific salmon and steelhead trout. International North Pacific Fisheries Commission, Bulletin Number 46, 105 p.

Hay, D. E., and McCarter, P. B. 2000. Status of the eulachon Thaleichthys pacificus in Canada. Department of Fisheries and Oceans Canada, Canadian Stock Assessment Secretariat, Research Document 2000-145. Ottawa, Ontario. Available at http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/eulachon-eulakane-eng.htm

Hay, D.E., P.B. McCarter, R. Joy, M. Thompson, and K. West. 2002. Fraser River eulachon biomass assessments and spawning distributions: 1995-2002. PSARC Working Paper P2002-08. 60 p.

Healey, M.C. 1991. The life history of Chinook salmon (Oncorhynchus tshawytscha). In C. Groot and L. Margolis (eds.), Life history of Pacific salmon, p. 311-393. Univ. B.C. Press, Vancouver, B.C.

Hedgecock, D. 1994. Does variance in reproductive success limit effective population sizes of marine organisms? In A.R. Beaumont (ed.), Genetics and Evolution of Aquatic Organisms, p. 122–134. Chapman & Hall, London.

Hockersmith, E.E., W.D. Muir, and others. 2000. Comparative performance of sham radiotagged and PIT-tagged juvenile salmon. Report to U.S. Army Corps of Engineers, Contract W66Qkz91521282, 25 p.

Hollender, B.A. and R.F. Carline. 1994. Injury to wild brook trout by backpack electrofishing. North American Journal of Fisheries Management 14:643‑649.

Hooton, R.S. 1987. Catch and release as a management strategy for steelhead in British Columbia. In R. Barnhart and T. Roelofs, editors. Proceedings of Catch and Release Fishing: a Decade of Experience, a National Sport Fishing Symposium. Humboldt State University, Arcata, California.

Howe, N.R. and P.R. Hoyt. 1982. Mortality of juvenile brown shrimp Penaeus aztecus associated with streamer tags. Transactions of the American Fisheries Society 111:317-325.

Idaho Department of Fish and Game (IDFG). 2002. Written comments submitted to National Marine Fisheries Service regarding status review updates. (Available from National Marine Fisheries Service, Northwest Region, 7600 Sand Point Way NE, Seattle, WA 98115.)

ISAB (Independent Scientific Advisory Board). 2007. Climate change impacts on Columbia River Basin fish and wildlife. ISAB Climate Change Report, ISAB 2007-2, Northwest Power and Conservation Council, Portland, Oregon.

Irving J.S., and T. Bjornn. 1981. A forecast of abundance of Snake River fall Chinook salmon. Prepared for National Marine Fisheries Service, Seattle, contract no. 82-ABC-00042. (Available from Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow, ID 83843.)

Israel, Joshua A.; Bando, K. J.; Anderson, Eric C.; May, Bernie. 2009. Polyploid microsatellite data reveal stock complexity among estuarine North American green sturgeon (Acipenser medirostris). Canadian Journal of Fisheries and Aquatic Sciences, Volume 66, Number 9, 1 September 2009 , pp. 1491-1504(14).

Israel, J.A. and B. May. 2010. Indirect genetic estimates of breeding population size in the polyploid green sturgeon (Acipenser medirostris). Molecular Ecology 19:1058-1070

Jackson, J. and Y.W. Cheng. 2001. Improving parameter estimation for daily egg production method of stock assessment of pink snapper in Shark Bay, Western Australia. Journal of Agricultural, Biological and Environmental Statistics 6:243-257.

Jacobs, S., J. Firman, G. Susac, D. Stewart, and J. Weybright. 2002. Status of Oregon coastal stocks of anadromous salmonids, 2000-2001 and 2001-2002; Monitoring Program Report Number OPSW-ODFW-2002-3, Oregon Department of Fish and Wildlife, Portland, Oregon.

Jenkins, W.E. and T.I.J. Smith. 1990. Use of PIT tags to individually identify striped bass and red drum brood stocks. American Fisheries Society Symposium 7: 341-345.

JCRMS (Joint Columbia River Management Staff). 2011. 2011 joint staff report concerning stock status and fisheries for sturgeon and smelt. Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife.

Kamler, J.F. and K.L. Pope. 2001. Nonlethal Methods of Examining Fish Stomach Contents. Reviews in Fisheries Science 9(1):1-11.

Kier, M.C., J. Hileman, and S. Cannata. 2015. Annual Report Trinity River Basin Salmon and Steelhead Monitoring Project.

Kime, D. E. 1995. The effects of pollution on reproduction in fish. Rev. Fish Biol. Fisheries 5:52–96.

Kohlhorst, D.W. 1979. Effect of first pectoral fin ray removal on survival and estimated harvest rate of white sturgeon in the Sacramento-San Joaquin estuary. California Fish and Game 65:173-177.

Kostow, K. 2004. Memorandum dated December 17, 2004 to TAC. 2005 Lwr. Col. Winter Steelhead Forecast, Oregon Basins.

Kostow, K.E., A.R. Marshall, and S.R. Phelps. 2002. Naturally Spawning Hatchery Steelhead Contribute to Smolt Production but Experience Low Reproductive Success. Transactions of the American Fisheries Society. 132:780-790.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2002. Status review of southern resident killer whales (Orcinus orca) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWFSC-54, U.S. Department of Commerce, Seattle, Washington.

Krahn, M.M., M.B. Hanson, R.W. Baird, R.H. Boyer, D.G. Burrows, C.E. Emmons, J.K.B. Ford, L.L. Jones, D.P. Noren, P.S. Ross, G.S. Schorr, and T.K. Collier. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales. Marine Pollution Bulletin 54(12): 1903-1911.

