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

Consultation on the Issuance of Nine ESA Section 10(a)(1)(A) Scientific Research Permits affecting Salmon, Steelhead, Rockfish, and Eulachon in the West Coast Region

NMFS Consultation Number: WCR-2017-8526
ARN 151422WCR2017PR00301

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

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?
Puget Sound (PS) Chinook salmon (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No	No
PS steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Hood Canal summer-run (HCS) chum salmon (*O. keta*)	Threatened	Yes	No	No	No
Ozette Lake (OL) sockeye salmon (*O. nerka*)	Threatened	Yes	No	No	No
Puget Sound/Georgia Basin (PS/GB) bocaccio (*Sebastes paucispinis*)	Endangered	Yes	No	No	No
PS/GB yelloweye rockfish (*S. ruberrimus*)	Threatened	Yes	No	No	No
Southern (S) eulachon (*Thaleichthys pacificus*)	Threatened	Yes	No	No	No
Southern Resident (SR) killer whale (*Orcinus orca*)	Threatened	No	No	No	No

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

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

Issued By: Chris E. Yates

FOR Barry A. Thom
Regional Administrator

Date: February 8, 2018

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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 nine proposed 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 listed salmonids, eulachon, and rockfish 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 at Portland, OR.

1.2 Consultation History

The West Coast Region's Protected Resources Division (PRD) received nine applications for original permits and permit renewals (see dates below). Because the permit requests are similar in nature and duration and are expected to affect the same listed species, we decided to combine them into a single consultation pursuant to 50 CFR 402.14(c). The affected species are PS Chinook salmon, HCS chum salmon, PS steelhead, OL sockeye salmon, S eulachon, PS/GB bocaccio, and PS/GB yelloweye rockfish. The proposed actions also have the potential to affect 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 received a permit renewal request (10020-5R) from the City of Bellingham on September 9, 2017. Requested edits were sent on September 22, 2017; and all requests were addressed and completed by October 6, 2017.

We received a permit renewal request (16303-2R) from the United States Geological Survey (USGS) on September 7, 2017. Requested edits were sent on September 27, 2017; and all requests were addressed and completed by October 6, 2017.

We received a permit renewal request (17258-2R) from the Washington State Department of Natural Resources (WDNR) on March 7, 2017. Requested edits were sent on September 8, 2017; and all requests were addressed and completed by September 14, 2017.

We received a permit renewal request (17798-2R) from the Northwest Fisheries Science Center (NWFSC) on March 22, 2017. Requested edits were sent on September 12, 2017; and all requests were addressed and completed by September 14, 2017.

We received a permit renewal request (17839-2R) from the United States Forest Service (USFS) on August 30, 2017. Requested edits were sent on September 13, 2017; and all requests were addressed and completed by September 30, 2017.

We received a permit renewal request (17851-3R) from the Coastal Watershed Institute (CWI) on July 22, 2017. Requested edits were sent on September 14, 2017; and all requests were addressed and completed by September 21, 2017.

We received a permit renewal request (18001-3R) from the Pierce County Department of Public Works and Utilities (PCDPWU) on August 14, 2017. Requested edits were sent on September 15, 2017; and all requests were addressed and completed by October 16, 2017.

We received a permit renewal request (20313) from the NWFSC on July 22, 2017. Requested edits were sent on September 18, 2017; and all requests were addressed and completed by October 17, 2017.

We received a permit renewal request (20451-2R) from the University of Washington (UW) on March 28, 2017. Requested edits were sent on September 14, 2017; and all requests were addressed and completed by September 19, 2017.

Most of the requests were deemed incomplete to varying extents when they arrived. After numerous phone call and e-mail exchanges, the applicants revised and finalized their applications. After the applications were determined to be complete, we published notice in the Federal Register on November 15, 2017 asking for public comment on them (82 FR 52884). The public was given 30 days to comment on the permit applications and, once that period closed on December 15, 2017, the consultation began. The full consultation histories for the actions are lengthy and not directly relevant to the analysis for the proposed actions and so are not detailed here. A complete record of this consultation is maintained by the PRD and kept on file in Portland, Oregon.

1.3 Proposed Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). "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. Thus, the proposed actions here are the activities proposed by the FWS, NWFSC, USFS, USGS, and NMFS' issuance of permits to them and to COB, CWI, PCDPWU, UW, and WDNR.

We are thus proposing to issue nine separate research permits pursuant to section 10(a)(1)(A) of the ESA. The permits would variously authorize researchers to take PS Chinook salmon, HCS chum salmon, PS steelhead, OL sockeye salmon, S eulachon, PS/GB bocaccio, and PS/GB yelloweye rockfish. "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]

Permit 10020-5R

The City of Bellingham (COB) is seeking to renew, for five years, a research permit that currently allows them to take juvenile and adult PS Chinook salmon and PS steelhead in Cemetery, Padden, Silver, and Squalicum creeks in Bellingham, WA. The purpose of the COB study is to assess the effectiveness of habitat restoration activities within the City of Bellingham by documenting population trends for salmonids inhabiting these urban creeks. These restoration actions include native riparian and upland plantings, large woody debris and gravel augmentation, re-routing and re-structuring of degraded stream channel, and floodplain re-connection. This research would benefit the affected species by informing future restoration designs, providing data to support future enhancement projects, and assess the status of salmonid populations in these urban systems. The COB proposes to capture fish using a smolt trap (V-shaped channel-spanning weirs with live boxes) in only one of the aforementioned streams annually. Captured fish would be anesthetized, identified to species, measured, have a tissue sample taken (to determine their origin), and allowed to recover in cool, aerated water before being released back to the stream. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 16303-2R

