National Marine Fisheries Service Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation

Consultation on the Issuance of Eight ESA Section 10(a)(1)(A) Scientific Research Permits Affecting Salmon, Steelhead, Green Sturgeon, and Eulachon in the West Coast Region Beginning in 2017

NMFS Consultation Number: WCR-2017-6650

Action Agencies: The National Marine Fisheries Service (NMFS)
U.S. Fish and Wildlife Service (FWS)
U.S. Forest Service (USFS)
U.S. Geological Survey (USGS)

Affected Species and Determinations:

ESA-Listed Species	Status	Is Action Likely To Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely To Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Lower Columbia River (LCR) Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
Upper Willamette River (UWR) Chinook salmon *(O. tshawytscha)*	Threatened	Yes	No	No	No
Columbia River (CR) chum salmon *(O. keta)*	Threatened	Yes	No	No	No
LCR coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Oregon Coast (OC) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
LCR steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
UWR steelhead *(O. mykiss)*	Threatened	Yes	No	No	No
Southern (S) eulachon *(Thaleichthys pacificus)*	Threatened	Yes	No	No	No
Southern (S) green sturgeon *(Acipenser medirostris)*	Threatened	Yes	No	No	No
Southern Resident (SR) killer whales (*Orcinus orca*)	Threatened	No	No	No	No

ESA Section 7 Consultation Number WCR-2017-6650

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:

FOR

Barry A. Thom
Regional Administrator

Date: May 23, 2017

Administrative record number: 151422WCR2017PR00106

TABLE OF CONTENTS

List of Acronyms

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 – Fish and Wildlife Service
GPNF – Gifford Pinchot National Forest
ISAB – Independent Scientific Advisory Board
LCR – Lower Columbia River
LCRFB – Lower Columbia River Fish Recovery Board
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration
OC – Oregon Coast
ODFW – Oregon Department of Fish and Wildlife
S – Southern
SR – Southern Resident
USFWS – United States Fish and Wildlife Service
USGS –United States Geological Survey
UWR – Upper Willamette River
VSP – Viable Salmonid Population
WDFW – Washington Department of Fish and Wildlife
WDOE – Washington Department of Ecology
WSDOT – Washington Department of Transportation

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 (ITS) 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. It constitutes NMFS' review of eight scientific research permit applications and is based on information provided in the applications for the proposed permits, published and unpublished scientific information on the biology and ecology of potentially affected species under NMFS' jurisdiction in the action areas, and other sources of information.

We also completed an essential fish habitat (EFH) consultation on the proposed action, 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 (DQA) (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 the Portland, Oregon office of NMFS's West Coast Region: 1201 NE Lloyd Blvd, Portland, Oregon 97232.

1.2 Consultation History

The West Coast Region's Protected Resources Division (PRD) received eight applications for scientific research permits from multiple state and Federal agencies. Because the permit requests are similar in nature and duration and are expected to affect the same listed species, we combined them into a single consultation pursuant to 50 CFR 402.14(c). The affected species are LCR Chinook salmon, UWR Chinook salmon, LCR steelhead, UWR steelhead, CR chum salmon, LCR coho salmon, OC coho salmon, S eulachon, and S green sturgeon. The proposed actions also have the potential to affect Southern Resident (SR) killer whales and their critical habitat by diminishing the whales' prey base. We concluded that the proposed activities are not likely to adversely affect SR killer whales or their critical habitat and the full analysis is found in the "Not Likely to Adversely Affect" Determination section (2.11).

We divide our permit and consultation workload for ESA Section 10(a)(1)(A) scientific research permits into five geographic areas: the Puget Sound/Georgia Basin, Lower Columbia-Upper Willamette/Oregon Coast, Interior Columbia-Snake basins, California Coast, and California Central Valley. This biological opinion covers the Lower Columbia, Upper Willamette and

Oregon Coast salmon ESUs and steelhead DPSs as well as S eulachon, S green sturgeon, and SR killer whales. Some of the permits we analyze here also request take for other ESUs/DPSs. ESA Section 7 Consultation Number WCR-2016-5949 covers the species and actions in the Puget Sound/Georgia Basin, and Consultation Number WCR-2017-6413 covers the species and actions in the Interior Columbia-Snake basins.

We received a permit renewal request (1135-9R) from the U.S. Geological Survey (USGS) on March 29, 2016. We requested additional information from the USGS on September 9, 2016, received all necessary information on September 20, 2016, and deemed the application complete on October 20, 2016.

We received a permit renewal request (1175-9R) from the U.S. Forest Service – Gifford Pinchot National Forest (GPNF) on March 22, 2016 and deemed it complete on October 20, 2016.

We received a permit renewal request (1345-8R) from the Washington Department of Fish and Wildlife (WDFW) on May 17, 2016. We requested additional information from the WDFW on September 13, 2016 and we received all necessary information and deemed the application complete on September 23, 2016.

We received a permit renewal request (1386-9R) from the Washington Department of Ecology (WDOE) on March 28, 2016 and deemed it complete on October 20, 2016.

We received a permit renewal request (1598-4R) from the Washington Department of Transportation (WSDOT) on September 22, 2016. We requested additional information from the WDOE on September 19, 2016 and we received all necessary information and deemed the application complete on September 22, 2016.

We received a permit renewal request (16069-2R) from the City of Portland on March 22, 2016. We requested additional information from the City of Portland on September 28, 2016, received all necessary information on October 13, 2016, and deemed the application complete on October 20, 2016.

We received a permit renewal request (16666-2R) from the U.S. Fish and Wildlife Service (FWS) on March 28, 2016 and deemed it complete on October 20, 2016.

We received a permit renewal request (20492) from the Oregon Department of Fish and Wildlife (ODFW) on April 29, 2016 and deemed the application complete on October 20, 2016.

When we requested additional information from applicants, typically it was to clarify the proposed sampling dates, locations, or methods. We asked some applicants to revise the numbers of fish in their requested take authorizations to account for updated information on the distribution and abundance of ESA-listed species.

We provided information on the applications in a Federal Register notice on November 3, 2016 (81 FR 76565). We accepted public comments on the applications until December 5, 2016, and then commenced consultation. We do not present the full consultation histories for the actions here because they are lengthy and not directly relevant to the analysis. We maintain a complete record of this consultation at NMFS Protected Resources Division in Portland, Oregon.

1.2 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). When analyzing 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 action here is NMFS’s proposal to issue permits to the various applicants.

“Take” is defined in section 3 of the ESA; it means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect [a listed species] or to attempt to engage in any such conduct. This opinion constitutes formal consultation and an analysis of effects solely for the evolutionarily significant units (ESUs) and distinct population segments (DPSs) that are the subject of this opinion.[1] Biological opinions WCR-2016-5949 and WCR-2017-6413 evaluate some of the take in proposed permit numbers 1175-9R, 1345-8R, 1386-9R, 1598-4R, 16069-2R, 16666-2R, and 20492. We issue permits after we sign all controlling biological opinions.

NMFS’ issuance of permits for scientific research activities proposed by the USGS, GPNF, WDFW, WDOE, WSDOT, City of Portland, FWS, and ODFW constitutes the proposed Federal action. As the action agency, NMFS is responsible for complying with section 7 of the ESA, which requires Federal agencies to ensure any actions they fund, permit, or carry out are not likely to jeopardize listed species’ continued existence nor destroy or adversely modify their critical habitat. This consultation examines the effects of the proposed research on LCR Chinook salmon, UWR Chinook salmon, LCR steelhead, UWR steelhead, CR chum salmon, LCR coho salmon, OC coho salmon, S eulachon, S green sturgeon, and SR killer whales. This consultation also examines the effects of the permits NMFS proposes to issue, and thus it fulfills NMFS’ section 7 consultation obligations.

Permit 1135-9R

The USGS is seeking to renew for five years a research permit that currently allows them to take juvenile LCR steelhead in the Wind River subbasin (Washington). The purpose of the study is to provide information on the growth, survival, habitat use, and life histories of LCR steelhead. This information would improve understanding of habitat associations and life history strategies for LCR steelhead in the Wind River and that, in turn, would help state, tribal, and Federal efforts to restore LCR steelhead. The USGS proposes to capture juvenile LCR steelhead using backpack electrofishing equipment, hold the fish in aerated buckets, anaesthetize them with MS-

---

[1] An ESU of Pacific salmon (Waples 1991) and a DPS of steelhead (71 FR 834) are considered to be “species” as the word is defined in section 3 of the ESA. In addition, it should be noted that we use the terms “artificially propagated” and “hatchery” are used interchangeably in the Opinion, and alsoas are the terms “naturally propagated” and “natural.”

222, measure length and weight, tag age-0 and age-1 fish with passive integrated transponders (PIT-tags), and release all fish at the site of collection after they recover from anesthesia. The researchers do not propose to kill any fish but a small number may die as an unintended result of research activities.

Permit 1175-9R

The Gifford Pinchot National Forest (GPNF) is seeking to renew for five years a permit that currently allows them to take juvenile LCR Chinook salmon, LCR coho salmon, and LCR steelhead in the Cowlitz and Middle Columbia-Hood subbasins (Washington). This consultation covers GPNF's proposed research in the Cowlitz (Lewis, Cowlitz, and Washougal Rivers) and Middle Columbia-Hood Subbasins (Wind, Little White Salmon, and Big White Salmon Rivers). The purpose of this research is to describe fish species presence, distribution, spawning areas, and habitat conditions on lands that the GPNF administers. The GPNF and other agencies would use that information in forest management, habitat restoration, and species recovery efforts. The GPNF proposes to use backpack electrofishing and seines to capture juvenile salmonids, hold fish for short periods in aerated buckets, identify, and then release the fish. The researchers do not propose to kill any fish, but a small number may die as an unintentional result of research activities.

Permit 1345-8R

The WDFW is seeking to renew for five years a research permit that currently allows them to take juvenile and adult LCR Chinook salmon, LCR coho salmon, and LCR steelhead. This consultation covers WDFW's proposed research in the Lower Columbia River basin. The purpose of the WDFW study is to assess inland game fish communities and thereby improve fishery management. The research would benefit salmonids by helping managers write warm-water fish species harvest regulations that reduce potential impacts on listed salmonids. The WDFW proposes to capture fish using boat electrofishing, fyke nets, and gillnets. After being captured, the listed salmon and steelhead would be placed in aerated live wells, identified, and released. The researchers do not propose to kill any listed fish being captured, but a small number may die as an unintended result of the activities.

Permit 1386-9R

The Washington Department of Ecology (WDOE) is seeking to renew for five years a research permit that currently allows them to take juvenile and adult LCR Chinook salmon, CR chum salmon, LCR coho salmon, and LCR steelhead in the state of Washington. The purpose of the research is to investigate the occurrence and concentrations of toxic contaminants in non-anadromous freshwater fish tissue, sediment, and water at sites throughout Washington. The WDOE conducts this research in order to meet Federal and state regulatory requirements. This research would benefit listed species by identifying toxic contaminants in fish and informing pollution control actions. The WDOE proposes to capture fish using various methods including backpack and boat electrofishing, beach seining, block, fyke, and gill netting, and angling. All captured salmon and steelhead would either be released immediately or held temporarily in an aerated live well to help them recover before release. The researchers do not propose to kill any fish but a small number may die as an unintended result of research activities.

Permit 1598-4R

The WSDOT is seeking to renew for five years a research permit that currently allows them to take juvenile, LCR Chinook salmon, CR chum salmon, LCR coho salmon, and LCR steelhead. Sample sites would be located throughout the state of Washington. The purpose of the WSDOT study is to determine the distribution and diversity of anadromous fish species in waterbodies crossed by or adjacent to the state transportation systems (highways, railroads, and/or airports). This information would be used to assess the impacts that projects proposed at those facilities may have on listed species. The research would benefit the listed species by helping WSDOT minimize project impacts on listed fish to the greatest extent possible. Depending on the size of the stream system, the WSDOT proposes to capture fish using dip nets, stick seines, baited gee minnow traps, or backpack electrofishing. The captured fish would be identified to species and immediately released. The researchers do not propose to kill any listed fish being captured, but a small number may die as an unintended result of the activities.

Permit 16069-2R

The City of Portland is seeking to renew for five years a research permit that currently allows them to take juvenile and adult LCR Chinook salmon, LCR coho salmon, LCR steelhead, CR chum salmon, UWR Chinook salmon, UWR steelhead, OC coho salmon, and S green sturgeon in the Columbia and Willamette rivers and tributaries (Oregon). The proposed research may also cause take of adult S eulachon, for which there are currently no ESA take prohibitions. This research is part of the Portland Watershed Management Plan, which aims to improve watershed health in the Portland area. Project staff sample 37 sites annually across all Portland watersheds for hydrology, habitat, water chemistry, and biological communities. The research would benefit listed salmonids by providing information to assess watershed health, status of critical habitat, effectiveness of watershed restoration actions, and compliance with regulatory requirements. The City of Portland proposes to capture juvenile fish using backpack and boat electrofishing, hold fish in a bucket of aerated water, take caudal fin clips for genetic analysis, and release fish. The researchers would avoid contact with adult fish. The researchers do not propose to kill any fish but a small number may die as an unintended result of research activities.