Langer, O. E., B. G. Shepherd, and P. R. Vroom. 1977. Biology of the Nass River eulachon 1977. Department of Fisheries and Environment Tech. Rep. Series PAC/T-77-10. 56 p

Larson, Z. S., and M. R. Belchik. 1998. A preliminary status review of eulachon and Pacific lamprey in the Klamath River Basin. Yurok Tribal Fisheries Program, Klamath, CA.

Lawson, P.W., and D.B. Sampson. 1996. Gear-related mortality in selective fisheries for ocean salmon. N. Amer. J. of Fish. Man. 16:512-520.

Lawson, P.W., E.P. Bjorkstedt, M.W. Chilcote, C.W. Huntington, J.S. Mills, K.M.S. Moore, T.E. Nickelson, G.H. Reeves, H.A. Stout, T.C. Wainwright, and L.A. Weitkamp. 2007. Identification of historical populations of Coho salmon (Oncorhynchus kisutch) in the Oregon coast evolutionarily significant unit. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-79, 129 p.

LeFleur, C. and C. Melcher. 2004. Addendum to the Wild Winter Steelhead Biological Assessment. November 2, 2004.

Lewis, A. F. J., McGurk, M. D. and Galesloot, M. G. 2002. Alcan's Kemano River eulachon (Thaleichthys pacificus) monitoring program 1988–1998. Consultant's report prepared by Ecofish Research Ltd. for Alcan Primary Metal Ltd., Kitimat, BC, xxiv + 136 pp.

Lichatowich, J.A. 1989. Habitat alteration and changes in abundance of coho (Oncorhynchus kisutch) and chinook (O. tshawytscha) salmon in Oregon's coastal streams. In C.D. Levings, L.B. Holtby, and M.A. Henderson (editors), Proceedings of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks, May 6-8, 1987, Nanaimo, B.C., p. 92-99. Can. Spec. Publ. Fish. Aquat. Sci. 105. ODFW 1995

Light, J.T. 1987. Coastwide abundance of North American steelhead trout. (Document submitted to the annual meeting of the Int. North Pac. Fish Comm., 1987) Fisheries Research Institute Report FRI-UW_8710. Univ. Washington, Seattle, 18 p.

Light, R.W., P.H. Adler, and D.E. Arnold. 1983. Evaluation of Gastric Lavage for Stomach Analyses. North American Journal of Fisheries Management 3:81-85.

Lindsay, R.B., R.K. Schroeder, and K.R. Kenaston. 2004. Hooking mortality by anatomical location and its use in estimating mortality of spring Chinook salmon caught and released in a river sport fishery. North American Journal of Fisheries Management 24:367-378.

Lindley, S. T., M. L. Moser, D. L. Erickson, M. Belchik, D. W. Welch, E. Rechisky, J. T. Kelly, J. C. Heublein, and A. P. Klimley. 2008. Marine migration of North American green sturgeon. Transactions of the American Fisheries Society 137:182–194.

Lower Columbia Fish Recovery Board (LCFRB). 2004. Lower Columbia Salmon Recovery and Fish and Wildilife Subbasin Plan. Volume I - Regional Plan. December 15, 2004.

Lower Columbia Fish Recovery Board (LCFRB). 2010. Lower Columbia Salmon Recovery and Fish and Wildilife Subbasin Plan. May 28, 2010.

Lower Columbia River Estuary Partnership (LCREP). 2006. Columbia River Estuary Recovery Planning Module. Prepared for National Oceanic and Atmospheric Administration. Portland, OR. September 27, 2006.

Malette, C. 2013. NOAA 2012 Protected Species Studies of Eulachon Smelt in Oregon and Washington – Progress Report. Grant Number NA10NMF470038. Oregon Department of Fish and Wildlife. Clackamas, OR. 10 pp.

Mallet, J. 1974. Inventory of salmon and steelhead resources, habitats, use and demands. Job performance report. Proj. F-58-R-1. Idaho Department of Fish and Game, Boise.

Matthews, G.M., and R.S. Waples. 1991. Status review for Snake River spring and summer Chinook salmon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-F/NWC-200, 75 p.

Matthews, K.R. and R.H. Reavis. 1990. Underwater tagging and visual recapture as a technique for studying movement patterns of rockfish. American Fisheries Society Symposium 7:168-172.

McClure, M.M., E.E. Holmes, B.L. Sanderson, and C.E. Jordan. 2003. A large-scale, multi-species status assessment: Anadromous salmonids in the Columbia River basin. Ecol. Appl. 13(4):964–989.

McElhaney, P., M. Chilcote, J. Myers, R. Beamesderfer. Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins. National Marine Fisheries Service Northwest Fisheries Science Center. September 2007.

McElhaney, P., T. Backman, C. Busack, S. Kolmes, J. Myers, D. Rawding, A. Steel, C. Stewar, T. Whitesel, and C. Willis. 2004. Status evaluation of salmon and steelhead populations in the Willamette and Lower Columbia river basins. Willamette/Lower Columbia Technical Recovery Team. July 2004.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E.P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo NMFS-NWFSC-42.

McFarlane, G. A., J. R. King, and R. J. Beamish. 2000. Have there been recent changes in climate? Ask the fish. Progr. Oceanogr. 47:147–169.

McLean, J.E., P. Bentzen, and T.P. Quinn. 2004. Differential reproductive success of sympatric, naturally spawning hatchery and wild steelhead, Oncorhynchus mykiss. Environmental Biology of Fishes. 69:359-369.

McMichael, G.A., L. Fritts, and T.N. Pearsons. 1998. Electrofishing Injury to Stream Salmonids; Injury Assessment at the Sample, Reach, and Stream Scales. North American Journal of Fisheries Management 18:894-904.

McMichael, G.A., L. Fritts, and T.N. Pearsons. 1998. Electrofishing Injury to Stream Salmonids; Injury Assessment at the Sample, Reach, and Stream Scales. North American Journal of Fisheries Management 18:894-904.