The United States Geological Survey (USGS) is seeking to renew, for five years, a research permit that currently allows them to take adult PS/GB bocaccio, juvenile HCS chum salmon and PS steelhead, and juvenile and adult PS Chinook salmon throughout the marine waters of Puget Sound, Hood Canal, and the Strait of Juan de Fuca (Washington state). The USGS research may also cause them to take adult S eulachon and PS/GB yelloweye rockfish, for which there are currently no ESA take prohibitions. The purpose of the USGS study is to examine salmonid stage-specific growth, bioenergetics, competition, and predation during the critical early marine growth period. Additionally, unlisted salmonid species, herring, and other forage fish species would be studied for the potential effects from temporal-spatial food supply, temperature, competition, and predation. This research would benefit the affected species by quantifying key factors limiting survival and production of Chinook salmon which can guide restoration efforts (e.g. water quality) to mechanistically address processes that impact marine mortality. The USGS proposes capturing fish by mid-water trawl, hook and line (micro-trolling), beach seine, and purse seine. The mid-water trawling would be conducted by Canadian Department of Fisheries and Oceans (CDFO) research

[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 the terms "artificially propagated" and "hatchery" are used interchangeably in the Opinion, as are the terms "naturally propagated" and "natural."

vessels using a mid-water rope trawl during daylight at various depths and velocities and would be coordinated with surveys in Canadian waters. For the mid-water trawls, the fish would be identified to species, weighed, measured for length, tissue samples taken (fin clip and scales), and checked for coded wire tags (CWTs). Viable sub-adult/adult salmon and rockfish would be released. Listed rockfish would be released via rapid submergence to their capture depth to reduce the effects from barotrauma, and sub-adult/adult salmonids would be released at the surface. Juvenile salmonids suffer lethal injuries due to crushing and descaling would be further sampled for CWTs, scales, fins, stomach contents, and otoliths. For the other capture methods, the fish would be anesthetized, identified to species, checked for CWTs, measured to length, gastric lavaged, tissue samples taken (fin clip and scales), and released. For the seining, all juvenile, hatchery-origin, CWT fish would be intentionally sacrificed to determine their origins. The researchers do not propose to kill any other captured fish, but some may die as an unintended result of the activities.

Permit 17258-2R

The Washington State Department of Natural Resources (WDNR) is seeking to renew, for five years, a research permit that currently allows them to take juvenile PS Chinook salmon, HCS chum salmon, PS steelhead, and OL sockeye salmon throughout the streams of Clallam, Jefferson, and Grays Harbor counties in western Washington state. The purpose of the WDNR study is to determine potential fish presence or absence in streams located on WDNR-managed lands in order to support a region-wide program of road maintenance and abandonment. This research would benefit the affected species by determining which streams with road-related passage barriers contain listed fish and, thus, allow WDNR to focus its resources on road improvements that would best help those species. The WDNR proposes to capture fish using backpack electrofishing equipment and minnow traps. Captured fish would be netted, identified to species, and released. In most cases, the stream survey would terminate with the location of one fish. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 17798-2R

The Northwest Fisheries Science Center (NWFSC) is seeking to renew, for five years, a research permit that currently allows them to take juvenile PS Chinook salmon and PS steelhead. The NWFSC research may also cause them to take adult S eulachon—a species for which there are currently no ESA take prohibitions. Study locations include several bays and estuaries throughout the Puget Sound that receive effluent exposures from municipal wastewater plants and industrial contaminant sources. The purpose of the NWFSC study is to assess the bioaccumulation and toxic effects of Chemicals of Emerging Concern (CECs) in Chinook salmon. Whole genome and molecular analyses of Chinook salmon would be conducted on various tissues, which would allow for identification of gene pathways and robust mechanism-based diagnostic indices for CEC toxicity. This research would benefit the listed species by identifying degraded estuaries, studying how CECs impact Chinook salmon, and providing information that can be used to mitigate and improve listed species habitat. The NWFSC proposes to capture fish using beach seines. Sampling would occur at seven locations up to twice annually. For each sample event, 40 juvenile Chinook salmon would be euthanized for whole body analysis. The researchers would prioritize using adipose-fin-clipped hatchery fish and unintentional mortalities over natural-origin fish. Excess Chinook salmon (and all other species) would be released immediately after capture. The researchers do not propose to kill any of the listed steelhead or eulachon being captured, but some may die as an unintended result of the activities.

Permit 17839-2R

The U.S. Forest Service (USFS) is seeking to renew, for five years, a research permit that currently allows them to take juvenile PS Chinook salmon and PS steelhead in the Nooksack, Sauk, Skagit, and Stillaguamish river drainages of western Washington. The purpose of the USFS study is to expand distributional knowledge of the Salish sucker (*Catostomus sp. cf. catostomus*), a species listed as endangered in Canada since 2005 by the Species At Risk Act (SARA). Tissue samples would also be collected from captured Salish suckers for genetic analysis to determine their genetic separation from the longnose sucker (*Catostomus catostomus*) – a species that they are considered to be diverging from. The research would benefit the listed species by providing information on their distribution. The main benefactor of this research is the Salish sucker whose status is not well understood in the United States. The USFS proposes to capture fish using minnow and feddes traps. Captured salmonids would be identified to species, checked for an adipose fin clip, and immediately released downstream. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 17851-3R