Permit 16666-2R

The U.S. Fish and Wildlife Service (FWS) is seeking to renew for five years a research permit that currently allows them to take juvenile LCR coho salmon and adult LCR Chinook salmon in Abernathy Creek (Washington). The goal of this research is to determine the natural reproductive success and relative fitness of hatchery origin and natural-origin steelhead and assess the overall demographic effects of hatchery fish supplementation in Abernathy Creek relative to two adjacent control streams. The research would benefit listed salmonids by producing data to be used in hatchery and genetic management plans. Steelhead are not listed in these streams, but the FWS have captured juvenile LCR coho salmon and observed adult LCR Chinook salmon in previous years. The FWS proposes capture, handle, and release juvenile LCR coho salmon during backpack electrofishing surveys. The researchers would avoid electrofishing near adult coho and Chinook salmon. The researchers do not expect to kill any listed fish, but a small number may die as an unintended result of the research activities.

Permit 20492

The ODFW is seeking to renew for five years a permit for research in the Willamette and Columbia basins (Oregon) and on the Oregon coast. ODFW proposes to take juvenile LCR Chinook salmon, LCR coho salmon, LCR steelhead, CR chum salmon, UWR Chinook salmon, UWR steelhead, OC coho salmon, and adult S green sturgeon. The ODFW research may also cause them to take adult S eulachon, for which there are currently no ESA take prohibitions. The new permit would cover the following projects: (1) Warmwater and Recreational Game Fish Management, (2) District Fish Population Sampling in the Upper Willamette Basin, and (3) Salmonid Assessment and Monitoring in the Deschutes River. The research would provide information on fish population structure, abundance, genetics, disease occurrences, and species interactions. This information would be used to direct management actions to benefit listed species. Juvenile salmonids would be collected using boat electrofishing. Some fish would be anesthetized, sampled for length and weight, allowed to recover from the anesthesia, and released. Most salmonids would be allowed to swim away after being electroshocked, or they would be netted and released immediately. The ODFW does not intend to kill any of the fish being captured, but a small number may die as an unintended result of the activities.

Common Elements among the Proposed Permit Actions

Each permit would expire on December 31, 2021. In each case, the applicant has requested take numbers that are slightly higher than they expect to occur, in order to avoid exceeding their take limits due to unforeseen circumstances, such as environmental conditions or higher-than-expected population abundance causing higher-than-expected encounter rates. Inflating take estimates slightly also helps us to conduct a conservative analysis of the effects of the actions, because the actual levels of take typically are lower than analyzed.

Research permits prescribe conditions to be followed before, during, and after research is conducted. These conditions are intended to (a) ensure that research activities are coordinated among permit holders and between permit holders and NMFS, (b) minimize impacts on listed species, and (c) ensure that NMFS receives information about the effects the permitted activities have on the species concerned. All research permits NMFS' NWR issues have the following conditions:

1. The permit holder must ensure that listed species are taken only at the levels, by the means, in the areas and for the purposes stated in the permit application, and according to the terms and conditions in the permit.

2. The permit holder must not intentionally kill or cause to be killed any listed species unless the permit specifically allows intentional lethal take.

3. The permit holder must handle listed fish with extreme care and keep them in cold water to the maximum extent possible during sampling and processing procedures. When fish are

transferred or held, a healthy environment must be provided; e.g., the holding units must contain adequate amounts of well-circulated water. When using gear that captures a mix of species, the permit holder must process listed fish first to minimize handling stress.

4. The permit holder must stop handling listed juvenile fish if the water temperature exceeds 70 degrees Fahrenheit at the capture site. Under these conditions, listed fish may only be visually identified and counted. In addition, electrofishing is not permitted if water temperature exceeds 64 degrees Fahrenheit.

5. If the permit holder anesthetizes listed fish to avoid injuring or killing them during handling, the fish must be allowed to recover before being released. Fish that are only counted must remain in water and not be anesthetized.

6. The permit holder must use a sterilized needle for each individual injection when passive integrated transponder tags (PIT-tags) are inserted into listed fish.

7. If the permit holder unintentionally captures any listed adult fish while sampling for juveniles, the adult fish must be released without further handling and such take must be reported.

8. The permit holder must exercise care during spawning ground surveys to avoid disturbing listed adult salmonids when they are spawning. Researchers must avoid walking in salmon streams whenever possible, especially where listed salmonids are likely to spawn. Visual observation must be used instead of intrusive sampling methods, especially when the only activity is determining fish presence.

9. The permit holder using backpack electrofishing equipment must comply with NMFS' Backpack Electrofishing Guidelines (June 2000) available at: http://www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf.

10. The permit holder must obtain approval from NMFS before changing sampling locations or research protocols.

11. The permit holder must notify NMFS as soon as possible but no later than two days after any authorized level of take is exceeded or if such an event is likely. The permit holder must submit a written report detailing why the authorized take level was exceeded or is likely to be exceeded.

12. The permit holder is responsible for any biological samples collected from listed species as long as they are used for research purposes. The permit holder may not transfer biological samples to anyone not listed in the application without prior written approval from NMFS.

13. The person(s) actually doing the research must carry a copy of this permit while conducting the authorized activities.

14. The permit holder must allow any NMFS employee or representative to accompany field personnel while they conduct the research activities.

15. The permit holder must allow any NMFS employee or representative to inspect any records or facilities related to the permit activities.

16. The permit holder may not transfer or assign this permit to any other person as defined in section 3(12) of the ESA. This permit ceases to be in effect if transferred or assigned to any other person without NMFS' authorization.

17. NMFS may amend the provisions of this permit after giving the permit holder reasonable notice of the amendment.

18. The permit holder must obtain all other Federal, state, and local permits/authorizations needed for the research activities.

19. On or before January 31st of every year, the permit holder must submit to NMFS a post-season report in the prescribed form describing the research activities, the number of listed fish taken and the location, the type of take, the number of fish intentionally killed and unintentionally killed, the take dates, and a brief summary of the research results. The report must be submitted electronically on our permit website, and the forms can be found at https://apps.nmfs.noaa.gov/. Falsifying annual reports or permit records is a violation of this permit.

20. If the permit holder violates any permit condition they will be subject to any and all penalties provided by the ESA. NMFS may revoke this permit if the authorized activities are not conducted in compliance with the permit and the requirements of the ESA or if NMFS determines that its ESA section 10(d) findings are no longer valid.

"Permit holder" means the permit holder or any employee, contractor, or agent of the permit holder. Also, NMFS may include conditions specific to the proposed research in the individual permits.

Finally, NMFS will use the annual reports to monitor the actual number of listed fish taken annually in the scientific research activities and will adjust permitted take levels if they are deemed to be excessive or if cumulative take levels rise to the point where they are detrimental to the listed species.

2. ENDANGERED SPECIES ACT BIOLOGICAL OPINION

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, each Federal agency must ensure that its 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 habitats. If incidental take is reasonably certain to occur, 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 (RPMs) and terms and conditions to minimize such impacts.

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and/or 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.

This biological opinion relies on the definition of "destruction or adverse modification," which "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" (81 FR 7214). The adverse modification analysis considers the Federal action's impacts on the conservation value of designated critical habitat.

The designation(s) of critical habitat for (species) use(s) the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

Section 4(d) protective regulations prohibit the take of naturally spawned salmonids and of listed hatchery salmonids with an intact adipose fin, but do not prohibit take of listed hatchery salmonids that have their adipose fins removed prior to release into the wild (70 FR 37160 and 71 FR 834). As a result, researchers do not require a permit to take hatchery fish that have had their adipose fin removed. Nevertheless, this document evaluates impacts on both natural and hatchery fish to allow a full examination of the effects of the action on the species as a whole. Section 4(d) protective regulations also prohibit the take of S green sturgeon (75 FR 30714). We have promulgated no protective regulations for S eulachon under section 4(d); thus, we can issue no permit to take them. Nonetheless, because S eulachon are a listed species with proposed or designated critical habitat, we must perform the jeopardy and adverse modification analyses laid out in the previous section.

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.* This section describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. For listed salmon and steelhead, NMFS has developed specific guidance for analyzing the status of the listed species' component populations in a "viable salmonid populations" paper (VSP; McElhaney et al. 2000). The VSP approach considers the abundance, productivity, spatial structure, and diversity of each population as part of the overall review of a species' status. For listed salmon and steelhead, the VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" (50 CFR 402.02). In describing the range-wide status of listed species, we rely on viability assessments and criteria in technical recovery team documents and recovery plans, where available, that describe how VSP criteria are applied to specific populations, major population groups, and species. We determine the rangewide status of critical habitat by examining the condition of its PBFs - which were identified when the critical habitat was designated. Species and critical habitat status are discussed in Section 2.2.
- *Describe the environmental baseline in the action area*. The environmental baseline includes the past and present impacts of Federal, state, or private actions and other human activities *in the action area*. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process. We discuss the environmental baseline in Section 2.4 of this opinion.
- *Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.* In this step, NMFS considers how the proposed action would affect the species' reproduction, numbers, and distribution or, in the case of salmon and steelhead, their VSP characteristics. NMFS also evaluates the proposed action's effects on critical habitat features. We describe the effects of the action in Section 2.5 of this opinion.
- *Describe any cumulative effect in the action area*. Cumulative effects, as defined in NMFS' implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation. Cumulative effects are considered in Section 2.6 of this opinion.
- *Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical*

habitat. In this step, NMFS adds the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6) to assess whether the action could reasonably be expected to: (1) appreciably reduce 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. These assessments are made in full consideration of the status of the species and critical habitat (Section 2.2). Integration and synthesis occurs in Section 2.7 of this opinion.

- *Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified*. Conclusions regarding jeopardy and the destruction or adverse modification of critical habitat are presented in Section 2.8. These conclusions flow from the logic and rationale presented in the Integration and Synthesis section (2.7).
- *If necessary, suggest 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 for each listed species, 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 PBFs 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. 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.* The steelhead listing units in this biological opinion constitute DPSs of the species *O. mykiss.* The ESUs and DPSs of salmon and steelhead include natural-origin populations and hatchery populations, as described below. Finally, the eulachon and green sturgeon listing units in this biological opinion constitute DPSs.

2.2.1 Climate Change

Average annual air temperatures in the Pacific Northwest have increased by approximately 1°C since 1900 and climate models predict that air temperatures will increase 0.1 to 0.6°C per decade over the next century. This change in air temperature affects freshwater, estuarine, and marine ecosystems (ISAB 2007).

Projected 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 increasing evidence that recent warming is due to 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).

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 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 during winter to alternating periods of snow and rain. 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).

Impacts on Salmon

Climate variation can affect salmon populations via numerous mechanisms. These include direct effects of temperature such as mortality from heat stress, changes in growth and development rates, and disease resistance. Changes in streamflow regimes, such as flooding and low flow events, 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 life stages. 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 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. Climate-induced contraction of thermally suitable habitat also can affect marine migration patterns. 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 medium and high emissions scenarios (NWFSC 2015).

Freshwater Habitat

Likely impacts of climate change on fish in freshwater systems in the Northwest include reduction of cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, and competition among species. Recent modeling results indicate that increased summer temperatures or decreased fall streamflow are likely to significantly reduce parr-smolt survival of salmon and steelhead by 2040, and this result may also be applicable to other species with similar life history strategies in the Northwest (ISAB 2007).

Estuarine Habitat

In estuaries, higher winter freshwater flows and higher sea level elevation may lead to increased sediment deposition and wave damage; lower freshwater flows in late spring and summer may lead to upstream extension of the salt wedge, possibly influencing the distribution of salmonid prey and predators; and increased temperature of freshwater inflows may extend the range of warm-adapted non-indigenous species that are normally found only in freshwater. In all of these cases, the specific effects on salmon and steelhead abundance, productivity, spatial distribution and diversity are poorly understood (ISAB 2007).

Marine Habitat

Climate change is likely to cause increased ocean temperature, increased stratification of the water column, and changes in intensity and timing of coastal upwelling. These continuing changes will alter primary and secondary productivity, the structure of marine communities, and in turn, the growth, productivity, survival, and migrations of salmonids. A mismatch between earlier smolt migrations (due to earlier peak spring freshwater flows and decreased incubation period) and altered upwelling may reduce marine survival rates. Increased concentration of CO2 reduces the availability of carbonate for shell-forming invertebrates, including some that are prey items for juvenile salmonids (ISAB 2007).

2.2.2 Status of the Species

For Pacific salmon, steelhead, 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 (McElhaney 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 (McElhaney 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" 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. McElhaney 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 (McElhaney et al. 2000).

Information on the status and distribution of all the species considered here can be found in the following discussions and documents:

- Status review of West Coast steelhead from Washington, Idaho, Oregon, and California (Busby et al. 1996)
- Status review of sockeye salmon from Washington and Oregon (Gustafson et al. 1997)
- Status review of chum salmon from Washington, Idaho, Oregon, and California (Johnson et al. 1997)
- Status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers et al. 1998)
- Updated status of Federally listed ESUs of West Coast salmon and steelhead (Good et al. 2005)
- Status review of Puget Sound steelhead (*Oncorhynchus mykiss*) (Hard et al. 2007)
- Status review of eulachon (*Thaleichthys pacificus*) in Washington, Oregon, and California (Gustafson et al. 2010)
- Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest (Ford 2011)
- Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest (NWFSC 2015)
- Status review update of eulachon (*Thaleichthys pacificus*) listed under the Endangered Species Act: Southern Distinct Population Segment (Gustafson et al. 2016)

2.2.2.1 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 1). 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 1. 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 1). 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 1). 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 (McElhaney 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 2).

Table 2. 5-year Average Adult Abundance Estimates for LCR Chinook Salmon Populations (ODFW 2016a; WDFW 2016).