McNeil, F.I. and E.J. Crossman. 1979. Fin clips in the evaluation of stocking programs for muskellunge (Esox masquinongy). Transactions of the American Fisheries Society 108:335-343.

Mears, H.C. and R.W. Hatch. 1976. Overwinter survival of fingerling brook trout with single and multiple fin clips. Transactions of the American Fisheries Society 105:669-674.

Meehan, W.R. and R.A. Miller. 1978. Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. J. Fish. Res. Board Can. 35:1359-1363.

Mellas, E.J. and J.M. Haynes. 1985. Swimming performance and behavior of rainbow trout (Salmo gairdneri) and white perch (Morone americana): effects of attaching telemetry transmitters. Canadian Journal of Fisheries and Aquatic Sciences 42:488-493.

Miller, R. 2010. Is the Past Present? Historical splash-dam mapping and stream disturbance detection in the Oregon Coastal Province. Masters of Science Thesis, Oregon State University. 96p.

Mongillo, P.E. 1984. A summary of salmonid hooking mortality. Washington Department of Game, Olympia.

Montgomery, D.R., T.M. Massong, and S.C.S. Hawley, 2003. Influence of debris flows and logjams on the location of pools and alluvial channel reaches, Oregon Coast Range. Geolog. Soc. Am. Bull. 115(1):78-88.

Moody, M. F. 2008. Eulachon past and present. Master's thesis, Univ. British Columbia, Vancouver, BC. 292 p. Available at http://circle.ubc.ca/handle/2429/676

Moore, K.M.S, K.K. Jones, and J.M. Dambacher. 2008. Methods for stream habitat surveys: Aquatic Inventories Project. Information Report 2007-01, ODFW, Corvallis. 67p.

Moring, J.R. 1990. Marking and tagging intertidal fishes: review of techniques. American Fisheries Society Symposium 7:109-116.

Morrison, J. and D. Zajac. 1987. Histologic effect of coded wire tagging in chum salmon. North American Journal of Fisheries Management 7:439-441.

Morrison, J., M. Quick, and M. G. G. Foreman. 2002. Climate change in the Fraser River watershed: Flow and temperature predictions. J. Hydrol. 263:230–244.

Moser, M. L., and S. T. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79:243–253.

Moyle, P. B., P. J. Foley, and R. M. Yoshiyama. 1992. Status of green sturgeon, Acipenser medirostris, in California. Final Report submitted to National Marine Fisheries Service. 11 p. University of California, Davis, CA 95616.

Moyle, P. B. 2002. Inland Fishes of California. Revised and Expanded. Univ. Calif. Press, Berkeley and Los Angeles, CA.

Moyle, P. B., Foley, P. J., and Yoshiyama, R. M. 1992. Status of green sturgeon, Acipenser medirostris, in California. Final Report submitted to National Marine Fisheries Service. 11 p. University of California Davis.

Moyle, P. B., R. M. Yoshiyama, , J. E. Williams, and E. D. Wikramanayake. 1995. Eulachon In Fish species of special concern in California, Second Edition, p. 123-127. California Department of Fish & Game, Inland Fisheries Division, Rancho Cordova, CA.

Mullen, J.W., A. Rockhold, and C.R. Chrisman. 1992a. Life histories and precocity of Chinook salmon in the mid-Columbia River. Prog. Fish-Cult. 54: 25-28.

Mullen, J.W., K.R. Williams, G. Rhodus, T.W. Hillman, and J.D. McIntyre. 1992b. Production and habitat of salmonids in mid-Columbia River tributary streams. U.S. Fish and Wildlife Service Monograph 1.

Mullen, R.E. 1981. Oregon's commercial harvest of coho salmon, Oncorhynchus kisutch (Walbaum), 1982-1960. Oregon Department of Fish and Wildlife Info. Rep. 81-3, 24 p.

Musick, J.A., M.M. Harbin, S.A. Berkeley, G.H. Burgess, A.M. Auckland, L. Lindley, R.G. Gilmore, J.T. Golden, D.S. Ha, G.R. Huntsman, J.C. McGovern, S.J. Parker, S.G. Poss, E. Sala, T. W. Schmidt, G.R. Sedberry, H. Weeks, and S.G. Wright. 2000. Marine, estuarine, and diadromous fish stocks at risk of extinction in North America (exclusive of Pacific Salmonids). Fisheries 25: 6-30.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D.M. Van Doornik, and M.T. Maher. 2006. Historical population structure of pacific salmonids in the Willamette River and Lower Columbia River Basins. NOAA Technical Memorandum NMFS-NWFSC-73, February, 2006. Seattle, WA.

Myers, J., C. Busack, D. Rawding, and A. Marshall. 2003. Historical Population Structure of Willamette and Lower Columbia River Basin Pacific Salmonids. WLC-TRT Report. NOAA Fisheries Northwest Fisheries Science Center. Seattle, WA.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 p.

Nakamoto, R.J., T.T. Kisanuki, and G.H. Goldsmith. 1995. Age and Growth of Klamath River Green Sturgeon (Acipenser medirostris). U.S. Fish and Wildlife Service. Project #93-FP-13.

National Marine Fisheries Service (NMFS). 1996. Endangered Species Act Section 7 Consultation on the Issuance and Funding of Section 10(a)(1)(A) Permits and Modifications for Scientific Research/Enhancement and Monitoring Involving Snake River Salmon for 1996-2000. Consultation # 960013. March 28, 1996.

National Marine Fisheries Service (NMFS). 1997a. Status Review Update for West Coast Steelhead from Washington, Idaho, Oregon, and California. Prepared by the West Coast Steelhead Biological Review Team. July 7, 1997.

National Marine Fisheries Service (NMFS). 1997b. Status Review Update for Coho Salmon from the Oregon and Northern California Coasts. Prepared by the West Coast Coho Salmon Biological Review Team. March 28, 1997.