The Coastal Watershed Institute (CWI) is seeking to renew, for five years, a research permit that currently allows them to take juvenile PS Chinook salmon, HCS chum salmon, and PS steelhead in the Elwha River estuary (Washington state). The CWI research may also cause them to take adult S eulachon—a species for which there are currently no ESA take prohibitions. The purpose of the CWI study is to research the nearshore restoration response to the Elwha River dam removals with an emphasis on ecological function of nearshore habitats for juvenile salmon and forage fish. The research would benefit listed species by providing a long term continuous dataset on the nearshore use of key salmonid species before, during, and after the dam removals on the Elwha River. This study provides information on how watersheds recover after dam removals and how well fish populations recover. The CWI proposes to capture fish using a beach seine. Captured fish would be identified to their lowest taxonomic level. At each sampling event, twenty individuals from each species would be measured and released. Salmonids would be scanned for fin clips and tags. The researchers do not propose to kill any listed fish being captured, but some may die as an inadvertent result of the research.

Permit 18001-3R

The Pierce County Department of Public Works and Utilities (PCDPWU) is seeking to renew, for five years, a research permit that currently allows them to take juvenile PS Chinook salmon and PS steelhead in the waterways of Pierce County, Washington. The purpose of the PCDPWU study is to determine the distribution and diversity of anadromous fish species in the waterbodies adjacent to and within the county's levee system. The surveys would help establish listed salmonid presence in waterbodies about which (1) there is currently little or inconclusive data and (2) could be used to assess the impacts proposed projects may have upon the listed species. The research would benefit the listed species by helping Pierce County assess its best management practice program and in-water work timing windows to minimize project harm to listed fish. The PCDPWU proposes to capture fish using seines, dip-netting, minnow traps, fyke nets, hook and line, and backpack electrofishing. Electrofishing would largely be “spotshocking” for presence and absence and would not typically cover broad, continuous areas. Captured fish would be identified, measured, and then released at or near their capture site. Fish would not be removed from the water unless absolutely necessary. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

Permit 20313

The NWFSC is seeking a two-year research permit to annually take adult PS/GB bocaccio and sub-adult PS Chinook salmon in the Puget Sound near the San Juan Islands (Washington state). The NWFSC research may also cause them to take adult PS/GB yelloweye rockfish, for which there are currently no ESA take prohibitions. The purpose of the NWFSC study is to assess the role of Chinook salmon residency relative to salmon recovery, including growth, movement patterns, and population structure. This research would benefit the affected species by understanding which populations contribute to the resident PS Chinook salmon population in the San Juan Islands and determining the relationship between the resident life-history type and overall marine survival. These efforts serve as the foundation for evaluating the relative contribution of residents to the broader ESU and the implications of this behavior type to salmon recovery both locally and throughout the region. The NWFSC proposes to capture fish using hook and line. Captured salmon would be scanned for CWT, measured for length, tissue samples taken (scales and fin clips), and released. Hatchery-origin Chinook salmon would also be anesthetized and gastric lavaged. Fifty adipose-clipped, hatchery-origin subadult Chinook salmon would be intentionally sacrificed annually for obtaining otolith samples for analysis of movement patterns and early growth history. Listed rockfish would be released immediately via rapid submergence to their capture depth to reduce the effects from barotrauma. The researchers do not propose to kill any other captured fish, but some may die as an unintended result of the activities.

Permit 20451-2R

The University of Washington (UW) is seeking to renew, for five years, a research permit that currently allows them to take juvenile and adult OL sockeye salmon in Lake Ozette (northwest Washington state). The purpose of the UW study is to investigate the interactions of native predators (i.e., northern pikeminnow, sculpin) and non-native predators (i.e. largemouth bass, yellow perch) with Olympic mudminnow (*Novumbra hubbsi*), a state sensitive species. The research would benefit the listed species because OL sockeye salmon are similarly threatened by the same predators. The UW proposes to capture fish using minnow traps, hoop nets, gill nets, trammel nets, and hook and line. For OL sockeye salmon, captured fish would be handled and released. After the listed fish are released, the remaining fish would be anesthetized, fin clipped, gastric lavaged, and released. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the research.

The proposed Federal action regarding these permits is for NMFS to issue a permit authorizing the research activities. 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 PS Chinook salmon, HCS chum salmon, PS steelhead, OL sockeye salmon, S eulachon, PS/GB bocaccio, and PS/GB yelloweye rockfish. Therefore, this consultation fulfills NMFS's section 7 consultation obligations for those species.

Common Elements among the Proposed Permit Actions

Research permits lay out the conditions to be followed before, during, and after the research activities are conducted. These conditions are intended to (a) manage the interaction between scientists and listed salmonids by requiring that research activities be 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' WC 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 AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, 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.

The NMFS determined that the proposed action is not likely to adversely affect PS Chinook salmon, HCS chum salmon, PS steelhead, OL sockeye salmon, S eulachon, PS/GB bocaccio, and PS/GB yelloweye rockfish or their critical habitat. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section (2.11).

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 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.

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; McElhany 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. The environmental baseline is discussed 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. The effects of the action are described 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 that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential 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 DPS 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 sockeye salmon listing units in this biological opinion constitute ESUs of the species *O. tshawytscha, O. keta,* and *O. nerka,* and the listed steelhead 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, all eulachon and rockfish listing units in this biological opinion constitute DPSs.

Section 4(d) protective regulations prohibit the take of naturally spawned salmonids and of listed hatchery fish 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. Furthermore, we have promulgated no protective regulations for S eulachon under section 4(d); thus, we can issue no permit to take them. Nonetheless, because they 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.