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 1). 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 2012-2016 is shown in Table 3 (Zabel 2013, 2014a, 2014b, 2015, 2016).

Table 3. Average Estimated Outmigration for Listed LCR Chinook Salmon (2012-2016).

Origin	Outmigration
Natural	12,427,062
Listed hatchery intact adipose	1,130,182
Listed hatchery adipose clip	34,347,631

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.

2.2.2.2 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 2011) identifies seven demographically independent populations of spring Chinook salmon: Clackamas, Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and the Middle Fork Willamette (Table 4). 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 4. Historical Population Structure and Viability Status for UWR Chinook Salmon (ODFW 2011).

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 (McElhaney 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 2011). 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 2011) rates diversity to be moderate to low in the UWR Chinook ESU (Table 4). 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 5).

Table 5. Estimated Recent Abundance, Viability Goals, and Abundance Targets for Upper Willamette Chinook Populations (ODFW 2011).

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 2011) rates all but two of the populations as very low for abundance and productivity (Table 4). Most populations of the UWR Chinook ESU are far below the recovery goal (Table 5). 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.

Abundance of adult UWR spring Chinook has declined since the highs witnessed around the turn of this century (Table 6). 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 6. Adult Upper Willamette River Spring Chinook Escapement to the Clackamas River and Willamette Falls Fish Ladder (ODFW and WDFW 2012, 2013, 2014, 2015; 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 2012-2016 is shown in Table 7 (Zabel 2013, 2014a, 2014b, 2015, 2016).

Table 7. Average Estimated Outmigration for Listed UWR Chinook Salmon (2012-2016).

Origin	Outmigration
Natural	1,287,502
Listed hatchery intact adipose	36,253
Listed hatchery adipose clipped	5,850,595

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 2011). 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 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 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 2011) 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 2011).

Many UWR Chinook populations are characterized by high proportions of hatchery fish on the spawning grounds (ODFW 2011). The vast majority of the UWR Chinook escapement is hatchery fish (Table 6). 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 2011). 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.

2.2.2.3 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 8 (Good et al. 2005).

Table 8. 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 9). 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 9. Recovery Goals for CR Chum Salmon Populations (LCFRB 2010, WDFW 2016a).

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 2012-2016 is shown in Table 10 (Zabel 2013, 2014a, 2014b, 2015, 2016).

Table 10. Average Estimated Outmigration for Listed CR Chum Salmon (2012-2016).

Origin	Outmigration
Natural	4,093,920
Listed hatchery intact adipose	662,814

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

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.

2.2.2.4 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 11).

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.

Table 11. 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)

The LCR coho salmon ESU includes 25 populations that historically existed in the Columbia River basin from the Hood River downstream (Table 12). 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 12). 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 12. 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 12). 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).

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 13).

Table 13. Estimated Abundance of Adult Lower Columbia River Coho Spawners (ODFW 2016a; WDFW 2016b).

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 2012-2016 is shown in Table 14 (Zabel 2013, 2014a, 2014b, 2015, 2016).

Table 14. Average Estimated Outmigration for Listed LCR Coho Salmon (2012-2016).

Origin	Outmigration
Natural	619,576
Listed hatchery intact adipose	239,784
Listed hatchery adipose clipped	7,514,080

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

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.

2.2.2.5 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 15). 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 15. 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 (Oregon 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.

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 16). 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.

Table 16. 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

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 2011). 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 2011). 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 2011). 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.

2.2.2.6 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 17). 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 17. 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 17). 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).

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 18). 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 18). Several populations appear to be approaching the abundance targets, and one (the E.F. Lewis) exceeded it.

Table 18. Abundance Estimates for Adult 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.

Data availability for abundance of naturally spawning adult steelhead is highly variable (Table 18). 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 2012-2016 is shown in Table 19 (Zabel 2013, 2014a, 2014b, 2015, 2016).

Table 19. Average Estimated Outmigration for Listed LCR Steelhead (2012-2016).

Origin	Outmigration
Natural	351,966
Listed hatchery intact adipose	12,449
Listed hatchery adipose clipped	1,134,744

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

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.

2.2.2.7 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 20). 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 20. 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 17). 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 17). 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 21). 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 21. 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 21). However, there is a considerable amount of uncertainty in these ratings. In their assessment of these populations, McElhaney 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 (2012-2016) of naturally-produced smolts is 163,084 (Zabel 2013, 2014a, 2014b, 2015, 2016). 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.

2.2.2.8 Southern Eulachon

Description and Geographic Range

On March 16, 2010, NMFS listed the southern Distinct Population Segment (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 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).

NMFS has not drafted a recovery7 plan for eulachon.

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).

Few direct estimates of eulachon abundance exist. 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[2]; and by 2010, had dropped to just 4 metric tons (Table 22). 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[3] effects and random genetic and demographic effects (Gustafson et al. 2010).

Table 22. 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]
2006	29	725,000
2007	41	1,025,000
2008	10	250,000
2009	14	350,000
2010	4	100,000
2011	31	775,000
2012	120	3,000,000
2013	100	2,500,000
2014	66	1,650,000
2015	317	7,925,000
2011-2015[b]	**95.11**	**2,378,000**

[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).

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

---

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

2011 through 2015, the Fraser River eulachon spawner population estimate is 2,378,000 adults (Table 22).

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 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 23).

Table 23. Eulachon spawning estimates for the lower Columbia River and tributaries (Gustafson et al. 2015).

Year	Estimated biomass (metric tons)	Estimated number of spawners[a]
2011	1,500	36,800,000
2012	1,500	35,700,000
2013	4,400	107,700,000
2014	7,300	180,000,000
2015	5,000	123,582,000
2011-2015[b]	**3,248**	**79,358,000**

[a] Estimated spawner population numbers are calculated by estimating an assumed sex ratio of 1:1, a mean relative fecundity of 802.3 eggs per gram female bodyweight, an assumed egg to larval survival of 100%, and a mean fish weight of 40.6 g.

[b] Four-year geometric mean of minimum eulachon biomass estimates (2011-2014).

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. Currently, commercial and recreational harvest of eulachon is prohibited in both Washington and Oregon.

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). Despite this reduction, bycatch of eulachon in these fisheries is still significant. The total estimated bycatch of eulachon in the Oregon and California pink shrimp fisheries ranged from 217,841 fish in 2004 to 1,008,260 fish in 2010 (the most recent year that data is available; Al-Humaidhi et al. 2012).

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

The southern DPS of eulachon is at very low abundance compared to historic levels. We have noted low and declining abundance in all surveyed populations, including the two remaining core populations (Columbia and Fraser rivers) (Gustafson et al. 2010). Climate change impacts, bycatch in the shrimp trawl fishery, dams and water diversions, dredging, pollution and predation are believed to be the most serious threats to persistence of eulachon.

2.2.2.9 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 2005a). 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 nocturnal. Juveniles appear to spend one to three years in freshwater before they enter the ocean (NMFS 2005a).

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 24; NMFS 2015). There are no estimates for juvenile S green sturgeon.

Table 24. 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 Habitat

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[4]; 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 with poor quality 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

---

[4] 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).

population it served (e.g., a population at the extreme end of geographic distribution), or serving other important roles (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 PBF-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 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.

2.2.3.1 Lower Columbia River Chinook Salmon

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 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.

2.2.3.2 Upper Willamette River Chinook Salmon

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.

2.2.3.3 Columbia River Chum Salmon

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.

2.2.3.4 Lower Columbia River Coho Salmon

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.

2.2.3.5 Oregon Coast Coho Salmon

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.

2.2.3.6 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.

2.2.3.7 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.

2.2.3.8 Southern 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.

2.2.3.9 Southern 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 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). For the purposes of this opinion, the action area includes all river reaches accessible to listed Chinook salmon, chum salmon, coho salmon, steelhead, S eulachon, and S green sturgeon in all sub-basins of the Lower Columbia River, Willamette River, and Oregon Coast. Additionally, the action area includes all marine waters off the West Coast of the continuous United States, including nearshore waters from the Mexican to Canadian borders, which are accessible to these species. Wherever possible we account for a more limited geographic scope when analyzing a proposed action’s impacts on listed species and their critical habitat.

The action area is thus spread out over large and discontinuous areas. Salmon exist in large areas between the locations for the multiple proposed actions, but they would not be affected by the proposed activities. There is one geographically distinct area: the portion of the Puget Sound occupied by SR killer whales. As noted earlier, the proposed actions could affect the killer whales’ prey base (Chinook salmon) and so it is possible that some effects of the actions could be felt as much as hundreds of miles away from where the proposed activities would take place. Those effects are described in the Not Likely to Adversely Affect section (2.11).

In all cases, the proposed research activities would take place in individually small sites. For example, the researchers might electrofish a few hundred feet of river, deploy a beach seine covering only a few hundred square feet of stream, or operate a screw trap in a few tens of square feet of habitat. Many of the actions would take place in designated critical habitat.

Detailed habitat information (e.g., migration barriers, physical and biological habitat features, and special management considerations) for species considered in this opinion may be found in the Federal Register notices designating critical habitat for LCR Chinook Salmon, UWR Chinook Salmon, CR chum salmon, LCR steelhead, and UWR steelhead (70 FR 52630); LCR coho salmon (81 FR 9251); OC coho salmon (73 FR 7816); S eulachon (76 FR 65324); and S green sturgeon (74 FR 52300).

2.4 Environmental Baseline

The “environmental baseline” includes past and present impacts of all Federal, state, or private actions and other human activities in the action area, anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and impacts of state or private actions that 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 much of the listed species’ ranges in Oregon and Washington (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 the majority of the work being contemplated here, the physical result of activities in the action area are indistinguishable from those effects described in the previous section on the species’ rangewide status. With respect to the species’ habitat, the environmental baseline is the culmination of these effects on the PBFs that are essential to the conservation of the species. However, in those instances where the action area can be narrowed for a more specific analysis, the baseline in those areas will be taken fully into account.

2.4.1 Summary for all Listed Species

2.4.1.1 Factors Limiting Recovery

The best scientific information presently available demonstrates that multiple factors have contributed to the decline of west coast salmonids. NMFS’ status reviews, Technical Recovery Team publications, and recovery plans for the listed species in this opinion identify factors that have caused decline and factors that prevent recovery. 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 25 is a summary of the major factors limiting recovery of the species considered in this opinion; more details are in the individual discussions of the species’ status. None of the references cited in previous sections identify scientific research as a factor associated with the decline or recovery potential of west coast salmonids.

Table 25. Major Factors Limiting Recovery. (Adapted from NOAA, NMFS, 2005 Report to Congress: Pacific Coast Salmon Recovery Fund FY 2000-2004, 51p. July 2005.)

	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
LCR Chinook	●	●	●	●	●		●	●		
UWR Chinook		●	●			●	●			
CR Chum	●	●	●	●	●		●			
LCR Coho		●	●	●	●	●		●		
OC Coho		●	●	●	●	●			●	
LCR Steelhead		●	●	●	●	●	●		●	
UWR Steelhead		●	●		●		●			
S. DPS Green Sturgeon	●	●	●	●	●	●	●			
S. DPS Eulachon				●		●	●	●	●	

For detailed information on how various factors have degraded PCEs in the Idaho, Oregon, and Washington see 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 (2010), Stout et al. (2011), Weitkamp et al. (1995), Ford et al. 2010, and WDFW (2010).

Research Effects

Although it has never been identified as a factor for decline or a threat preventing recovery, scientific research has the potential to affect the species' survival and recovery by killing listed fish. Several dozen section 10(a)(1)(A) scientific research permits have already been authorized, permitting lethal and non-lethal take of listed salmonids, eulachon, and green sturgeon in the Pacific Northwest. In addition, NMFS has re-authorized state scientific research programs for Oregon, Washington, and Idaho under ESA section 4(d). Table 26 summarizes the previously authorized take for research permits in 2017.

Table 26. Previously Authorized Take of Salmon, Steelhead, green sturgeon, and eulachon for Scientific Research and Monitoring in 2017.

DPS/ESU	Origin	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
CR Chum	Natural	49	1	22,618	296
	Listed Hatchery Intact Adipose	0	0	536	5
LCR Chinook	Natural	1,202	12	1,152,139	13,889
	Listed Hatchery Intact Adipose	76	2	619	5
	Listed Hatchery Adipose Clip	1,344	9	82,805	1,534

DPS/ESU	Origin	Adults Handled	Adults Killed	Juveniles Handled	Juveniles Killed
LCR Coho	Natural	3,257	31	220,243	2,540
	Listed Hatchery Intact Adipose	290	4	2547	19
	Listed Hatchery Adipose Clip	3,488	57	67,335	1,133
LCR Steelhead	Natural	3,544	34	56,296	792
	Listed Hatchery Adipose Clip	147	4	51,266	1,016
OC Coho	Natural	25,983	110	786,837	13,993
	Listed Hatchery Adipose Clip	223	0	720	23
UWR Chinook	Natural	271	3	48,839	701
	Listed Hatchery Intact Adipose	0	0	96	1
	Listed Hatchery Adipose Clip	343	5	,9589	139
UWR Steelhead	Natural	257	2	7,278	164
Green sturgeon	Natural	509	6	4,361	311
Eulachon	Natural	9,845	7,180	325	226

Actual take levels associated with research activities are almost certain to be 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 thus it is likely that fewer fish than authorized would be killed during any given research project.

2.5 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.