NMFS. 1998. Conclusions regarding the updated status of Puget Sound, Lower Columbia River, Upper Willamette River, and Upper Columbia River ESUs of spring-run west coast Chinook salmon. Memorandum dated 23 December 1998 to U. Varanasi and W. Stelle, Northwest Fisheries Science Center, and W. Hogarth, Southwest Fisheries Science Center, from M. Schiewe, Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.

National Marine Fisheries Service (NMFS). 1999. Evaluation of the status of Chinook and chum salmon and steelhead hatchery populations for speciess identified in final listing determinations. Memorandum from M. Schiewe thru U. Varanasi to W. Stelle, dated March 4, 1999.

National Marine Fisheries Service (NMFS). 2000a. Reinitiation of Consultation on Operation of Federal Columbia River Power System, Including the Juvenile Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin. NMFS, Hydro Program, Portland, Oregon. Consultation # F/NWR/2001/00249. December 21, 2000.

National Marine Fisheries Service (NMFS). 2000b. Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act, June 2000. Available at www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf.

National Marine Fisheries Service (NMFS). 2003. Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead. West Coast Salmon Biological Review Team, NWFSC. Co-manager Review Draft. February, 2003.

NMFS (National Marine Fisheries Service). 2003b. Endangered Species Act - Section 7 Consultation Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consultation on: 1) Issuance of an incidental take statement (ITS) to the USFWS; 2) Issuance of an ITS to the

BPA and the Confederated Tribes and Bands of the Yakama Nation (Yakama Nation); and 3) Issuance of permit 1347 jointly to the Washington Department of Fish and Wildlife (WDFW), the Public Utility District No. 1 of Chelan County (Chelan PUD), and the Public Utility District No. 1 of Douglas County (Douglas PUD). NMFS, Portland, Oregon.

National Marine Fisheries Service (NMFS). 2004. Status Evaluation of Salmon and Steelhead Populations in the Willamette and Lower Columbia River Basins. Willamette/Lower Columbia Technical Recovery Team. July 2004.

National Marine Fisheries Service (NMFS). 2005a. Status Review Update for Puget Sound Steelhead. July 2005. NW Fisheries Science Center, U.S. Dept. Commer., NMFS, Seattle, WA.

NMFS. 2005b. Green Sturgeon (Acipenser medirostris) Status Review Update. Biological Review Team. Santa Cruz Laboratory. Southwest Fisheries Science Center. NOAA Fisheries. February 2005.

National Marine Fisheries Service (NMFS). 2006a. Supplement to the Hood Canal and Eastern Strait of Juan de Fuca Summer Chum Salmon Recovery Plan. Available at www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/recovery_plans_supporting_documents.html.

National Marine Fisheries Service (NMFS). 2006b. Interim Regional Recovery Plan for Portions of Three Evolutionarily Significant Units (ESUs) of Salmon and Steelhead—Lower Columbia River Chinook (Oncorhynchus tshawytscha), Columbia River Chum (Oncorhynchus keta), and Lower Columbia River Steelhead (Oncorhynchus mykiss)—within the Washington Lower Columbia Management Unit. NMFS supplement to the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan. February 3, 2006.

National Marine Fisheries Service (NMFS). 2008a. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Willamette River Basin Flood Control Project. NOAA's National Marine Fisheries Sevice (NMFS), Northwest Region. July 11, 2008. F/NWR/2000/02117.

National Marine Fisheries Service (NMFS). 2008b. Recovery Plan for Southern Resident Killer Whales (Orcinus orca). National Marine Fisheries Service, Northwest Region, Seattle, Washington.

National Marine Fisheries Service (NMFS). 2008c. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Consultation on the Approval of rEvised Regimes under the Pacific Salmon Treaty and the Deferral of Management to Alaska of Certain Fisheries Included in those Regimes. December 22, 2008. F/NWR/2008/07706.

National Marine Fisheries Service (NMFS). 2009. Middle Columbia River Steelhead Distinct Population Segment ESA Recovery Plan. November 30, 2009.

National Marine Fisheries Service (NMFS). 2010a. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Issuance of Two Section 10(a)(1)(A) Scientific Research Permits in the Puget Sound. NOAA's National Marine Fisheries Sevice (NMFS), Northwest Region. April 14, 2010. F/NWR/2010/00314.

National Marine Fisheries Service (NMFS). 2010b. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Issuance of Two Section 10(a)(1)(A) Scientific Research Permits in the Puget Sound.. NOAA's National Marine Fisheries Sevice (NMFS), Northwest Region. June 10, 2010. F/NWR/2010/01926.

National Marine Fisheries Service (NMFS). 2010c. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Issuance of Four Section 10(a)(1)(A) Scientific Research Permits in Idaho, Oregon and Washington. NOAA's National Marine Fisheries Sevice (NMFS), Northwest Region. June 18, 2010. F/NWR/2010/02753.

National Marine Fisheries Service (NMFS). 2010d. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion & Magnuson-Stevens Fishery Conservation & Management Act Essential Fish Habitat Consultation: Issuance of Six Section 10(a)(1)(A) Scientific Research Permits in Oregon and Washington. NOAA's National Marine Fisheries Sevice (NMFS), Northwest Region. June 29, 2010. F/NWR/2010/02572.

NMFS. 2011a. Scientific Conclusions of the Status Review for Oregon Coast Coho Salmon (Oncorhynchus kisutch). Draft Revised Report of the Biological Review Team. May 16, 2011.

NMFS. 2011b. Southern Oregon/Northern California Coast Recovery Domain 5-Year Review: Summary and Evaluation of Southern Oregon/Northern California Coast Coho Salmon ESU. November 4, 2011.

NMFS. 2012. Public Draft Recovery Plan for Southern Oregon/Northern California Coast Coho Salmon (Oncorhynchus kisutch). National Marine Fisheries Service. Arcata, CA.