2.2.1 Climate Change

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

Projected Climate Change

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

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

Freshwater environments

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

Impacts on Salmon

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

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

2.2.2 Status of the Species

For Pacific salmon, steelhead, eulachon, and rockfish, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (McElhany et al. 2000). These "viable salmonid population" (VSP) criteria therefore encompass the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. (Though these criteria were not expressly established for non-salmonids during the listing process for those animals, they are nonetheless critical to understanding the species' statuses and we therefore use them when discussing any of the species covered by this opinion.) When these parameters are collectively at appropriate levels, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species' entire life cycle, and these characteristics, in turn, are influenced by habitat and other environmental conditions.

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

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

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

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

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

A species' status is a function of how well its biological requirements are being met; the greater degree to which its requirements are fulfilled, the better the species' status. 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)

- Yelloweye rockfish (*Sebastes ruberrimus*), canary rockfish (*Sebastes pinniger*), and bocaccio (*Sebastes paucispinis*) of the Puget Sound/Georgia Basin – 5-year review: summary and evaluation (Tonnes et al. 2016)

2.2.2.1 Puget Sound Chinook Salmon

Description and Geographic Range

On June 28, 2005, NMFS listed PS Chinook salmon—both natural-origin and some artificially-propagated fish—as a threatened species (70 FR 37160). The species includes all naturally spawned Chinook salmon populations from rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward. This includes rivers and streams flowing into Hood Canal, South Sound, North Sound, and the Strait of Georgia in Washington. The following 26 artificial propagation programs are part of the species and are also listed (79 FR 20802; Table 1): Kendall Creek Hatchery Program; Marblemount Hatchery Program (spring subyearlings and summer-run), Harvey Creek Hatchery Program (summer-run and fall-run), Whitehorse Springs Pond Program, Wallace River Hatchery Program (yearlings and subyearlings), Tulalip Bay Program, Issaquah Hatchery Program, Soos Creek Hatchery Program, Icy Creek Hatchery Program, Keta Creek Hatchery Program, White River Hatchery Program, White Acclimation Pond Program, Hupp Springs Hatchery Program, Voights Creek Hatchery Program, Diru Creek Program, Clear Creek Program, Kalama Creek Program, George Adams Hatchery Program, Rick's Pond Hatchery Program, Hamma Hamma Hatchery Program, Dungeness/Hurd Creek Hatchery Program, Elwha Channel Hatchery Program, and the Skookum Creek Hatchery Spring-run Program. Under the final listing in 2005, the section 4(d) protections (and limits on them) apply to natural-origin and hatchery PS Chinook salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

Table 1. Expected 2018 Puget Sound Chinook salmon hatchery releases (WDFW 2017).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Deschutes	Tumwater Falls	2017	Fall	3,800,000	-
Dungeness-Elwha	Dungeness	2017	Spring	-	50,000
	Elwha	2016	Fall	-	200,000
		2017	Fall	250,000	2,250,000
	Gray Wolf River	2017	Spring	-	50,000
	Hurd Creek	2016	Spring	-	50,000
	Upper Dungeness Pond	2017	Spring	-	50,000
Duwamish	Icy Creek	2016	Fall	300,000	-
	Palmer	2017	Fall	-	1,000,000
	Soos Creek	2017	Fall	3,000,000	200,000
Hood Canal	Hood Canal Schools	2017	Fall	-	500
	Hoodsport	2016	Fall	120,000	-
		2017	Fall	2,300,000	-
Kitsap	Bernie Gobin	2016	Spring	40,000	-
		2017	Fall	-	200,000
			Summer	2,300,000	100,000
	Chambers Creek	2017	Fall	400,000	-

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
	Garrison	2017	Fall	450,000	-
	George Adams	2017	Fall	3,575,000	225,000
	Gorst Creek	2017	Fall	1,530,000	-
	Grovers Creek	2017	Fall	450,000	-
	Hupp Springs	2017	Spring	-	400,000
	Lummi Sea Ponds	2017	Fall	500,000	-
	Minter Creek	2017	Fall	1,250,000	-
Lake Washington	Friends of ISH	2017	Fall	-	1,425
	Issaquah	2017	Fall	2,000,000	-
Nisqually	Clear Creek	2017	Fall	3,300,000	200,000
	Kalama Creek	2017	Fall	600,000	-
	Nisqually MS	2017	Fall	-	90
Nooksack	Kendall Creek	2017	Spring	800,000	-
	Skookum Creek	2017	Spring	-	1,000,000
Puyallup	Clarks Creek	2017	Fall	400,000	-
	Voights Creek	2017	Fall	1,600,000	-
	White River	2016	Spring	-	55,000
		2017	Spring	-	340,000
San Juan Islands	Glenwood Springs	2017	Fall	725,000	-
	Orcas Island SD	2017	Fall	-	225
Skykomish	Wallace River	2016	Summer	500,000	-
		2017	Summer	800,000	200,000
Stillaguamish	Brenner	2017	Fall	-	200,000
	Whitehorse Pond	2017	Summer	220,000	-
Strait of Georgia	Samish	2017	Fall	3,800,000	200,000
Upper Skagit	Marblemount	2017	Spring	387,500	200,000
			Summer	200,000	-
Total Annual Release Number				**36,097,500**	**7,172,240**

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

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

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

Spatial Structure and Diversity

The PS Chinook salmon ESU contains 31 "historically independent populations," of which nine are believed to be extinct (Ruckelshaus et al. 2006). The extinct populations were mostly composed of early-returning fish from the mid- and southern parts of the Puget Sound and in the Hood Canal/Strait of Juan de Fuca (Table 2).