2.5.1 Effects on Critical Habitat

We describe the effects of the proposed activities in detail in the following section. In general, the activities would be (1) electrofishing, (2) capturing fish with angling equipment, traps, and nets of various types, (3) sampling tissues from live fish, and (4) tagging fish. These techniques are minimally intrusive in terms of their effect on habitat because they would involve little, if any, disturbance of streambeds or adjacent riparian zones. None of the activities will measurably affect any habitat PBF listed earlier. Moreover, the proposed activities are all of short duration. Therefore, we conclude that the proposed activities are not likely to have an adverse impact on any designated critical habitat.

2.5.2 Effects on the Species

As discussed above, the proposed research activities will have no measurable effects on the habitat of listed salmonids, eulachon, or green sturgeon. The actions are therefore not likely to affect measurably any of the listed species by reducing their habitat's ability 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 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, populations, and species.

The following subsections describe the types of activities being proposed. We describe the activities 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.

Observation

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 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 traps and nets are not tended 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 traps are not monitored regularly. The permit conditions identified 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. 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.

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). 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.

Angling

Fish caught with hook and line and released alive may still die due to injuries and stress they experience during capture and handling. Angling-related mortality rates vary depending on the type of hook (barbed vs barbless), the type of bait (natural vs artificial), water temperature, anatomical hooking location, species, and the care with which fish are handled and 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.

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.

2.5.3 Species-specific Effects of Each Permit

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 27 displays the estimated annual abundance of hatchery-propagated and naturally produced listed salmonids.

Table 27. Estimated Annual Abundance of Salmonids, Eulachon, and Green Sturgeon.

Species	Life Stage	Origin/Production		
		Natural	Listed Hatchery Intact Adipose*	Listed Hatchery Adipose Clip*
LCR Chinook	Adult	29,469	38,594	
	Smolt	12,427,062	1,130,182	34,347,631
UWR Chinook	Adult	11,443	34,454	
	Smolt	1,287,502	36,253	5,850,595
CR Chum	Adult	10,644	426	
	Smolt	4,093,920	662,814	0
LCR Coho	Adult	32,986	23,082	
	Smolt	619,576	239,784	7,514,080
OC Coho	Adult	234,203	2,046	
	Parr	16,394,210	60,000	0
LCR Steelhead	Adult	12,920	22,297	
	Smolt	351,966	12,449	1,134,744
UWR Steelhead	Adult	5,971		
	Smolt	163,084		
Eulachon	Adult	81,736,000		
Green Sturgeon	Adult	1,348		

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

Wherever possible in our analysis, we tied the effects of each proposed action to impacts on populations or groups of populations. In some instances, the nature of the project (i.e., it is broadly distributed or in marine habitat) was such that the take could not be assigned reliably to any population or group of populations. In those cases, effect of the action are measured in terms of impact on the relevant species' total abundance by origin (Natural) and production [Listed Hatchery Adipose Clip (LHAC) and Listed Hatchery Intact Adipose (LHIA)].

2.5.3.1 Permit 1135-9R

The USGS is seeking to renew for five years a research permit that currently allows them to take juvenile LCR steelhead in the Wind River subbasin (Washington). The purpose of the study is to provide information on the growth, survival, habitat use, and life-histories of LCR steelhead. The USGS would capture juvenile LCR steelhead using backpack electrofishing equipment, hold the fish in aerated buckets, anaesthetize them with MS-222, measure length and weight, tag age-0 and age-1 fish with passive integrated transponders (PIT-tags), and release all fish at the site of collection after they recover from anesthesia. The researchers do not propose to kill any fish but a small number may die as an unintended result of research activities (Table 28).

Table 28. Requested Take for Permit 1135-9R. 'Unintentional Mortalities' are also counted in the 'Requested Take' column, i.e., in row 1, up to 75 of 2500 juveniles taken would be expected to die as a result of research activities.

ESU/DPS	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortalities
LCR Steelhead	Juvenile	Natural	Capture/Handle/Release Fish	2,500	75
LCR Steelhead	Juvenile	Natural	Capture/Mark, Tag, Sample Tissue/Release Live Animal	3,500	105

Given the USGS' proposed research methods, we expect at least 97% of the fish captured during research activities to survive with no long-term consequences. To determine the effects of the research, we compared the numbers of fish that may be killed to the abundance of naturally produced juveniles that we expect at the population and DPS scales. Direct measurements of juvenile steelhead abundance are not available for the Wind River. We estimated average smolt abundance for the Wind River as the *0.5 x number of spawners x fecundity x egg-to-smolt survival rate*, using assumptions that half of the escapement was female and prespawn mortality was zero. Using data for the naturally produced escapement in the Wind River (763 spawners, Table 18) and other parameters (4923 eggs/female x 0.04 smolts/egg) from Quinn (2005) we estimated average smolt abundance for the Wind River to be approximately 26,294. Average smolt abundance for the DPS (2012-2016) was 351,966 (Table 19).

The proposed research would kill up to 180 juveniles, which we estimated to be 0.7% of the Wind River population and 0.05% of the LCR steelhead DPS annually (Table 29). Therefore, the proposed research would have a small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity. The USGS has requested what they expect would be the maximum possible amount of take. Likely, they will catch far fewer fish. Annual reports for the project show that in the last eight years the USGS killed between 0 and 31% of the levels authorized, so actual effects at the population and DPS scales are likely to be smaller than described above. In addition, the proposed research would benefit salmonid recovery planning by providing information on growth, survival, habitat use, and life histories of LCR steelhead in the Wind River subbasin.

Table 29. Percent of the Average Abundance (2012-2016) Potentially Taken or Killed by Activities Conducted Under Permit 1135-9R.

Life Stage	Origin	Total Take	Percent of Population Handled	Percent of DPS Handled	Total Lethal Take	Percent of Population Killed	Percent of DPS Killed
Juvenile	Natural	6,000	22.8%	1.7%	180	0.7%	0.05%

2.5.3.2 Permit 1175-9R

The Gifford Pinchot National Forest (GPNF) is seeking to renew for five years a permit that currently allows them to take juvenile LCR Chinook salmon, LCR coho salmon, and LCR steelhead in the Cowlitz and Middle Columbia-Hood subbasins (Washington). The purpose of the research is to describe fish species presence, distribution, spawning areas, and habitat conditions. The GPNF proposes to use backpack electrofishing, seines, and angling to capture juvenile salmonids, hold fish for short periods in aerated buckets, identify, and then release the fish. The researchers do not propose to kill any fish, but a small number may die as an unintentional result of research activities (Table 30).

Table 30. Requested Take for Permit 1175-9R. 'Unintentional Mortalities' are also counted in the 'Requested Take' column.

ESU/DPS	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortalities
LCR Chinook	Juvenile	Natural	Capture/Handle/Release Fish	50	3
LCR Steelhead	Juvenile	Natural	Capture/Handle/Release Fish	300	14
LCR Coho	Juvenile	Natural	Capture/Handle/Release Fish	300	14

Given the GPNF's proposed research methods, we expect at least 94% of the fish captured during research activities to survive with no long-term consequences. To determine the effects of the research, we compared the numbers of fish that may be killed to the abundance of naturally produced juveniles that we expect to occur at the "population group" scale and ESU/DPS scales. The population groups analyzed for LCR Chinook, LCR steelhead, and LCR coho are the subset of populations in an ESU/DPS that could be affected by the proposed research. Direct measurements of juvenile salmonid abundance are not available but estimates of adult abundance are available at the population scale. So we estimated juvenile abundance for each population by assuming that the ratio of population:ESU or population:DPS abundance is the same for juveniles as it is for adults.

The GPNF's proposed research has the potential to affect all populations of LCR Chinook except those in the Sandy, Clackamas, and Hood Rivers, and those in the Coast fall Chinook Stratum. For the potentially affected populations of LCR Chinook (24,588 natural origin spawners, Table 2) we estimated average annual smolt abundance to be 83% of the ESU total, or 10,368,747. Average abundance of natural origin smolts at the ESU scale was 12,427,062 (Table 3). The proposed research would kill up to 3 smolts, which we estimated to be 0.00003% of the smolts in the potentially affected populations, and 0.00002% of smolts in the LCR Chinook ESU annually (Table 31).

The GPNF's proposed research has the potential to affect all populations of LCR steelhead except those in the Sandy, Clackamas, and Hood Rivers. For the potentially affected populations of LCR steelhead (4,824 natural origin spawners, Table 18), we estimated average annual smolt abundance to be 37% of the DPS total, or 131,415. Average abundance of natural origin smolts at the DPS scale was 351,966 steelhead (Table 19). The proposed research would kill up to 14 smolts, which we estimated to be 0.01% of smolts in the potentially-affected populations and 0.004% of smolts in the LCR steelhead DPS annually (Table 31).

The GPNF's proposed research has the potential to affect all populations of LCR coho except the Sandy, Clackamas, and 'Oregon Upper Gorge tributaries and Hood River early coho' populations. For the potentially affected populations of LCR coho (25,892 natural origin spawners, Table 13), we estimated average annual smolt abundance to be 68% of the ESU total, or 420,643. Average abundance of natural-origin smolts at the ESU scale was 619,576 coho

(Table 14). The proposed research would kill up to 14 smolts, which we estimated to be 0.003% of smolts in the potentially-affected populations and 0.002% of smolts in the LCR coho ESU annually (Table 31).

Table 31. Percent of the Average Abundance (2012-2016) of Naturally Produced Juvenile Salmonids Potentially Handled or Killed by Activities Conducted Under Permit 1175-9R.

ESU/DPS	Total Take	Percent of Potentially-Affected Populations Handled	Percent of ESU/DPS Handled	Total Lethal Take	Percent of Potentially-Affected Populations Population Killed	Percent of ESU/DPS Killed
LCR Chinook	50	0.0005%	0.0004%	3	0.00003%	0.00002%
LCR Steelhead	300	0.22%	0.09%	14	0.01%	0.004%
LCR Coho	300	0.07%	0.05%	14	0.003%	0.002%

The proposed research would have a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity for LCR Chinook, LCR steelhead, and LCR coho. The GPNF has requested what they expect would be the maximum possible amount of take. Annual reports for this project show that they tend to catch far fewer fish than authorized. In the past nine years, the GPNF has not captured any juvenile LCR Chinook. In the same timeframe, the GPNF reported no unintentional mortalities and their nonlethal take ranged from 0-7% of levels authorized for LCR steelhead and 0-26% of levels authorized for LCR coho; therefore, the actual effects of the proposed research are likely to be negligible. In addition, the proposed research would benefit listed salmonids by providing the GPNF with information to improve forest management, habitat restoration, and species recovery efforts.

2.5.3.3 Permit 1345-8R

The WDFW is seeking to renew for five years a research permit that currently allows them to take juvenile and adult LCR Chinook salmon, LCR coho salmon, and LCR steelhead. The purpose of the WDFW study is to assess inland game fish communities to aid in fishery management. The WDFW proposes to capture fish using boat electrofishing, fyke nets, and gillnets. After capture, listed salmon and steelhead would be held in aerated live wells, identified, and released. The researchers do not propose to kill any listed fish, but a small number may die as an unintended result of the activities (Table 32).

Table 32. Requested Take for Permit 1345-8R. 'Unintentional Mortalities' are also counted in the 'Requested Take' column.

ESU/DPS	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortalities
LCR Chinook	Adult	Natural	Capture/Handle/Release	6	0
		Listed Hatchery Adipose Clip	Capture/Handle/Release	6	0
	Juvenile	Natural	Capture/Handle/Release	30	2
		Listed Hatchery Adipose Clip	Capture/Handle/Release	30	2
LCR Coho	Adult	Natural	Capture/Handle/Release	6	0
		Listed Hatchery Adipose Clip	Capture/Handle/Release	6	0
	Juvenile	Natural	Capture/Handle/Release	30	2
		Listed Hatchery Adipose Clip	Capture/Handle/Release	30	2
LCR Steelhead	Adult	Natural	Capture/Handle/Release	6	0
		Listed Hatchery Adipose Clip	Capture/Handle/Release	6	0
	Juvenile	Natural	Capture/Handle/Release	30	2
		Listed Hatchery Adipose Clip	Capture/Handle/Release	30	2

Given the research methods proposed in the WDFW's permit application, we expect all adults and at least 93% of the small number of juveniles captured during research activities to survive with no long-term consequences. Research activities would occur throughout the Lower Columbia River region and so we cannot describe effects at the population scale. To determine the effects of the research, we compared the requested take and unintentional mortality rates (Table 32) to ESU/DPS abundance by life stage and origin (Table 27). We used the total count reported for all hatchery-origin adults and the ratio of adipose-clipped hatchery juveniles relative to all hatchery-origin juveniles (Table 27) to estimate the number of adipose-clipped, hatchery-origin adults.

For LCR Chinook, the proposed research would not kill any adults and would kill up to 2 juveniles (0.00002%) of natural origin and 2 adipose-clipped juveniles (0.000006%) of hatchery origin in the ESU annually. For LCR coho, the proposed research would not kill any adults and would kill up to 2 juveniles (0.0003%) of natural origin and 2 adipose-clipped juveniles (0.00003%) of hatchery origin in the ESU annually. For LCR steelhead, the proposed research would not kill any adults and would kill up to 2 juveniles (0.0006%) of natural origin and 2 adipose-clipped juveniles (0.0002%) of hatchery origin in the DPS annually (Table 33).

Table 33. Percent of the ESU/DPS Potentially Handled or Killed by Activities Conducted Under Permit 1345-8R.