NMFS. 2014. Salmon Population Summary Database. NOAA Fisheries Northwest Fisheries Science Center. https://www.webapps.nwfsc.noaa.gov/

National Oceanic and Atmospheric Administration (NOAA). 1992. Final Rule, Endangered and Threatened Species: Threatened Status for Snake River Spring/summer Chinook Salmon and Threatened Status for Snake River Fall Chinook Salmon. April 22, 1992. Federal Register 57(78): 14653-14663.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

Nickelson, T.E., J.W. Nicholas, A.M. McGie, R.B. Lindsay, D.L. Bottom, R.J. Kaiser, and S.E. Jacobs. 1992. Status of anadromous salmonids in Oregon coastal basins. Oregon Department of Fish and Wildlife, Research and Development Section, Corvallis, and Ocean Salmon Management, Newport, Oregon.

Nickelson, T.E. 1998. A Habit-Based Assessment of Coho Salmon Production Potential and Spawner Escapement Needs for Oregon Coastal Streams. INFORMATION REPORTS NUMBER 98-4. Oregon Department of Fish and Wildlife. April, 1998.

Nicola, S.J. and A.J. Cordone. 1973. Effects of Fin Removal on Survival and Growth of Rainbow Trout (Salmon gairdneri) in a Natural Environment. Transactions of the American Fisheries Society 102(4):753-759.

Nielsen, L.A. 1992. Methods of marking fish and shellfish. American Fisheries Society Special Publication 23. Bethesda, Maryland 1992, 208p.

Northwest Fisheries Science Center (NWFSC). 2015. NOAA Salmon Population Summary: SPS Database. Available at http://www.nwfsc.noaa.gov/research/datatech/data/scidata.cfm.

ODFW and WDFW. 2012a. 2012 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulation. Joint Columbia River Management Staff.

ODFW and WDFW. 2012b. 2012 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. Joint Columbia River Management Staff.

ODFW and WDFW. 2013a. 2013 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulation. Joint Columbia River Management Staff.

ODFW and WDFW. 2013b. 2013 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. Joint Columbia River Management Staff.

ODFW and WDFW. 2014a. 2014 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulation. Joint Columbia River Management Staff.

ODFW and WDFW. 2014b. 2014 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. Joint Columbia River Management Staff.

ODFW and WDFW. 2015a. 2015 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulation. Joint Columbia River Management Staff.

ODFW and WDFW. 2015b. 2015 Joint Staff Report: Stock Status and Fisheries for Fall Chinook Salmon, Coho Salmon, Chum Salmon, Summer Steelhead, and White Sturgeon. Joint Columbia River Management Staff.

ODFW and WDFW. 2015. 2015 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulation. Joint Columbia River Management Staff.

Oregon Department of Fish and Wildlife (ODFW). 1995. Oregon coho salmon biological status assessment and staff conclusions for listing under the Oregon Endangered Species Act. Oregon Department of Fish and Wildlife, Portland, OR. 22 February 1995. (Attachment to II-B-I to the Draft OCSRI Plan dated 8/20/96.)

ODFW. 2000. Hatchery and Genetic Management Plan. Hood River Winter Steelhead Program. Oregon Department of Fish and Wildlife/Confederated Tribes of Warm Springs Reservation of Oregon.

ODFW. 2005a. Fisheries Management and Evaluation Plan for the Lower Columbia River Coho in Oregon Freshwater Fisheries of the Lower Columbia River Tributaries (between the Pacific Ocean and Hood River). September 2005.

ODFW. 2005b. 2005 Oregon Native Fish Status Report. Oregon Department of Fish and Wildlife, Fish Division, 3406 Cherry Avenue N.E., Salem, OR 97303-4924.

Oregon. 2009. Oregon Plan for Salmon and Watersheds 2007-2009 Biennial Report. Available online at: http://www.oregon.gov/OWEB/biennialreport_0507.shtml accessed Feb 7, 2012.

ODFW. 2010a. Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead. August 6, 2010.

ODFW. 2010b. Rock Creek Hatchery Operations Plan 2008. Available at http://www.dfw.state.or.us/fish/hatchery/

ODFW. 2010c. Cole Rivers Hatchery Operations Plan 2008. Available at http://www.dfw.state.or.us/fish/hatchery/

ODFW. 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. August, 2011.

ODFW. 2016a. Oregon Adult Salmonid Inventory & Sampling Project. Available at http://odfw.forestry.oregonstate.edu/spawn/index.htm

ODFW. 2016b. Willamette Falls Fish Passage Counts. Available at http://www.dfw.state.or.us/fish/fish_counts/willamette%20falls.asp

Pacific Coastal Salmon Recovery Fund (PCSRF). 2007. Pacific Coastal Salmon Recovery Fund 2007 Report to Congress for FY 2000-2006. U.S. Department of Commerce. National Oceanic and Atmospheric Administration. National marine Fisheries Service. Online at www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/recovery_plans_supporting_documents.html

PFMC (Pacific Fishery Management Council). 1997. Review of the 1996 ocean salmon fisheries. (Available from Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 200, Portland, OR 97220.)

PFMC (Pacific Fishery Management Council). 2009. Preseason Report 1: Stock Abundance Analysis for 2009 Ocean Salmon Fisheries. Prepared for the Council and its advisory entities. Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Parker, K. 1985. Biomass model for the egg production method. P. 5-6 in: R. Lasker (editor). An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy, Engraulis mordax. U.S. Department of Commerce, NOAA Technical Report 36. Washington, D.C.

Pauley, G.B., B.M. Bortz, and M.F. Shepard. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- steelhead trout. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.62). U.S. Army Corps of Engineers, TR EL-82-4. 24 pp.