Table 2. Historical populations of Chinook salmon in the Puget Sound (Ruckelshaus et al. 2006; NWFSC 2015).

Population	MPG	Status	Run Timing
NF Nooksack River	Strait of Georgia	Extant	Early
SF Nooksack River	Strait of Georgia	Extant	Early
Nooksack River late	-	*Extinct*	Late
Lower Skagit River	Whidbey Basin	Extant	Late
Upper Skagit River	Whidbey Basin	Extant	Late
Cascade River	Whidbey Basin	Extant	Early
Lower Sauk River	Whidbey Basin	Extant	Late
Upper Sauk River	Whidbey Basin	Extant	Early
Suiattle River	Whidbey Basin	Extant	Early
NF Stillaguamish River	Whidbey Basin	Extant	Late
SF Stillaguamish River	Whidbey Basin	Extant	Late
Stillaguamish River early	-	*Extinct*	Early
Skykomish River	Whidbey Basin	Extant	Late
Snoqualmie River	Whidbey Basin	Extant	Late
Snohomish River early	-	*Extinct*	Early
Sammamish River	Central and South Puget Sound	Extant	Late
Cedar River	Central and South Puget Sound	Extant	Late
Duwamish/Green River	Central and South Puget Sound	Extant	Late
Duwamish/Green River early	-	*Extinct*	Early
White River	Central and South Puget Sound	Extant	Early
Puyallup River	Central and South Puget Sound	Extant	Late
Puyallup River early	-	*Extinct*	Early
Nisqually	Central and South Puget Sound	Extant	Late
Nisqually River early	-	*Extinct*	Early
Skokomish River	Hood Canal	Extant	Late
Skokomish River early	Hood Canal	*Extinct*	Early
Mid-Hood Canal	Hood Canal	Extant	Late
Mid-Hood Canal early	Hood Canal	*Extinct*	Early
Dungeness River	Strait of Juan de Fuca	Extant	Late

Population	MPG	Status	Run Timing
Elwha River	Strait of Juan de Fuca	Extant	Late
Elwha River early	Strait of Juan de Fuca	*Extinct*	Early

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

Chinook salmon population diversity can range in scale from genetic differences within and among populations to complex life-history traits. The loss of early-run populations is a leading factor affecting ESU diversity. As stated above, eight of the nine extinct populations were composed of early-returning fish (Table 2). Run-timing is a life-history trait considered to be an adaptation to variable environmental conditions. The early-run populations were an evolutionary legacy of the ESU, and the loss of these populations reduces the overall ESU's diversity.

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

According to recent production estimates, Puget Sound hatcheries release over 42 million juvenile Chinook salmon each year (Table 1). Most hatchery fish production is for commercial harvest and sport fishing. However, tens of thousands of these fish escape harvest each year and return to spawn in Puget Sound tributaries. From 1990 through 2014, there has been a declining trend in the proportion of natural-origin spawners across the whole ESU (NWFSC 2015). For 2010-2014, more than 70% of the spawners are hatchery fish in eight of the 22 populations (Table 3). For the five MPGs, only the Whidbey Basin MPG had over half of their spawners be of natural-origin in the majority of the populations (NWFSC 2015).

Table 3. Five-year means of fraction wild for PS Chinook salmon by population (NWFSC 2015).

Population	Five-year means for fraction wild				
	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Strait of Georgia MPG					
NF Nooksack River	0.53	0.29	0.07	0.18	0.16
SF Nooksack River	0.76	0.63	0.62	0.63	0.28
Strait of Juan de Fuca MPG					
Elwha River	0.65	0.41	0.54	0.34	0.15
Dungeness River	0.17	0.17	0.16	0.33	0.26
Hood Canal MPG					
Skokomish River	0.52	0.40	0.46	0.45	0.17
Mid-Hood Canal	0.79	0.82	0.79	0.61	0.29
Whidbey Basin MPG					
Skykomish River	0.73	0.46	0.55	0.72	0.73
Snoqualmie River	0.85	0.67	0.87	0.68	0.78
NF Stillaguamish River	0.75	0.65	0.80	0.57	0.59
SF Stillaguamish River	1.00	1.00	1.00	0.99	0.83
Upper Skagit River	0.96	0.98	0.96	0.94	0.96
Lower Skagit River	0.96	0.96	0.97	0.96	0.96
Upper Sauk River	0.96	0.96	0.96	0.96	0.96
Lower Sauk River	0.96	0.96	0.95	0.95	0.96
Suiattle River	0.98	0.98	0.98	0.97	0.98
Cascade River	0.98	0.98	0.98	0.98	0.98
Central / South Sound MPG					
Sammamish River	0.24	0.20	0.40	0.23	0.11
Cedar River	0.74	0.70	0.63	0.82	0.82
Green River	0.44	0.32	0.63	0.44	0.43
Puyallup River	0.84	0.70	0.70	0.40	0.57
White River	0.88	0.93	0.95	0.79	0.56
Nisqually River	0.78	0.80	0.68	0.31	0.30

Abundance and Productivity

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

NMFS concluded in 1998 (Myers et al. 1998), 2005 (Good et al. 2005), 2011 (Ford 2011), and 2015 (NWFSC 2015) that the Puget Sound ESU was likely to become endangered in the foreseeable future. In the first status review, the Puget Sound Biological Review Team (BRT) estimated the total PS Chinook salmon run size[2] in the early 1990s to be approximately 240,000 Chinook salmon, with the vast majority as hatchery-origin. Based on current estimates, 67,000 of those fish were naturally produced Chinook salmon (Unpublished data, Norma Sands, NWFSC, March 5, 2010).