ESU/DPS	Life Stage	Origin	Total Take	Percent of ESU/DPS Handled	Total Lethal Take	Percent of ESU/DPS Killed
LCR Chinook	Adult	Natural	6	0.02%	0	0
		Listed Hatchery Adipose Clip	6	0.02%	0	0
	Juvenile	Natural	30	0.0002%	2	0.00002%
		Listed Hatchery Adipose Clip	30	0.00009%	2	0.000006%
LCR Coho	Adult	Natural	6	0.02%	0	0
		Listed Hatchery Adipose Clip	6	0.03%	0	0
	Juvenile	Natural	30	0.005%	2	0.0003%
		Listed Hatchery Adipose Clip	30	0.0004%	2	0.00003%
LCR Steelhead	Adult	Natural	6	0.05%	0	0
		Listed Hatchery Adipose Clip	6	0.03%	0	0
	Juvenile	Natural	30	0.009%	2	0.0006%
		Listed Hatchery Adipose Clip	30	0.003%	2	0.0002%

The proposed research would have a negligible impact on abundance, productivity, spatial structure, and diversity for LCR Chinook, LCR coho, and LCR steelhead. The WDFW has requested what they expect would be the maximum possible amount of take. Annual reports show that during the past 5 years under this permit, the WDFW reported take for LCR Chinook, LCR steelhead, or LCR coho only once, when they inadvertently killed 17 adipose-clipped coho in a gill net in a lake where ESA listed fish species were not thought to be present. Actual take levels for this permit are likely to be less than the levels analyzed here. In addition, the research would benefit salmonids by helping managers write warmwater fish harvest regulations that reduce potential impacts on listed salmonids.

2.5.3.4 Permit 1386-9R

The WDOE is seeking to renew for five years a research permit that currently allows them to take juvenile and adult LCR Chinook salmon, CR chum salmon, LCR coho salmon, and LCR steelhead in the state of Washington. The purpose of the research is to investigate the occurrence and concentrations of toxic contaminants in non-anadromous freshwater fish tissue, sediment, and water, in order to meet Federal and state regulatory requirements. The WDOE proposes to capture fish using backpack and boat electrofishing, beach seining, block, fyke, and gill netting, and angling. All captured salmon and steelhead would be released immediately or held temporarily in an aerated live well before release. The researchers do not propose to kill any fish but a small number may die as an unintended result of research activities (Table 34).

Table 34. Requested Take for Permit 1386-9R. 'Unintentional Mortalities' are also counted in the 'Requested Take' column.

ESU/DPS	Life Stage	Origin	Take Activity	Requested Take	Unintentional Mortalities
LCR Chinook	Adult	Natural	Capture/Handle/Release	5	0
		Listed Hatchery Adipose Clip	Capture/Handle/Release	5	0
	Juvenile	Natural	Capture/Handle/Release	10	1
		Listed Hatchery Adipose Clip	Capture/Handle/Release	10	1
CR Chum	Adult	Natural	Capture/Handle/Release	5	0
	Juvenile	Natural	Capture/Handle/Release	10	1
LCR Coho	Adult	Natural	Capture/Handle/Release	5	0
		Listed Hatchery Adipose Clip	Capture/Handle/Release	10	1
	Juvenile	Natural	Capture/Handle/Release	10	1
		Listed Hatchery Adipose Clip	Capture/Handle/Release	20	1
LCR Steelhead	Adult	Natural	Capture/Handle/Release	5	0
		Listed Hatchery Adipose Clip	Capture/Handle/Release	5	0
	Juvenile	Natural	Capture/Handle/Release	10	1
		Listed Hatchery Adipose Clip	Capture/Handle/Release	10	1

Given the research methods proposed in the WDOE's permit application, we expect all adults and at least 90% of the small numbers of juveniles captured during research activities to survive with no long-term consequences. Research activities would occur throughout the Lower Columbia River region in Washington and so we cannot describe effects at the populations scale. To determine the effects of the research, we compared the requested take and unintentional mortality rates (Table 34) to ESU/DPS abundance by life stage and origin (Table 27). We used the total count reported for all hatchery-origin adults and the ratio of adipose-clipped hatchery juveniles relative to all hatchery-origin juveniles (Table 27) to estimate the number of adipose-clipped, hatchery-origin adults.

For LCR Chinook, the proposed research would not kill any adults and would kill up to 1 juvenile (0.000008%) of natural origin and 1 adipose-clipped juvenile (0.000003%) of hatchery origin in the ESU annually. For CR chum, the proposed research would not kill any adults and would kill up to 1 natural-origin juvenile (0.00002%) in the ESU annually. For LCR coho, the proposed research would not kill any adults and would kill up to 1 juvenile (0.0002%) of natural origin and 1 adipose-clipped juvenile (0.00001%) of hatchery origin in the ESU annually. For LCR steelhead, the proposed research would not kill any adults and would kill up to 1 juvenile (0.0003%) of natural origin and 1 adipose-clipped juvenile (0.00009%) of hatchery origin in the DPS annually (Table 35).

Table 35. Percent of the ESU/DPS Potentially Handled or Killed by Activities Conducted Under Permit 1386-9R.

ESU/DPS	Life Stage	Origin	Total Take	Percent of ESU/DPS Handled	Total Lethal Take	Percent of ESU/DPS Killed
LCR Chinook	Adult	Natural	5	0.01697%	0	0
		Listed Hatchery Adipose Clip	5	0.01296%	0	0
	Juvenile	Natural	10	0.00008%	1	0.000008%
		Listed Hatchery Adipose Clip	10	0.00003%	1	0.000003%
CR Chum	Adult	Natural	5	0.04697%	0	0
	Juvenile	Natural	10	0.00024%	1	0.00002%
LCR Coho	Adult	Natural	5	0.01516%	0	0
		Listed Hatchery Adipose Clip	10	0.04471%	1	0.005%
	Juvenile	Natural	10	0.00161%	1	0.0002%
		Listed Hatchery Adipose Clip	20	0.00027%	1	0.00001%
LCR Steelhead	Adult	Natural	5	0.03870%	0	0
		Listed Hatchery Adipose Clip	5	0.02267%	0	0
	Juvenile	Natural	10	0.00284%	1	0.0003%
		Listed Hatchery Adipose Clip	10	0.00088%	1	0.00009%

The proposed research would have a very small impact on abundance, a similarly small impact on productivity, and no measureable effect on spatial structure or diversity of LCR Chinook, CR chum, LCR coho, and LCR steelhead. The WDOE has requested what they expect would be the maximum possible amount of take. Annual reports show that from 2008-2015, the WDOE did not capture any listed fish while conducting work for this project. The research would benefit salmonids by helping managers write warmwater fish harvest regulations that reduce potential impacts on listed salmonids.

2.5.3.5 Permit 1598-4R

The WSDOT is seeking to renew for five years a research permit that currently allows them to take juvenile, LCR Chinook salmon, CR chum salmon, LCR coho salmon, and LCR steelhead. Sample sites would be located throughout the state of Washington. WSDOT proposes to capture fish using dip nets, stick seines, minnow traps, or backpack electrofishing, and then identify and release the fish. The researchers do not propose to kill any listed fish, but a small number may die as an unintended result of the activities (Table 36).

Table 36. Requested Take for Permit 1598-4R. 'Unintentional Mortalities' are also counted in the 'Requested Take' column.

ESU/DPS	Life Stage	Origin	Take Activity	Requested Take	Potential Mortalities
LCR Chinook	Juvenile	Natural	Capture/Handle/Release	6	1
		Capture/Handle/Release	Capture/Handle/Release	12	1
CR Chum	Juvenile	Natural	Capture/Handle/Release	30	1
LCR Coho	Juvenile	Natural	Capture/Handle/Release	30	1
		Listed Hatchery Adipose Clip	Capture/Handle/Release	30	1
LCR Steelhead	Juvenile	Natural	Capture/Handle/Release	5	1
		Listed Hatchery Adipose Clip	Capture/Handle/Release	10	1

Given the research methods proposed in the WSDOT's permit application, we expect that a very small number of juveniles would be captured and the majority of these (at least 80%) would survive with no long-term consequences. Research activities would occur throughout the Lower Columbia River region in Washington and so we cannot describe effects at the populations scale. To determine the effects of the research, we compared the requested take and unintentional mortality rates (Table 36) to ESU/DPS abundance by life stage and origin (Table 27).

The researchers do not propose to take any adult fish. For LCR Chinook, the proposed research would kill up to 1 juvenile (0.000008%) of natural origin and 1 adipose-clipped juvenile (0.000003%) of hatchery origin in the ESU annually. For CR chum, the proposed research would kill up to 1 natural-origin juvenile (0.00002%) in the ESU annually. For LCR coho, the proposed research would kill up to 1 juvenile (0.0002%) of natural origin and 1 adipose-clipped juvenile (0.00001%) of hatchery origin in the ESU annually. For LCR steelhead, the proposed research would kill up to 1 juvenile (0.0003%) of natural origin and 1 adipose-clipped juvenile (0.00009%) of hatchery origin in the DPS annually (Table 37).

Table 37. Percent of the ESU/DPS Potentially Handled or Killed by Activities Conducted Under Permit 1598-4R.

ESU/DPS	Life Stage	Origin	Total Take	Percent of ESU/DPS Handled	Total Lethal Take	Percent of ESU/DPS Killed
LCR Chinook	Juvenile	Natural	6	0.00005%	1	0.000008%
		Listed Hatchery Adipose Clip	12	0.00003%	1	0.000003%
CR Chum	Juvenile	Natural	30	0.0007%	1	0.00002%
LCR Coho	Juvenile	Natural	30	0.005%	1	0.0002%
		Listed Hatchery Adipose Clip	30	0.0004%	1	0.00001%
LCR Steelhead	Juvenile	Natural	5	0.001%	1	0.0003%
		Listed Hatchery Adipose Clip	10	0.0009%	1	0.00009%

The proposed research would have a negligible impact on abundance, productivity, spatial structure, and diversity of LCR Chinook, CR chum, LCR coho, and LCR steelhead. The WSDOT has requested what they expect would be the maximum possible amount of take.

Annual reports show that from 2008-2015 the WSDOT did not capture any listed fish while conducting work for this project. The research would benefit the listed species by helping WSDOT assess and minimize transportation project impacts on listed fish.

2.5.3.6 Permit 16069-3R

The City of Portland is seeking to renew for five years a research permit that currently allows them to take juvenile and adult LCR Chinook salmon, LCR coho salmon, LCR steelhead, CR chum salmon, UWR Chinook salmon, UWR steelhead, OC coho salmon, and S green sturgeon in the Columbia and Willamette rivers and tributaries (Oregon). The proposed research may also cause take of adult S eulachon, for which there are currently no ESA take prohibitions. The City of Portland proposes to capture juvenile fish using backpack and boat electrofishing, hold fish in a bucket of aerated water, take caudal fin clips for genetic analysis, and release fish. The researchers would avoid contact with adult fish. The researchers do not propose to kill any fish but a small number may die as an unintended result of research activities (Table 38).

Table 38. Requested Take for Permit 16069-3R. 'Unintentional Mortalities' are also counted in the 'Requested Take' column. Take Activities include Capture (C), Handle (H), Mark, Tag, Sample Tissue (M,T,S), and Release (R).

ESU/DPS	Life Stage	Origin	Take Activity	Requested Take	Potential Mortalities
LCR Chinook	Adult	Natural	C/H/R	3	0
		Listed Hatchery Adipose Clip	C/H/R	3	0
	Juvenile	Natural	C/M,T,S/R	300	9
		Listed Hatchery Adipose Clip	C/M,T,S/R	310	9
UWR Chinook	Adult	Natural	C/H/R	3	0
		Listed Hatchery Adipose Clip	C/H/R	3	0
	Juvenile	Natural	C/M,T,S/R	150	5
	Juvenile	Listed Hatchery Adipose Clip	C/M,T,S/R	190	6
CR chum		Natural	C/M,T,S/R	40	2
LCR coho	Adult	Natural	C/H/R	3	0
		Listed Hatchery Adipose Clip	C/H/R	3	0
	Juvenile	Natural	C/M,T,S/R	290	9
	Juvenile	Listed Hatchery Adipose Clip	C/M,T,S/R	325	10
LCR steelhead	Adult	Natural	C/H/R	3	0
	Adult	Listed Hatchery Adipose Clip	C/H/R	3	0
	Juvenile	Natural	C/M,T,S/R	250	8
	Juvenile	Listed Hatchery Adipose Clip	C/M,T,S/R	245	8
UWR steelhead	Adult	Natural	C/H/R	3	0
	Juvenile	Natural	C/M,T,S/R	150	1
Sturgeon, green	Adult	Natural	C/H/R	1	0
Eulachon	Adult	Natural	C/H/R	20	1

The action area for this project is the Columbia and Willamette rivers and tributaries in Portland, Oregon. Given the research methods proposed by the City of Portland, we expect all adults and at least 96% of the juveniles captured during research activities to survive with no long-term consequences. Fish captured could come from all populations within each ESU/DPS. To determine the effects of the research, we compared the requested take and unintentional mortality rates (Table 38) to ESU/DPS abundance by life stage and origin (Table 27). We used the total count reported for all hatchery-origin adults and the ratio of adipose-clipped hatchery juveniles relative to all hatchery-origin juveniles (Table 27) to estimate the number of adipose-clipped, hatchery-origin adults.