Peery, C.A., and T.C. Bjornn. 1991. Examination of the extent and factors affecting downstream emigration of Chinook salmon fry from spawning grounds in the upper Salmon River. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Unpublished Report, Moscow.

Peltz, L. and J. Miller. 1990. Performance of half-length coded wire tags in a pink salmon hatchery marking program. American Fisheries Society Symposium 7:244-252.

Pettit, S.W. 1977. Comparative reproductive success of caught-and-released and unplayed hatchery female steelhead trout (Salmo gairdneri) from the Clearwater River, Idaho. Transactions of American Fisheries Society 106(5):431-435.

Phillips, A. J., S. Ralston, R. D. Brodeur, T. D. Auth, R. L. Emmett, C. Johnson, and V. G. Wespestad. 2007. Recent pre-recruit Pacific hake (Merluccius productus) occurrences in the northern California Current suggest a northward expansion of their spawning area. Calif. Coop. Ocean. Fish. Investig. Rep. 48:215–229.

Phillips, A. J., S. Ralston, R. D. Brodeur, T. D. Auth, R. L. Emmett, C. Johnson, and V. G. Wespestad. 2007. Recent pre-recruit Pacific hake (Merluccius productus) occurrences in the northern California Current suggest a northward expansion of their spawning area. Calif. Coop. Ocean. Fish. Investig. Rep. 48:215–229.

PNPTC (Point No Point Treaty Council), Lower Elwha Klallam Tribe, and WDFW. 2013. Winter steelhead harvest management plan for the Dungeness Management Unit in Dungeness Bay (Area 6D) and Dungeness River (Area 76A). 14 pp.

Prentice, E.F. and D.L. Park. 1984. A study to determine the biological feasibility of a new fish tagging system. Annual Report of Research, 1983-1984. Project 83-19, Contract DEA179-83BP11982.

Prentice, E.F., T.A. Flagg, and C.S. McCutcheon. 1987. A study to determine the biological feasibility of a new fish tagging system, 1986-1987. Bonneville Power Administration, Portland, Oregon.

Prentice, E.F., T.A. Flagg, and C.S. McCutcheon. 1990. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. American Fisheries Society Symposium 7: 317-322.

Puget Sound Technical Recovery Team (PSTRT). 2002. Planning ranges and preliminary guidelines for the delisting and recovery of the Puget Sound Chinook salmon evolutionarily significant unit.

PSTRT. 2006. The Hood Canal Summer Chum ESU. TRT and NMFS domain team review draft.

PSTRT. 2009. Determination of independent populations and viability criteria for the Hood Canal summer chum salmon evolutionarily significant unit.

PSSTRT (Puget Sound Steelhead Technical Recovery Team). 2013a. Identifying historical populations of steelhead within the Puget Sound Distinct Population Segment. Final Review Draft. 149 pp.

PSSTRT. 2013b. Viability criteria for Puget Sound Steelhead. Final Review Draft. 373 pp.

Quinn, T. P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. Published by University of Washington Press. 2005. 378 pages

Reingold, M. 1975. Effects of displacing, hooking, and releasing on migrating adult steelhead trout. Transactions of the American Fisheries Society 104(3):458-460.
Reisenbichler, R.R. and S.P. Rubin. 1999. Genetic Changes from Artificial Propagation of Pacific Salmon Affect the Productivity and Viability of Supplemented Populations. ICES Journal of Marine Science. 56:459-466.

Rexstad, E. A., and E. K. Pikitch. 1986. Stomach contents and food consumption estimates of Pacific hake, Merluccius productus. Fish. Bull. 84:947–956.

Roemmich, D., and J. McGowan. 1995. Climatic warming and the decline of zooplankton in the California Current. Science 267:1324–1326.

Rondorf, D.W. and W.H. Miller. 1994. Identification of the spawning, rearing and migratory requirements of fall Chinook salmon in the Columbia River Basin. Prepared for the U.S. Dept. of Energy, Portland, OR. 219 p.

Ruckelshaus, M.H., K.P. Currens, W.H. Graeber, R.R. Fuerstenberg, K. Rawson, N.J. Sands, and J.B. Scott. 2006. Independent populations of Chinook salmon in Puget Sound. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-78, 125 p.

Sandercock, F.K. 1991. The life history of coho salmon (Oncorhynchus kisutch). In C. Groot and L. Margolis (eds.), Life history of Pacific salmon, p. 311-393. Univ. B.C. Press, Vancouver, B.C.

Schaller, H., P. Wilson, S. Haeseker, C. Peterosky, E. Tinus, T. Dalton, R. Woodin, E. Weber, N. Bouwes, T. Berggren, J. McCann, S. Rassk, H. Franzoni, P. McHugh. 2007. COMPARATIVE SURVIVAL STUDY (CSS) of PIT-Tagged Spring/Summer Chinook and Steelhead In the Columbia River Basin: Ten-year Retrospective Analyses Report. Project #1996-020-00, BPA Contract #s 25634, 25264, 20620. Project #1994-033-00, BPA Contract #25247.

Schill, D.J., and R.L. Scarpella. 1995. Wild trout regulation studies. Annual performance report. Idaho Department of Fish and Game, Boise.

Schisler, G.J. and E.P. Bergersen. 1996. Post release hooking mortality of rainbow trout caught on scented artificial baits. North American Journal of Fisheries Management 16(3):570-578.

Schroeder, R.K., K.R. Kenaston, and R.B. Lindsay. 2000. Spring Chinook salmon in the Willamette and Sandy Rivers. October 1998 through September 1999. Annual progress report, Fish Research Project Oregon. Oregon Department of Fish and Wildlife, Portland.

Seiler, D., G. Volkhardt, P. Topping, L. Kishimoto. 2002. 2000 Green River Juvenile Salmonid Production Evalutation. Washington Department of Fish and Wildlife.