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

ESU escapement (total spawners) increased to 47,686 (2000-2004), but has since declined to 40,411(2005-2009) and to 32,451 (2010-2014; Tables 4 and 5).

Table 4. Abundance–five-year geometric means for adult (age 3+) natural-origin and total spawners (natural- and hatchery-origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NWFSC 2015).

Population	Geometric means					
	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Strait of Georgia MPG						
NF Nooksack River	52 (102)	97 (476)	229 (3,476)	277 (1,675)	154 (1,167)	-44 (-30)
SF Nooksack River	126 (171)	133 (217)	235 (398)	244 (388)	88 (418)	-64 (8)
Strait of Juan de Fuca MPG						
Elwha River	420 (658)	274 (735)	357 (716)	193 (597)	164 (1,152)	-15 (93)
Dungeness River	20 (117)	18 (104)	71 (527)	162 (508)	119 (447)	-27 (-6)
Hood Canal MPG						
Skokomish River	506 (994)	478 (1,232)	479 (1,556)	500 (1,216)	256 (1,627)	-49 (34)
Mid-Hood Canal	93 (119)	152 (186)	169 (217)	47 (88)	75 (314)	60 (257)
Whidbey Basin MPG						
Skykomish River	1,658 (2,325)	1,494 (3,327)	2,606 (4,842)	2,388 (3,350)	1,693 (2,320)	-29 (-31)
Snoqualmie River	873 (1,035)	739 (1,187)	2,161 (2,480)	1,311 (1,965)	885 (1,143)	-32 (-42)
NF Stillaguamish River	553 (742)	603 (946)	967 (1,225)	550 (984)	574 (976)	4 (-1)
SF Stillaguamish River	150 (150)	241 (241)	219 (219)	101 (102)	71 (87)	-30 (-15)
Upper Skagit River	5,389 (5,599)	6,159 (6,267)	12,039 (12,484)	9,975 (10,611)	6,924 (7,194)	-31 (-32)
Lower Skagit River	1,417 (1,473)	1,001 (1,041)	2,765 (2,857)	2,118 (2,216)	1,391 (1,446)	-34 (-35)
Upper Sauk River	394 (409)	258 (268)	413 (428)	498 (518)	836 (867)	68 (67)
Lower Sauk River	399 (414)	414 (433)	812 (853)	546 (572)	413 (432)	-24 (-24)
Suiattle River	295 (302)	373 (382)	405 (415)	254 (261)	351 (360)	38 (38)
Cascade River	185 (189)	208 (213)	364 (371)	334 (341)	338 (345)	1 (1)
Central / South Sound MPG						
Sammamish River	52 (227)	32 (160)	385 (1,040)	289 (1,281)	160 (1,679)	-45 (31)
Cedar River	367 (509)	369 (541)	405 (643)	1,043 (1,275)	881 (1,075)	-16 (-16)
Green River	2,253 (5,331)	2,149 (7,272)	4,099 (6,624)	1,334 (3,187)	897 (2,168)	-33 (-32)
Puyallup River	2,143 (2,543)	1.611 (2,340)	1,171 (1,687)	795 (2,012)	598 (1,186)	-25 (-41)
White River	565 (645)	1,307 (1,415)	3,128 (3,309)	4,170 (5,301)	1,689 (3,471)	-59 (-35)
Nisqually River	630 (806)	596 (748)	891 (1,319)	587 (1,963)	701 (2,577)	19 (31)

In their population viability criteria assessment, the Puget Sound Technical Recovery Team (PSTRT) presented viable spawning abundances for 16 of the 22 populations (PSTRT 2002). For the 2010 status review (Ford 2011), viable spawning abundances for the remaining six populations were extrapolated based on a recovered productivity equal to the average for the 16 populations (recruits per spawner = 3.2). It is important to note that these are viability abundances assuming replacement only productivity – higher productivity would result in lower viable spawning abundances. For this reason, we use the low productivity planning range to evaluate the current abundance trends of PS Chinook salmon (Table 5).

Table 5. Average abundance estimates for PS Chinook salmon natural- and hatchery-origin spawners 2011-2015 (unpublished data, Mindy Rowse, NWFSC, November 17, 2017).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Minimum Viability Abundance[b]	Expected Number of Outmigrants[c]
Strait of Georgia MPG					
NF Nooksack River	159	953	85.70%	16,000	89,003
SF Nooksack River	15	10	38.94%	9,100	1,983
Strait of Juan de Fuca MPG					
Elwha River	202	1,985	90.75%	15,100	174,974
Dungeness River	96	290	75.08%	4,700	30,949
Hood Canal MPG					
Skokomish River	205	951	82.27%	12,800	92,453
Mid-Hood Canal	102	204	66.55%	11,000	24,507
Whidbey Basin MPG					
Skykomish River	1,617	839	34.16%	17,000	196,483
Snoqualmie River	710	195	21.54%	17,000	72,427
NF Stillaguamish River	331	374	53.10%	17,000	56,418
SF Stillaguamish River	63	14	18.09%	15,000	6,111
Upper Skagit River	7,755	381	4.68%	17,000	650,852
Lower Skagit River	1,673	90	5.09%	16,000	141,009
Upper Sauk River	849	24	2.75%	3,000	69,829
Lower Sauk River	383	6	1.57%	5,600	31,104
Suiattle River	417	3	0.80%	600	33,651
Cascade River	232	20	7.86%	1,200	20,148
Central / South Sound MPG					
Sammamish River	88	1,083	92.48%	10,500	93,699
Cedar River	825	260	23.97%	11,500	86,834
Duwamish/Green River	796	1,562	66.24%	17,000	188,698
Puyallup River	529	643	54.86%	17,000	93,766
White River	685	2,018	74.65%	14,200	216,295
Nisqually River	679	1,321	66.04%	13,000	159,971
ESU Average	**18,413**	**13,227**	**41.80%**		**2,531,163**