For all combinations of ESU/DPS, life stage, and origin, fewer than 0.05% of the fish would be handled. The proposed research activities would kill no more than 0.002% of the natural components and 0.0007% of the listed hatchery components of LCR Chinook salmon, CR chum salmon, LCR coho salmon, and LCR steelhead. The permitted activities would kill an even smaller percentage of the expected abundance of green sturgeon and eulachon (Table 39).

The proposed research would have a negligible impact on the abundance, productivity, spatial structure and diversity of these species. The City of Portland requested what they expect would be the maximum possible amount of take. Annual reports show that from 2012-2015 the City of Portland never exceeded 17% of permitted levels for lethal take, and typically during sampling they encountered few or no listed fish. The research would benefit the species by providing information to assess watershed health, freshwater habitat, effectiveness of restoration actions, and compliance with regulatory requirements.

Table 39. Percent of the ESU/DPS Potentially Handled or Killed by Activities Conducted Under Permit 16069-3R.

ESU/DPS	Life Stage	Origin	Total Take	Percent of ESU/DPS Handled	Total Lethal Take	Percent of ESU/DPS Killed
LCR Chinook	Adult	Natural	3	0.01%	0	0
	Adult	Listed Hatchery Adipose Clip	3	0.008%	0	0
	Juvenile	Natural	300	0.002%	9	0.00007%
	Juvenile	Listed Hatchery Adipose Clip	310	0.0009%	9	0.00003%
UWR Chinook	Adult	Natural	3	0.03%	0	0
	Adult	Listed Hatchery Adipose Clip	3	0.009%	0	0
	Juvenile	Natural	150	0.01%	5	0.0004%
	Juvenile	Listed Hatchery Adipose Clip	190	0.003%	6	0.0001%
CR chum	Juvenile	Natural	40	0.001%	2	0.00005%
LCR coho	Adult	Natural	3	0.009%	0	0
	Adult	Listed Hatchery Adipose Clip	3	0.01%	0	0
	Juvenile	Natural	290	0.05%	9	0.001%
	Juvenile	Listed Hatchery Adipose Clip	325	0.004%	10	0.0001%
LCR steelhead	Adult	Natural	3	0.02%	0	0
	Adult	Listed Hatchery Adipose Clip	3	0.01%	0	0
	Juvenile	Natural	250	0.07%	8	0.002%
	Juvenile	Listed Hatchery Adipose Clip	245	0.02%	8	0.0007%
UWR steelhead	Adult	Natural	3	0.03%	0	0
	Juvenile	Natural	150	0.0001%	1	0.0000008%
Sturgeon, green	Adult	Natural	1	0.0007%	0	0
Eulachon	Adult	Natural	20	0.0000002%	1	0.00000001%

2.5.3.7 Permit 16666-2R

The FWS is seeking to renew for five years a research permit that currently allows them to take juvenile LCR coho salmon and adult LCR Chinook salmon in Abernathy Creek (Washington). The goal of this research is to determine the natural reproductive success and relative fitness of hatchery origin and natural-origin steelhead and assess the demographic effects of hatchery fish supplementation in Abernathy Creek relative to two adjacent control streams. Steelhead are not listed in these streams, but the FWS have captured juvenile LCR coho salmon and observed adult LCR Chinook salmon in previous years. The FWS proposes to capture, handle, and release juvenile LCR coho salmon during backpack electrofishing surveys. The researchers would avoid electrofishing near adult coho and Chinook salmon. The researchers do not expect to kill any listed fish, but a small number may die as an unintended result of the research activities (Table 40).

Table 40. Requested Take for Permit 16666 (O/H=observe/harass, C/H/R=capture, handle, release).

ESU/DPS	Life Stage	Origin	Take Activity	Requested Take	Potential Mortalities
LCR Chinook	Adult	Natural	Observe/Harass	20	0
	Adult	Natural	Capture/Handle/Release	1	0
LCR Coho	Juvenile	Natural	Capture/Handle/Release	2000	20

Given the FWS' proposed research methods, we expect at least 99% of the fish captured during research activities to survive with no long-term consequences. To determine the effects of the research, we compared the number of naturally produced juvenile coho that may be killed to the abundance at the population and DPS scales. For the years 2012 to 2016, WDFW estimated abundance of coho smolts in Abernathy Creek to range from 3319 to 8106 (mean 6,049; WDFW 2012, 2013, 2014, 2015, and 2016). LCR coho abundance at the ESU scale was 619,576 (Table 27). Thus the permitted activities may kill at most 0.3% of LCR coho smolts in Abernathy Creek and 0.003% of LCR coho smolts in the ESU. The FWS does not expect to kill any LCR Chinook salmon.

The proposed research would have a very small impact on the species' abundance and productivity and no measureable effect on spatial structure or diversity. The FWS requested what they expect would be the maximum possible amount of take. Annual reports show that from 2012-2016 the FWS captured 0-67% of the levels permitted and they did not kill any listed fish while conducting work for this project. The research would benefit listed salmonids by producing data to be used in hatchery and genetic management plans.

Table 41. Percent of LCR coho in Abernathy Creek and in the ESU Potentially Handled or Killed by Activities Conducted Under Permit 16666-2R.

ESU/DP/S	Life Stage	Origin	Total Take	Percent of Population Handled	Percent of ESU Handled	Total Lethal Take	Percent of Population Killed	Percent of ESU Killed
LCR coho	Juvenile	Natural	2000	33.1%	0.3%	20	0.3%	0.003%

2.5.3.8 Permit 20492

The ODFW is seeking to renew for five years a permit (previous permit 1318-9R) for research in the Willamette and Columbia basins (Oregon) and on the Oregon coast. ODFW proposes to take juvenile LCR Chinook salmon, LCR coho salmon, LCR steelhead, CR chum salmon, UWR Chinook salmon, UWR steelhead, OC coho salmon, and adult S green sturgeon. The ODFW research may also cause them to take adult S eulachon, for which there are currently no ESA take prohibitions. Section 7 Consultation Number WCR-2017-6413 described effects of the ODFW's proposed research on UCR spring-run Chinook salmon, UCR steelhead, SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, SR Basin steelhead, SR sockeye salmon, MCR steelhead. The new permit would cover the following projects: (1) Warmwater and Recreational Game Fish Management, (2) District Fish Population Sampling in the Upper Willamette Basin, and (3) Salmonid Assessment and Monitoring in the Deschutes River. Juvenile salmonids would be collected using boat electrofishing. Some fish would be anesthetized, sampled for length and weight, allowed to recover from the anesthesia, and released. Most salmonids would be allowed to swim away after being electroshocked, or they would be netted and released immediately. The ODFW does not intend to kill any of the fish being captured, but a small number may die as an unintended result of the activities (Table 42).

Table 42. Requested Take for Permit 20492 (C=capture, H=handle, R=release). 'Unintentional Mortalities' are also counted in the 'Requested Take' column.

ESU/DPS	Life Stage	Origin	Take Activity	Requested Take	Potential Mortalities
LCR Chinook	Juvenile	Natural	C/H/R	395	10
	Juvenile	Listed Hatchery Adipose Clip	C/H/R	120	6
	Juvenile	Listed Hatchery Intact Adipose	C/H/R	120	6
UWR Chinook	Juvenile	Natural	C/H/R	220	10
	Juvenile	Listed Hatchery Adipose Clip	C/H/R	250	11
CR Chum	Juvenile	Listed Hatchery Adipose Clip	C/H/R	50	2
LCR Coho	Juvenile	Natural	C/H/R	150	6
	Juvenile	Listed Hatchery Adipose Clip	C/H/R	340	16
	Juvenile	Listed Hatchery Intact Adipose	C/H/R	45	2
OC Coho	Juvenile	Natural	C/H/R	500	25
LCR Steelhead	Juvenile	Natural	C/H/R	60	3
	Juvenile	Listed Hatchery Adipose Clip	C/H/R	120	4
UWR Steelhead	Juvenile	Natural	C/H/R	60	3
S eulachon	Adult	Natural	C/H/R	5	1
S green sturgeon	Adult	Natural	C/H/R	5	1

Given the research methods proposed by ODFW, we expect all adults and at least 95% of the juveniles captured during research activities to survive with no long-term consequences. Fish captured could come from any population within each ESU/DPS. To determine the effects of the research, we compared the requested take and unintentional mortality rates (Table 42) to ESU/DPS abundance by life stage and origin (Table 27). We used the total count reported for all hatchery-origin adults and the ratio of adipose-clipped hatchery juveniles relative to all hatchery-origin juveniles (Table 27) to estimate the number of adipose-clipped, hatchery-origin adults.

For all combinations of ESU/DPS, life stage, and origin, less than 0.02% of the fish would be handled. The proposed research activities would kill no more than 0.001% of the natural components and 0.0008% of the listed hatchery components of LCR Chinook salmon, UWR Chinook salmon, CR chum salmon, LCR coho salmon, OC coho salmon, LCR steelhead, and UWR steelhead. The permitted would kill up to one green sturgeon and one eulachon, and encounter rates with these species would be expected to be very low (Table 43).

Table 43. Percent of the ESU/DPS Potentially Handled or Killed by Activities Conducted Under Permit 20492.

ESU/DPS	Life Stage	Origin	Total Take	Percent of ESU/DPS Handled	Total Lethal Take	Percent of ESU/DPS Killed
LCR Chinook	Juvenile	Natural	395	0.003%	10	0.00008%
	Juvenile	Listed Hatchery Adipose Clip	120	0.0004%	6	0.00002%
	Juvenile	Listed Hatchery Intact Adipose	120	0.01%	6	0.0005%
UWR Chinook	Juvenile	Natural	220	0.02%	10	0.0008%
	Juvenile	Listed Hatchery Adipose Clip	250	0.004%	11	0.0002%
CR Chum	Juvenile	Listed Hatchery Adipose Clip	50	0.001%	2	0.00005%
LCR Coho	Juvenile	Natural	150	0.02%	6	0.001%
	Juvenile	Listed Hatchery Adipose Clip	340	0.005%	16	0.0002%
	Juvenile	Listed Hatchery Intact Adipose	45	0.02%	2	0.0008%
OC Coho	Juvenile	Natural	500	0.003%	25	0.0002%
LCR Steelhead	Juvenile	Natural	60	0.02%	3	0.0009%
	Juvenile	Listed Hatchery Adipose Clip	120	0.01%	4	0.0004%
UWR Steelhead	Juvenile	Natural	60	0.005%	3	0.0002%
S eulachon	Adult	Natural	5	0.00001%	1	0.000001%
S green sturgeon	Adult	Natural	5	0.4%	1	0.07%

There would be a very small impact on abundance and productivity and no measureable impact on spatial structure or diversity for these listed species. The ODFW has requested what they believe to be the maximum possible amount of take. Annual reports for permit 1318-9R, which included the projects considered here, show that ODFW did not often take listed species during fieldwork for these projects. Non-lethal take occurred at rates of 0-7% of authorized levels. Mortalities occurred at rates of 0-3% of authorized levels. This research would provide information on fish population structure, abundance, genetics, disease occurrences, and species interactions, which would be used to inform management actions to benefit listed species.

2.6 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). We do not consider future Federal actions that are unrelated to the proposed action in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline versus cumulative effects. Therefore, we describe all relevant future climate-related environmental conditions in the action area in the environmental baseline (Section 2.4).

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 affect 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, projects affecting salmon, steelhead, and other listed fish species generally require Federal funding or authorization to be completed, and so we can reasonably state that the vast majority of such actions in the region will undergo section 7 consultation.

In developing this biological opinion we considered efforts at the local, tribal, state, and national levels to conserve listed salmonids. These include the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (LCFRB 2010), the ESA Recovery Planning for Salmon and Steelhead in the Willamette and Lower Columbia River Basins (NMFS 2005b), the Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead (ODFW 2010), the Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (ODFW 2011), the Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan (WDFW 2010), and the Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest (Ford et al. 2011). The result of that review was that salmon take—particularly associated with research, monitoring, and habitat restoration—is likely to continue to increase in the region for the foreseeable future. However, as noted above, all actions falling in those categories would also have to undergo consultation before they are allowed to proceed.

Non-Federal activities are likely to continue to affect listed species and habitat within the action area. These 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, it seems likely that they will continue to increase as a general pattern over time. The primary cumulative effects will arise from those water quality and quantity impacts that occur as upland human population growth and development shift the pattern of water use and land use, 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. Although state, tribal, and local governments have developed plans and initiatives to benefit listed fish, they must be applied and sustained in a comprehensive way before we can consider them “reasonably foreseeable” in an analysis of cumulative effects.

One final point to consider regarding cumulative effects is the length of time over which the proposed action would occur. These permits would be approved for up to five years. Considering the life history for all potentially affected speices, the proposed actions could affect the listed species for up to four years after an action ceases, with effects diminishing gradually over that time. We are unaware of any major non-Federal activity that could affect listed salmonids and is certain to occur in the action area during that time frame.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat due to implementing the proposed action. In this section, we assess this risk by integrating information on the status of the species and critical habitat (Section 2.2), the environmental baseline (Section 2.4), the potential effects of the proposed action (Section 2.5), and cumulative effects (Section 2.6). We formulate the agency’s biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) diminish appreciably the value of designated or proposed critical habitat for the conservation of the species. We integrate the take proposed for the permits considered here with that for research permits previously authorized under ESA Sections 10(a)(1)(A) or 4(d) to determine total take. We then compare this total take for research permits to the estimated annual abundance of each species (Table 44). As discussed in Section 2.5.2, effects of the proposed research on listed species are likely to be lower than the levels calculated in this analysis, because actual take described in annual reports is typically far less than the levels analyzed and authorized for research permits.