Seiler, D., G. Volkhardt, P. Topping, L. Kishimoto. 2004. 2001 Green River Juvenile Salmonid Production Evalutation. Washington Department of Fish and Wildlife.

Seiler, D., Volkhardt, G., and L. Fleischer. 2005. Evaluation of Downstream Migrant Salmon Production in 2004 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife.

Sharber, N.G. and S.W. Carothers. 1988. Influence of electrofishing pulse shape on spinal injuries in adult rainbow trout. North American Journal of Fisheries Management 8:117-122.

Sharber, N.G., S.W. Carothers, J.P. Sharber, J.C. DeVos, Jr. and D.A. House. 1994. Reducing electrofishing-induced injury of rainbow trout. North American Journal of Fisheries Management 14:340-346.

Shared Strategy Development Committee (SSDC). 2005. Draft Puget Sound Salmon Recovery Plan. Shared Strategy for Puget Sound. Seattle, WA.

Sharpe, C.S., D.A. Thompson, H.L. Blankenship, C.B. Schreck. 1998. Effects of Routine Handling and Tagging Procedures on Physiological Stress Responses in Juvenile Chinook Salmon. The Progressive Fish-Culturist. 60(2):81-87.

Smith, W. E., and R. W. Saalfeld. 1955. Studies on Columbia River smelt Thaleichthys pacificus (Richardson). Washington Department of Fisheries, Fisheries Research Paper 1(3): 3–26.

Snyder, D.E. 1992. Impacts of Electrofishing on fish. Contribution number 50 of the Larval Fish Laboratory, Colorado State University, Fort Collins.

Snyder, D.E. 1995. Impacts of electrofishing on fish. Fisheries 20(1):26-27.

Stolte, L.W. 1973. Differences in survival and growth of marked and unmarked coho salmon. Progressive Fish-Culturist 35:229-230.

Strange, C.D. and G.J. Kennedy. 1981. Stomach flushing of salmonids: a simple and effective technique for the removal of the stomach contents. Fish. Manage. 12:9-15.

Streamnet. 2016. Salmon and steelhead abundance data. Available at http://www.streamnet.org/

Stout, H.A., P.W. Lawson, D. Bottom, T. Cooney, M. Ford, C. Jordan, R. Kope, L. Kruzic, G.Pess, G. Reeves, M. Scheuerell, T. Wainwright, R. Waples, L. Weitkamp, J. Williams and T. Williams. 2011. Scientific conclusions of the status review for Oregon Coast coho salmon (Oncorhynchus kisutch). Draft revised report of the Oregon Coast Coho Salmon Biological Review Team. NOAA/NMFS/NWFSC, Seattle, WA.

TAC (U.S. v. Oregon Technical Advisory Committee). 2008. Biological assessment of incidental impacts on salmon species listed under the Endangered Species Act in the 2008-2017 non-Indian and treaty Indian fisheries in the Columbia River Basin.

Taylor, M.J., and K.R. White. 1992. A meta-analysis of hooking mortality of non-anadromous trout. North American Journal of Fisheries Management 12:760-767.

Taylor, G., and R.A. Barnhart. 1999. Mortality of angler caught and released steelhead. California Cooperative Fish and Wildlife Research Unit, Arcata.

Thompson, K.G., E.P. Bergersen, R.B. Nehring, and D.C. Bowden. 1997. Long-term effects of electrofishing on growth and body condition of brown and rainbow trout. North American Journal of Fisheries Management 17:154-159.

Thompson, R.N., J.B. Haas, L.M. Woodall, and E.K. Holmberg. 1958. Results of tagging program to enumerate the numbers and to determine the seasonal occurrence of anadromous fish in the Snake River and its tributaries. Final report. Fish Commission of Oregon, Clackamas, OR. Contract DA-35-026-eng-20609.

United States Fish and Wildlife Service (USFWS). 1995. Working paper on restoration needs: habitat restoration actions to double natural production of anadromous fish in the Central Valley of California. Volume 3. May 9, 1995. Prepared for the U.S. Fish and Wildlife Service under the direction of the Anadromous Fish Restoration Program Core Group. Stockton, California. 544 p.

USFWS and NMFS. 1998. Endangered Species Consultation Handbook Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act. U.S. Fish &Wildlife Service and National Marine Fisheries Service.

Van Eenennaam J.P., J. Linares-Casenave, S.I. Doroshov. D. C. Hillemeier, T. E. Willson, and A. A. Nova. 2006. Reproductive conditions of the Klamath river green sturgeon (Acipenser medirostris). Transactions of the American Fisheries Society 135: 151-163.

Volkhardt, G., P. Topping, L. Fleischer, T. Miller, S. Schonning, D. Rawding, M. Groesbeck. 2005. 2004 Juvenile Salmonid Production Evaluation Report. Green River, Wenatchee River, and Cedar Creek. Washington Department of Fish and Wildlife.

Waples, R.S., R.P. Jones, Jr., B.R. Beckman, and G.A. Swan. 1991. Status review for Snake River fall Chinook salmon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-F/NWC-201, 73p.

Ward, B.R., P.A. Slaney. 1993. Egg-to-Smolt Survival and Fry-to-Smolt Density Dependence of Keogh River Steelhead Trout. P. 209-217. In R.J. Gibson and R.E. Cutting [ed.] Production of juvenile Atlantic salmon, Salmon salar, in natural waters. Can. Spec. Publ. Fish. Aquat. Ci. 118.

Ward, E., B. Hanson, L. Weitkamp, and M. Ford. Unpublished report. Modeling killer whale prey size selection based upon available data. Northwest Fisheries Science Center. October 22, 2008.

Washington Department of Fisheries (WDF). 1974. 1974 Fisheries Statistical Report. Department of Fisheries, State of Washington.

Washington Department of Fisheries (WDF). 1991. Revised stock transfer guidelines. Memo, 28 May 1991, Salmon Culture Division Olympia, WA, 10 p.