[a] Five-year geometric mean of post-fishery spawners.
[b] Ford 2011
[c] Expected number of outmigrants=Total spawners*40% proportion of females*2,000 eggs per female*10% survival rate from egg to outmigrant

The average[3] abundance (2011-2015) for PS Chinook salmon populations is 31,640 adult spawners (18,413 natural-origin and 13,227 hatchery-origin spawners). Natural-origin spawners range from

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

15 (in the South Fork Nooksack River population) to 7,755 fish (in the Upper Skagit population). No populations are meeting minimum viability abundance targets, and only three of 22 populations average greater than 20% of the minimum viability abundance target for natural-origin spawner abundance (all of which are in the Skagit River watershed). The populations closest to planning targets (Upper Skagit, Upper Sauk, and Suiattle) need to increase substantially just to meet the minimum viability abundance target. The Lower Skagit population is the second most abundant population, but its natural-origin spawner abundance is only 10% of the minimum viability abundance target.

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

Juvenile listed hatchery PS Chinook salmon abundance estimates come from the annual hatchery production goals. Hatchery production varies annually due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggest that production averages from previous years is not a reliable indication of future production. For these reasons, abundance approximately equals production goals. The combined hatchery production goal for listed PS Chinook salmon from Table 1 is 43,269,740 adipose-fin-clipped and non-clipped juvenile Chinook salmon.

Fifteen-year trends in wild spawner abundance were calculated for each PS Chinook salmon population for two time series – 1990-2005 and 1999-2014 (Table 6). Trends were calculated from a linear regression applied to the smoothed wild spawner log abundance estimate (NWFSC 2015). For the 1990-2005 time series, trends were negative for only two of 22 populations. Recent trends (1999-2014), however, were negative for 17 of the 22 populations (NWFSC 2015).

Table 6. Fifteen year trends for PS Chinook salmon for two time series – 1990-2005 and 1999-2014 (NWFSC 2015).

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

Currently, for every natural-origin juvenile that migrates into Puget Sound 17 listed hatchery juveniles are released into Puget Sound watersheds. The hatchery fish are then targeted for fisheries and mostly removed when they return to their release sites. However, some will stray and others will be missed. For Puget Sound, an average of 40% (range of 2-90%) of the naturally spawning Chinook salmon are first-generation hatchery fish with more than a third of all populations (9 of 22) having more hatchery-origin than natural-origin spawners (Table 5). Studies have documented that hatchery fish spawning in the wild have a lower success rate than naturally produced fish (McLean et al. 2004, Kostow et al. 2002, Berejikian et al. 2001, Reisenbichler and Rubin 1999).

Limiting Factors

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

Status Summary

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

2.2.2.2 Hood Canal Summer-run Chum Salmon

Description and Geographic Range

On June 28, 2005, NMFS listed HCS chum salmon—both natural-origin and some artificially-propagated fish—as a threatened species (70 FR 37160). The species comprises all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington. Under the final listing in 2005, the section 4(d) protections (and limits on them) apply to natural-origin and hatchery-origin HCS chum salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. Four artificial propagation programs were listed as part of the ESU (79 FR 20802; Table 7): Hamma Hamma Fish Hatchery Program, Lilliwaup Creek Fish Hatchery Program, Tahuya River Program; and Jimmycomelately Creek Fish Hatchery Program.

Table 7. Expected 2018 Hood Canal summer-run juvenile chum salmon hatchery releases (WDFW 2017).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Hood Canal	LLTK - Lilliwaup	2017	Summer	-	150,000
Total Annual Release Number				**-**	**150,000**

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

Spatial Structure and Diversity

The HCS chum salmon ESU has two populations, each containing multiple stocks or spawning aggregations (Table 8). In the Strait of Juan de Fuca population, state and tribal biologists assessing the species' status in the early 1990s identified small but persistent natural spawning aggregations in three streams (Salmon, Snow, and Jimmycomelately creeks). In the Dungeness River, spawning of unknown aggregations occurred. In Chimacum Creek, HCS chum salmon extirpation occurred in the mid-1980's.

Table 8. Historical populations, spawning aggregations, and the status of summer-run chum salmon in the Hood Canal ESU (Good et al. 2005, Sands et al. 2009; Ford 2011).

Population	Spawning Aggregations	Status	Supplementation/Reintroduction Program
Strait of Juan de Fuca	Dungeness River	Unknown	---
	Jimmycomelately Creek	Extant	Supplementation program began in 1999.
	Salmon Creek	Extant	Supplementation program began in 1992.
	Snow Creek	Extant	---
	Chimacum Creek	*Extinct*	Reintroduction program began in 1996; natural spawning reported starting in 1999.
Hood Canal	Big Quilcene River	Extant	Supplementation program began in 1992.
	Little Quilcene River	Extant	---
	Dosewallips River	Extant	---
	Duckabush River	Extant	---
	Hamma Hamma River	Extant	Supplementation program began in 1997.
	Lilliwaup Creek	Extant	---
	Big Beef Creek	*Extinct*	Reintroduction program began in 1996; returns reported starting in 2001
	Anderson Creek	*Extinct*	---
	Dewatto River	*Extinct*	Natural re-colonization occurring, but numbers remain low (<70).
	Tahuya River	*Extinct*	Reintroduction program began in 2000 with increased returns starting in 2006.
	Union River	Extant	---
	Skokomish River	*Extinct*	Spawning documented in recent years.
	Finch Creek	*Extinct*	---

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

In 1992, state and tribal co-managers initiated an extensive rebuilding program for the HCS chum salmon (WDFW/PNPTT 2000 and 2001). Their recovery plan called for five supplementation and three reintroduction projects (Table 8). After individual projects' production level goals specified in the Summer Chum Salmon Conservation Initiative were met, supplementation or reintroduction programs were terminated on several streams (WDFW/PNPTT 2000 and 2001).