Table 44. Take and Mortalities for Proposed Permits Analyzed in this Opinion (‘Proposed’) and Proposed Permits Plus Already Authorized Permits (‘Proposed Plus Baseline’) Relative to Abundance (LHAC[a] = Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose).

				Proposed				Proposed Plus Baseline			
ESU/DPS	Life Stage	Origin	Abundance	Proposed Take	Proposed % Taken	Proposed Mortality	Proposed % Killed	Total Take	Total % Take	Total Mortality	Total % Mortality
CR chum	Adult	Natural	10,644	5	0.05%	0	0 %	54	0.5%	1	0.009%
	Adult	Total	10,644	5	0.05%	0	0 %	54	0.5%	1	0.009%
	Juvenile	Natural	4,093,920	130	0.003%	6	0.0002%	22,748	0.6%	302	0.007%
	Juvenile	Total	4,093,920	130	0.003%	6	0.0002%	22,748	0.6%	302	0.007%
LCR Chinook	Adult	LHAC	37,365	14	0.04%	0	0 %	1,358	3.6%	9	0.02%
	Adult	Natural	29,469	35	0.1%	0	0 %	1,237	4.2%	12	0.04%
	Adult	Total	66,834	49	0.07%	0	0 %	2,595	3.9%	21	0.03%
	Juvenile	LHAC	34,347,631	482	0.001%	19	0.00006%	83,287	0.2%	1,553	0.005%
	Juvenile	LHIA	1,130,182	120	0.01%	6	0.0005%	739	0.07%	11	0.001%
	Juvenile	Natural	12,427,062	791	0.006%	26	0.0002%	1,152,930	9.3%	13,915	0.1%
	Juvenile	Total	47,904,875	1,393	0.003%	51	0.0001%	1,236,956	2.6%	15,479	0.03%
LCR coho	Adult	LHAC	22,368	19	0.09%	1	0.004%	3,507	15.7%	58	0.3%
	Adult	Natural	32,986	14	0.04%	0	0.00000%	3,271	9.9%	31	0.09%
	Adult	Total	55,354	33	0.06%	1	0.002%	6,778	12.2%	89	0.2%
	Juvenile	LHAC	7,514,080	745	0.01%	30	0.0004%	68,080	0.9%	1,163	0.02%
	Juvenile	LHIA	239,784	45	0.02%	2	0.0008%	2,592	1.08%	21	0.009%
	Juvenile	Natural	619,576	2,810	0.5%	53	0.009%	223,053	36.0%	2,593	0.4%
	Juvenile	Total	8,373,440	3,600	0.04%	85	0.001%	293,725	3.5%	3,777	0.05%
LCR steelhead	Adult	LHAC	22,055	14	0.06%	0	0 %	161	0.7%	4	0.02%
	Adult	Natural	12,920	14	0.1%	0	0 %	3,558	27.54%	34	0.3%
	Adult	Total	34,975	28	0.08%	0	0 %	3,719	10.6%	38	0.1%
	Juvenile	LHAC	1,134,744	415	0.04%	16	0.001%	51,681	4.6%	1,032	0.09%
	Juvenile	Natural	351,966	6,655	1.9%	209	0.06%	62,951	17.9%	1,001	0.3%
	Juvenile	Total	1,486,710	7,070	0.5%	225	0.02%	114,632	7.7%	2,033	0.1%

				Proposed				Proposed Plus Baseline			
ESU/DPS	Life Stage	Origin	Abundance	Proposed Take	Proposed % Taken	Proposed Mortality	Proposed % Killed	Total Take	Total % Take	Total Mortality	Total % Mortality
OC coho	Juvenile	Natural	16,394,210	500	0.003%	25	0.0001%	787,337	4.8%	14,018	0.09%
	Juvenile	Total	16,394,210	500	0.003%	25	0.0001%	787,337	4.8%	14,018	0.09%
UWR Chinook	Adult	LHAC	34,242	3	0.009%	0	0 %	346	1.01%	5	0.01%
	Adult	Natural	11,443	3	0.03%	0	0 %	274	2.4%	3	0.03%
	Adult	Total	45,685	6	0.01%		0 %	620	1.4%	8	0.25%
	Juvenile	LHAC	5,850,595	440	0.008%	17	0.0003%	10,029	0.2%	156	0.003%
	Juvenile	Natural	1,287,502	370	0.03%	15	0.001%	49,209	3.8%	716	0.06%
	Juvenile	Total	7,138,097	810	0.011%	32	0.0005%	59,238	0.8%	872	0.01%
UWR steelhead	Adult	Natural	11,443	3	0.03%	0	0 %	260	2.3%	2	0.02%
	Adult	Total	11,443	3	0.03%	0	0 %	260	2.3%	2	0.02%
	Juvenile	Natural	1,287,502	210	0.01%	4	0.0003%	7,488	0.6%	168	0.00%
	Juvenile	Total	1,287,502	210	0.01%	4	0.0003%	7,488	0.6%	168	0.01%
S Eulachon	Adult	Natural	81,736,000	25	0.000%	2	0 %	9,870	0.01%	7,182	0.009%
	Adult	Total	81,736,000	25	0.000%	2	0 %	9,870	0.01%	7,182	0.009%
S green sturgeon	Adult	Natural	1,348	6	0.4%	1	0.08%	515	38.2%	7	0.5%
	Adult	Total	1,348	6	0.4%	1	0.08%	515	38.2%	7	0.5%

[a]We estimate the abundance of LHAC adults using data on (1) abundance of all hatchery adults (LHAC + LHIA) and (2) the ratio of LHAC:LHIA for juveniles, assuming equal survival of LHAC and LHIA juveniles to the adult life stage.

Salmonids

The proposed research activities would cause low rates of non-lethal take and low numbers of mortalities of salmon and steelhead (Table 44). The vast majority of fish that researchers capture and release would recover quickly with no long-term consequences. The proposed research projects may kill, in sum, as much as 0.06% of the fish from any component of any listed salmonid species; that component is juvenile natural LCR steelhead with take requested for permits 1135-9R, 1175-9R, 1345-8R, 16069-2R, and 20492. For other ESU/DPSs, the proposed mortalities are always less than 0.01% of estimated abundance for each component. Among all of the proposed permits, researchers have requested authorization to kill only 1 adult salmonid, a hatchery origin LCR coho. No mortalities of natural origin adult salmonids have been requested. These very small effects would be spread across much of the range of each affected ESU/DPS (see Section 2.5.2).

When considering effects of the proposed research added to previous ESA Sections 10(a)(1)(A) and 4(d) research authorizations (i.e., the baseline), total effects of research on the listed species remain small. We estimate that the proposed plus baseline mortalities would always be less than 0.4% of the total abundance for any ESU/DPS – typically far less – with highest take rates occurring for LCR coho and LCR steelhead. (Table 44). Eighty-three mortalities for natural origin adult salmonids could occur annually. Thirty-four of these mortalities are for natural origin adult LCR steelhead, representing 0.3% of the estimated abundance for natural origin adult LCR steelhead. Thirty-one of these mortalities are for natural origin adult LCR coho, representing 0.09% of the estimated abundance for natural origin adult LCR coho. A few incidental mortalities of natural origin adults also could occur annually for CR chum, LCR Chinook, UWR Chinook, and UWR steelhead. As stated previously, all but one of these mortalities were authorized previously and are not a part of the proposed action described in this opinion.

Our analysis of effects is likely to be conservative. As discussed previously, permit applications tend to overestimate actual take so that researchers are not likely to exceed their take authorization. In addition, we use conservative estimates of juvenile abundance. While we describe potential effects on all juvenile life stages (smolts, suyearlings, parr, and fry) as effects on "juveniles," for all but one ESU/DPS, we estimate abundance of juveniles using data for smolts (Table 27). The exception is OC coho, for which we use estimates of parr abundance but treat these individuals in our analysis as if they were smolts. Sub-yearlings, parr, and fry are life stages that represent multiple spawning years and have many more individuals than survive to the smolt life stage – perhaps as much as an order of magnitude more.

Eulachon

For S eulachon, the proposed permits did not request any directed mortalities. Only two unintentional mortalities were requested, one each for permits 16069-2R and 20492, to account for one accidental death in each project. Mortalities for the proposed plus previously authorized research permits represent 0.009% of the estimated abundance of eulachon (Table 44). In practice, researchers typically take fewer eulachon than authorized. Annual reports for 2009 to

2015 show that non-lethal and lethal take were 37.7% and 38.4%, respectively, of levels authorized for Section 10(a)(1)(A) research permits in Oregon and Washington.

Green Sturgeon

For S green sturgeon, the proposed permits do not request any directed mortalities. Only one unintentional mortality was requested, for permit 20492, to account for a potential accidental death. Mortalities for the proposed plus previously authorized research permits represent 0.5% of the estimated adult abundance of green sturgeon (Table 44). While this take level of 0.5% is the upper limit of what we generally consider to be protective of green sturgeon, past annual reports indicate that, in actuality, researchers in Oregon and Washington do not tend to encounter green sturgeon. From 2011 to 2016, research in Oregon and Washington that was authorized under ESA Section 10(a)(1)(A) did not cause any mortalities of green sturgeon. Most permit holders do not expect to encounter the species but may still request a single incidental mortality to allow for the unlikely event that they encounter and accidentally kill one individual. Thus, the actual take for this species has always been far below what was authorized.

Critical Habitat

As noted earlier, we do not expect the individual actions to have any appreciable effect on any listed species' critical habitat. This holds true for all the proposed permit actions taken together. The short duration, minimal intrusion, and overall lack of measureable effect of the actions on critical habitat signify that the proposed permit actions would have no discernible impact on critical habitat.

Summary

No listed species currently has all of its biological requirements met, as we discussed in Section 2.2. For these species to recover, there must be substantial improvement in habitat and other factors affecting survival. While the proposed research activities would have some negative effect on abundance and productivity for the species considered here, these effects are so small as to be negligible. Research activities have never been identified as a threat to listed fish in the pacific Northwest. We therefore conclude that the proposed research activities, individually and in sum, do not threaten the listed species.

While specific future cumulative effects are uncertain, cumulative effects will likely continue to be negative. The effects of climate change are also likely to continue to be negative. However, the very small effects from the proposed research activities on abundance and productivity, and even smaller effects on spatial structure and diversity, will not exacerbate any negative cumulative effects on the listed species.

The proposed research activities may benefit these species by providing information on status, trends, and ecological requirements. These data inform NMFS' 5-year status reviews for listed species and species recovery efforts. For example, juvenile fish trapping studies inform population inventories, PIT-tagging efforts increase our knowledge of fish migration timing and survival, and fish passage studies enhance our understanding of behavior and survival as fish migrate past dams and through reservoirs. The resulting information improves our understanding of these species' life histories, biological requirements, genetics, migration timing, responses to human activities, and freshwater and marine survival. By issuing research authorizations, NMFS facilitates science-based management of fisheries resources.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed actions are not likely to jeopardize the continued existence of LCR Chinook, UWR Chinook, CR chum, LCR coho, OC coho, LCR steelhead, UWR steelhead, S eulachon, or S green sturgeon or destroy or adversely modify designated critical habitat for these species.

2.9 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. "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.

There is no incidental take for the actions considered in this opinion. The take associated with these scientific research permits is direct 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 be considered "incidental" under the definition given 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 (2.5). 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.

2.10 Reinitiation of Consultation

As 50 CFR 402.16 states, 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 taking specified in the incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or 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 that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

As noted above, in the context of this opinion, there is no incidental take anticipated and the reinitiation trigger set out in (1) is not applicable. However, if any of the direct take amounts specified in this opinion's effects analysis section (2.5) 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.

2.11 "Not Likely to Adversely Affect" Determination

NMFS's 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 (USFWS and NMFS 1998). 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 on the species or their critical habitat.

SR Killer Whales Determination

The SR killer 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 SR 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 SR killer whales (NMFS 2008).

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 2008, Hilborn et al. 2012).

SR killer whales consume a variety of fish and one species of squid, but salmon, and Chinook salmon in particular, are their preferred prey (review in NMFS 2008). 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). Therefore, our knowledge of diet preferences is specific to inland waters. Less is known about diet preferences of SR killer whales off the Pacific Coast. There are direct observations of two SR killer whale predation events in coastal waters, and in both the prey species was identified as Columbia River Chinook (Hanson et al. 2010). Chemical analyses also support the importance of salmon in the year-round diet of SR killer whales (Krahn et al. 2002; Krahn et al. 2007). SR killer whales' preference for Chinook salmon in inland waters, even when other species are more abundant, combined with information indicating that the killer whales consume salmon year round, makes it reasonable to expect that SR killer whales likely prefer Chinook salmon when available in coastal waters.

The proposed actions may affect SR killer whales indirectly by reducing availability of their preferred prey, Chinook salmon. As described in the effects analysis for salmonids, approximately 83 juveniles and no adults from the LCR Chinook and UWR Chinook ESUs may be killed during the course of the proposed research. The ten-year 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). If one percent of the 83 juvenile Chinook salmon that may be killed by the proposed research activities were otherwise to survive to adulthood, this would translate to the effective loss of one adult Chinook salmon per year. Additionally, this take estimate is likely an overestimate of the actual number of Chinook salmon that would be taken during research activities, and thus the actual reduction in prey available to the whales is likely to be even smaller. Given the total quantity of prey available to SR killer whales throughout their range, this reduction in prey is negligible (based on NMFS previous analysis of the effects of salmon harvest on SR killer whales; NMFS 2008). Therefore, the anticipated take of salmonids associated with the proposed actions would result in an insignificant reduction in adult equivalent prey resources for SR killer whales.