Washington Department of Fisheries (WDF), Washington Department of Wildlife (WDW), and Western Washington Treaty Indian Tribes (WWTIT). 1993. 1992 Washington State salmon and steelhead stock inventory (SASSI). Wash. Dep. Fish Wildlife, Olympia, 212p. and 5 regional volumes. (Available from Washington Department of Fish and Wildlife, 600 Capitol Way N, Olympia, WA 98501-1091.)

Washington Department of Fish and Wildlife (WDFW) and the Point No Point Treaty (PNPT). 2000. Summer Chum Salmon Conservation Initiative: An implementation plan to recovery summer chum in the Hood Canal and Strait of Juan de Fuca Region. Wash. Dept. Fish and Wild., Olympia, WA. 423 p. + appendix.

WDFW (Washington Department of Fish and Wildlife) and ODFW (Oregon Department of Fish and Wildlife). 2001. Washington and Oregon eulachon management plan. Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. Available at http://wdfw.wa.gov/fish/creel/smelt/.

WDFW and the Point No Point Treaty (PNPT). 2001. Summer Chum Salmon Conservation Initiative: Annual Report for the 2000 Summer Chum Salmon Return to the Hood Canal and Strait of Juan de Fuca Region. Wash. Dept. Fish and Wild., Olympia, WA. p.138.

WDFW. 2003. WDFW comments on draft status review dated 31 March 2003 from Bruce Sanford and Bob Leland. (Available from Washington Department of Fish and Wildlife, Fish Program, 600 Capitol Way N., Olympia, WA 98501.)

WDFW. 2006a. Onchorhynchus mykiss: Assessment of Washington State’s Anadromous Populations and Programs. Washington Department of Fish and Wildlife, Olympia, WA.

WDFW. 2006b. Steelhead Historical Database. Washington Department of Fish and Wildlife, Olympia, WA. Available at http://wdfw.wa.gov/fish/papers/steelhead/.

WDFW. 2010a. Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Lower Columbia Fish Recovery Board. May 28, 2010.

WDFW. 2010b. WDFW Salmonid Stock Inventory (SaSI) database. Data submitted by WDFW in response to the five-year status review of listed species.

WDFW. 2010c. 2010 Wild Coho Forecasts for Puget Sound, Washington Coast, and Lower Columbia River. Available at http://wdfw.wa.gov/publications/.

WDFW. 2011. 2011 Wild Coho Forecasts for Puget Sound, Washington Coast, and Lower Columbia River. Available at http://wdfw.wa.gov/publications/.

WDFW. 2013b. 2013 Future Brood Document (Final Draft - August 2013). Online at http://wdfw.wa.gov/hatcheries/future_brood.html

WDFW. 2016. Salmonid Stock Inventory. Online at https://data.wa.gov/Natural-Resources-Environment/WDFW-Salmonid-Stock-Inventory-Populations/

WDFW and ODFW (Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife). 2016. Progress Report: Studies of Eulachon in the Columbia River.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.K. Teel, R.G. Kope, and R.S. Waples. 1995. Status Review of Coho Salmon from Washington, Oregon, and California. September 1995.

Welch H.E. and K.H. Mills. 1981. Marking fish by scarring soft fin rays. Canadian Journal of Fisheries and Aquatic Sciences 38:1168-1170.

Williams, T.H., E.P. Bjorkstedt, W.G. Duffy, D. Hillemeier, G. Kautsky, T.E. Lisle, M. McCain, M. Rode, R.G. Szerlong, R.S. Schick, M.N. Goslin, and A. Agrawal. 2006. Historical population structure of coho salmon in the Southern Oregon/Northern California Coasts Evolutionarily Significant Unit. NOAA-TM-NMFS-SWFSC-390. June 2006.

Wilson, M. F., R. H. Armstrong, M. C. Hermans, and K Koski. 2006. Eulachon: a review of biology and an annotated bibliography. Alaska Fisheries Science Center Processed Report 2006-12. Auke Bay Laboratory, Alaska Fish. Sci. Cent., NOAA, Natl. Mar, Fish. Serv., Juneau, AK. Online at http://www.afsc.noaa.gov/publications/ProcRpt/PR%202006-12.pdf.

Wydoski, R.S. 1997. Relation of hooking mortality and sublethal hooking stress to quality fishery management. Pages 43-87 in R.A. Barnhart and T.D. Roelofs, editors. Proceedings of a national symposium on catch-and-release fishing as a management tool. Humboldt State University, Arcata, California.

Wydoski, R. S., and R. R. Whitney. 2003. Inland fishes of Washington, second edition, revised and expanded. University of Washington Press, Seattle.

Yakima/Klickitat Fisheries Project. 2014. Klickitat River Subbasin Data: Lyle Falls Adult Trap Data. http://www.ykfp.org/klickitat/Data_lyleadulttrap.htm (website access October 4, 2014).

Zamon, J. E., and D. W. Welch. 2005. Rapid shift in zooplankton community composition on the northeast Pacific shelf during the 1998–1999 El Niño-La Niña event. Can. J. Fish. Aquat. Sci. 62:133–144.

Zabel, Richard W. 2014a. Memorandum to Donna Weiting: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2013. Northwest Fisheries Science Center. March 13, 2014.

Zabel, Richard W. 2014b. Memorandum to Donna Weiting: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2014. Northwest Fisheries Science Center. November 4, 2014.

Zabel, Richard W. 2015. Memorandum to Donna Weiting: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2015. Northwest Fisheries Science Center. October 5, 2015.

Zabel, Richard W. 2016. Memorandum to Donna Weiting: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2016. Northwest Fisheries Science Center. September 26, 2016.

Zabel, Richard W. 2017. Memorandum to James H. Lecky: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2017. Northwest Fisheries Science Center. November 3, 2017.