Future loss of Chinook salmon from Chinook salmon ESU populations could affect the prey PBF of designated critical habitat. As described above, however, considering the estimate of up to 1 adult equivalent Chinook salmon that could be taken by the proposed actions, and the total amount of prey available in the critical habitat, the reduction would be insignificant and would not affect the conservation value of the critical habitat. Proposed research activities would have discountable effects on the water quality or passage PBFs for SR killer whales.

Given these circumstances, and the fact that we anticipate no direct interaction between any of the researchers and the SR killer whales, NMFS finds that potential adverse effects of the proposed research on Southern Residents are insignificant and determines that the proposed action may affect, but is not likely to adversely affect, SR killer whales or their critical habitat.

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 the EFH assessment provided by the NMFS and descriptions of EFH for Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) 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. The EFH identified within the action areas are identified in the Pacific coast salmon fishery management plan (PFMC 2014). 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. 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 adverse effects upon EFH are expected; therefore, no EFH 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 NMFS 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 NMFS' 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 opinion are the applicants and funding/action agencies listed on the first page. The agencies, applicants, and the American public will benefit from the consultation.
Individual copies of this opinion were made available to the applicants and it will be posted on the Public Consultation Tracking System website (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). 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 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 reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5. REFERENCES

5.1 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.

June 28, 2005 (70 FR 37160). 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: Designated Critical Habitat: 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 and Threatened Wildlife and Plants: 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.

November 29, 2006 (71 FR 69054). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for Southern Resident Killer Whale.

March 18, 2010 (75 FR 13012). Final Rule: Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of Eulachon.

October 20, 2011 (76 FR 65324). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for the Southern Distinct Population Segment of Eulachon.

April 14, 2014 (79 FR 20802). Final Rule: Endangered and Threatened Wildlife; Final Rule To Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service.

February 11, 2016 (81 FR 7214). Final Rule: Interagency Cooperation—Endangered Species Act of 1973, as Amended; Definition of Destruction or Adverse Modification of Critical Habitat.

February 11, 2016 (81 FR 7414). Final Rule: Listing Endangered and Threatened Species and Designating Critical Habitat; Implementing Changes to the Regulations for Designating Critical Habitat.

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.

November 3, 2016 (81 FR 76565). Notice: Endangered and Threatened Species; Take of Anadromous Fish.

5.2 Literature Cited

Abdul-Aziz, O. I., N. J. Mantua, and K. W. Myers. 2011. Potential climate change impacts on thermal habitats of Pacific salmon (*Oncorhynchus spp.*) in the North Pacific Ocean and adjacent seas. Can. J. Fish. Aquat. Sci. 68:1660-1680.

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.

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.

Beechie, T., E. Buhle, M. Ruckelshaus, A. Fullerton, and L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. Biological Conservation. 130:560-572.

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.

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.

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.

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. Commerce, NOAA Tech. Memo. NMFS-NWFSC-27.

Busack, C., and D. Rawding. 2003. HPVA results for salmon and steelhead production in Washington Lower Columbia basins. In McElhaney 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.)

CDFG (California Department of Fish and Game). 2002. California Department of Fish and Game Comments to NMFS Regarding Green Sturgeon Listing. 129 p

Chisholm, I.M. and W.A. Hubert. 1985. Expulsion of dummy transmitters by rainbow trout. Transactions of the American fisheries Society 114:766-767.

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 for 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

Crozier, L.G. and R.W. Zabel. 2006. Climate impacts at multiple scales: evidence for differential population responses in juvenile Chinook salmon. Journal of Animal Ecology. 75:1100-1109.

Crozier, L., R.W. Zabel, S. Achord, and E.E. Hockersmith. 2010. Interacting effects of density and temperature on body size in multiple populations of Chinook salmon. Journal of Animal Ecology. 79:342-349.

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.

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 1996–1998. EPA 910-R-02-006, Environmental Protection Agency, Region 10, Seattle, WA. Online at: http://yosemite.epa.gov/r10/oea.nsf/0703bc6b0c5525b088256bdc0076fc44/c3a9164ed269353788256c09005d36b7/$FILE/Fish%20Study.PDF

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.

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, J. K. B. and G. M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus* orca in British Columbia. Marine Ecology Progress Series. 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. Depart. of Commer., NOAA Tech. Memo. NOAA-TM-NWFSC-113, 281 pp.

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. 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. Commerce, NOAA Tech. Memo. NMFS-NWFSC-66, 598 pp.

Gustafson, R. G., T. C. Wainwright, G. A. Winans, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-33.

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.

Gustafson, R., Y.-W. Lee, E. Ward, K. Somers, V. Tuttle, and J. Jannot. 2016. Status review update of eulachon (*Thaleichthys pacificus*) listed under the Endangered Species Act: southern distinct population segment. 25 March 2016 Report to National Marine Fisheries Service – West Coast Region from Northwest Fisheries Science Center, 2725 Montlake Blvd. E., Seattle, WA 98112.

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., 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.

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.

Hanson, M. B., K. L. Ayres, R. W. Baird, K. C. Balcomb, K. Balcomb-Bartok, J. R. Candy, C. K. Emmons, J. K. B. Ford, M. J. Ford, B. Gisborne, J. Hempelmann-Halos, G. S. Schorr, J. G. Sneva, D. M. Van Doornik, and S. K. Wasser. 2010. Species and stock identification of prey consumed by endangered 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 pp.

Hard, J. J., J. M. Myers, E. J. Connor, R. A. Hayman, R. G. Kope, G. Lucchetti, A. R. Marshall, G. R. Pess, and B. E. Thompson. 2015. Viability criteria for steelhead within the Puget Sound distinct population segment. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-129.

Hay, D. E., and P. B. McCarter. 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.

Healey, M. 2011. The cumulative impacts of climate change on Fraser River sockeye salmon (*Oncorhynchus nerka*) and implications for management. Canadian Journal of Fisheries and Aquatic Sciences. 68:718-737.

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.

Hilborn, R., S. P. Cox, F. M. D. Gulland, D. G. Hankin, N. T. Hobbs, D. E. Schindler, and A. W. Trites. 2012. The effects of salmon fisheries on Southern Resident Killer Whales: Final report of the Independent Science Panel. Prepared with the assistance of D. R. Marmorek and A. W. Hall, ESSA Technologies Ltd., Vancouver, B.C. for National Marine Fisheries Service (Seattle. WA) and Fisheries and Oceans Canada (Vancouver, B.C.). xv + 61 pp. + Appendices.

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.

IPCC (Intergovernmental Panel on Climate Change). 2013. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. Available from: http://www.climatechange2013.org/ Cambridge, United Kingdom and New York, NY, USA.

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.

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).

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.

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.

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.

Johnson, O. W., W. S. Grant, R. G. Kope, K. Neely, F. W. Waknitz, R. S. Waples. 1997. Status review of chum salmon from Washington, Idaho, Oregon, and California. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-32, 280 p.

Kime, D. E. 1995. The effects of pollution on reproduction in fish. Rev. Fish Biol. Fisheries 5:52–96.

Klos, P.Z., T.E. Link, and T.J. Abatzoglou. 2014. Extent of the rain-snow transition zone in the western U.S. under historic and projected climate. Geophysical Research Letters. 41:4560-4568.

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.

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 pp.

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.

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

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.

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.

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.

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.

McElhaney, 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., D. E. Hay, and E. B. Taylor. 1999. Marine population structure in an anadromous fish: Life history influences patterns of mitochondrial DNA variation in the eulachon, Thaleichthys pacificus. Mol. Ecol. 8:S143–S158.

McMichael, G. A. 1993. Examination of electrofishing injury and short term mortality in hatchery rainbow trout. North American Journal of Fisheries Management 13:229 233.

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.

Melillo, J.M., T.C Richmond, and G.W. Yohe. 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program.

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. 2002. Inland Fishes of California. Revised and Expanded. Univ. Calif. Press, Berkeley and Los Angeles, CA.

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, 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.

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. Commerce, NOAA Tech. Memo. NMFS-NWFSC-35, 443 pp.

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.

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). 2000. 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.

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.

NMFS. 2005a. Green Sturgeon (Acipenser medirostris) Status Review Update. Biological Review Team. Santa Cruz Laboratory. Southwest Fisheries Science Center. NOAA Fisheries. February 2005.

NMFS. 2005b. Final assessment of NOAA Fisheries' critical habitat analytical review teams for 12 Evolutionarily Significant Units of West Coast salmon and Steelhead. August 2005.

NMFS. 2006. 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.

NMFS. 2008. Recovery Plan for Southern Resident Killer Whales (Orcinus orca). National Marine Fisheries Service, Northwest Region, Seattle, Washington.

NMFS. 2011a. Scientific Conclusions of the Status Review for Oregon Coast Coho Salmon (Oncorhynchus kisutch). Draft Revised Report of the Biological Review Tea m. May 16, 2011.

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.

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.

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.

NOAA Fisheries. 2005. Critical habitat analytical review teams for 12 evolutionarily significant units of west coast salmon and steelhead. Protected Resources Division, Portland, Oregon. August. 27 pp.

NWFSC (Northwest Fisheries Science Center). 2015. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. December 21, 2015. 357 pp.

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. 2010. Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead. August 6, 2010.

ODFW. 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. August, 2011.

ODFW and WDFW. 2012. 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. 2013. 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. 2014. 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. 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.

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

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.

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.

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.

PFMC. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. 227 pp.

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.

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.

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.

Quinn, T. P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. Published by University of Washington Press. 2005. 378 pp.

Reingold, M. 1975. Effects of displacing, hooking, and releasing on migrating adult steelhead trout. Transactions of the American Fisheries Society. 104(3):458-460.

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.

Rykaczewski, R.R., J.P. Dunne, W.J. Sydeman, M. Garcia-Reyes, B.A. Black, and S.J. Bograd. 2015. Poleward displacement of coastal upwelling-favorable winds in the ocean's eastern boundary currents through the 21st century. Geophysical Research Letters. 42:6424-6431.

Salathe, E.P., A.F. Hamlet, C.F. Mass, S.Y. Lee, M. Stumbaugh, and R. Steed. 2014. Estimates of Twenty-First-Century Flood Risk in the Pacific Northwest Based on Regional Climate Model Simulations. Journal of Hydrometeorology. 15:1881-1899.

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.

Sawaske, S.R. and D.L. Freyberg. 2014. An analysis of trends in baseflow recession and low-flows in rain-dominated coastal streams of the pacific coast. Journal of Hydrology. 519:599-610.

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.

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.

Sharpe, C. S., D. A. Thompson, H. L. Blankenship, and C. B. Schreck. 1998. Effects of routine handling and tagging procedures on physiological stress responses in juvenile Chinook salmon. 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.

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.

Streamnet. 2016. Salmon and steelhead abundance data. Available at http://www.streamnet.org/

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, G., and R.A. Barnhart. 1999. Mortality of angler caught and released steelhead. California Cooperative Fish and Wildlife Research Unit, Arcata.

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.

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.

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.

Wade, A.A., T.J. Beechie, E. Fleishman, N.J. Mantua, H.Wu, J.S. Kimball, D.M. Stoms, and J.A. Stanford. 2013. Steelhead vulnerability to climate change in the Pacific Northwest. Journal of Applied Ecology. 50:1093-1104.

Wainwright, T.C. and L.A. Weitkamp. 2013. Effects of Climate Change on Oregon Coast Coho Salmon: Habitat and Life-Cycle Interactions. Northwest Science. 87:219-242.

Waples, R. S. 1991. Definition of "Species" under the Endangered Species Act: Application to Pacific Salmon. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS, F/NWC-194. 29 pp.

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.

WDF. 1991. Revised stock transfer guidelines. Memo, 28 May 1991, Salmon Culture Division Olympia, WA, 10 pp.

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. 2010. Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Lower Columbia Fish Recovery Board. May 28, 2010.

WDFW. 2011. 2011 Wild Coho Forecasts for Puget Sound, Washington Coast, and Lower Columbia River. Available at http://wdfw.wa.gov/publications/.

WDFW. 2012. 2012 Wild Coho Forecasts for Puget Sound, Washington Coast, and Lower Columbia River. Available at http://wdfw.wa.gov/publications/.

WDFW. 2013. 2013 Wild Coho Forecasts for Puget Sound, Washington Coast, and Lower Columbia River. Available at http://wdfw.wa.gov/publications/.

WDFW. 2014. 2014 Wild Coho Forecasts for Puget Sound, Washington Coast, and Lower Columbia River. Available at http://wdfw.wa.gov/publications/.

WDFW. 2015. 2015 Wild Coho Forecasts for Puget Sound, Washington Coast, and Lower Columbia River. Available at http://wdfw.wa.gov/publications/.

WDFW. 2016a. Salmonid Stock Inventory. Online at https://data.wa.gov/Natural-Resources-Environment/WDFW-Salmonid-Stock-Inventory-Populations/

WDFW. 2016b. 2016 Wild Coho Forecasts for Puget Sound, Washington Coast, and Lower Columbia River. Available at http://wdfw.wa.gov/publications/.

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.

Wydoski, R. S., and R. R. Whitney. 2003. Inland fishes of Washington, second edition, revised and expanded. University of Washington Press, Seattle.

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.

Zabel, Richard W. 2013. 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 2012. Northwest Fisheries Science Center. January 23, 2013.

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.

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.