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

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

Abundance and Productivity

Historical HCS chum salmon abundance is mostly unknown. Harvest records indicate that chum salmon in the Puget Sound (including the HCS chum salmon ESU) were historically more numerous than Chinook salmon. During the years 1914-1919, four times as many chum salmon were harvested as Chinook salmon in the Puget Sound (WDF 1974). In 1968, spawning escapement records indicate that 45,000 adult HCS chum salmon returned to tributaries (WDF et al. 1993). During the early 1970s, adult chum salmon spawners dropped to about 20,000 annually (Ford 2011). By the 1980s, HCS chum salmon abundance began to decline ever more precipitously with several spawning aggregations extirpated during this period with seven spawning aggregations going extinct (Sands et al. 2009). Spawner abundances in both Hood Canal and Strait of Juan de Fuca populations were lowest throughout the 1990’s but increased in the early 2000’s (NWFSC 2015). Since the late 2000’s, abundances have increased by 25% for the Hood Canal population and 53% for the Strait of Juan de Fuca population (Table 9).

Table 9. Abundance–five-year geometric means for adult natural-origin and total spawners (natural- and hatchery-origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NWFSC 2015).

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

The current average run size of 27,452 adult spawners (25,542 natural-origin and 1,910 hatchery-origin spawners; Table 10) is largely the result of aggressive reintroduction and supplementation programs throughout the ESU. In the Strait of Juan de Fuca population, the annual natural-origin spawners returns for Jimmycomelately Creek dipped to a single fish in 1999 and again in 2002 (unpublished data, Mindy Rowse, NWFSC, Feb 2, 2017). From 2011 to 2015, Jimmycomelately Creek averaged 2,299 natural-origin spawners. Salmon and Snow Creeks have improved substantially. Natural-origin spawner abundance was 130 fish in 1999, whereas the average for Salmon and Snow creeks were 2,990 and 539, respectively, for the 2011-2015 period.

Table 10. Abundance of natural-origin and hatchery-origin HCS chum salmon spawners in escapements 2011-2015 (unpublished data, Mindy Rowse, NWFSC, Nov 1, 2017).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[c]
Strait of Juan de Fuca Population				
Jimmycomelately Creek	2,299	964	29.55%	477,215
Salmon Creek	2,990	2	0.05%	437,468
Snow Creek	539	2	0.36%	79,071
Chimacum Creek	1,273	0	0.00%	186,186
Population Average[d]	7,100	968	12.00%	1,179,941
Hood Canal Population				
Big Quilcene River	7,509	0	0.00%	1,098,212
Little Quilcene River	726	0	0.00%	106,243
Big Beef Creek	68	0	0.00%	9,891
Dosewallips River	2,387	4	0.17%	349,672
Duckabush River	4,136	11	0.25%	606,502
Hamma Hamma River	1,810	7	0.37%	265,673

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[c]
Anderson Creek	1,810	0	0.00%	264,700
Dewatto River	100	0	0.00%	14,560
Lilliwaup Creek	544	488	47.32%	150,934
Tahuya River	176	419	70.42%	87,029
Union River	980	39	3.79%	148,984
Population Average[d]	18,438	967	4.98%	2,837,988
ESU Average	**25,538**	**1,935**	**7.04%**	**4,017,929**

[a] Five-year geometric mean of post fishery natural-origin spawners (2011-2015).
[b] Five-year geometric mean of post fishery hatchery-origin spawners (2011-2015).
[c] Expected number of outmigrants=Total spawners*45% proportion of females*2,500 eggs per female*13% survival rate from egg to outmigrant.
[d] Averages are calculated as the geometric mean of the annual totals (2011-2015).

The Hood Canal populations have a similar success story. In 1989, only two summer chum salmon were found in spawning surveys conducted on the Big and Little Quilcene Rivers. Now, they have a combined average of 8,235 natural-origin spawners annually from 2011-2015. Hamma Hamma River returns averaged in the thousands between 1968 and 1979. But by 1989, there were an estimated 16 natural-origin spawners in the Hamma Hamma River. Recent estimates show an average of 1,810 natural-origin HCS chum salmon returning to the Hamma Hamma River annually.

The PSTRT defined interim planning ranges for population level abundance for both high productivity and low productivity (Table 10) (Sands et al. 2009). As the next section illustrates, productivity is low in both populations. Abundance in both populations is currently below the PSTRT planning targets for average natural-origin spawner abundance of 13,000 to 36,000 for the Strait of Juan de Fuca population and 25,000 to 85,000 for the Hood Canal population.

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

Linear regressions of smoothed log natural-origin spawner abundance were applied to both HCS chum salmon populations for two 15-year time series trend analyses (1990-2005 and 1999-2014) (Table 11) (NWFSC 2015). For both time series, trends were positive for both populations (NWFSC 2015).

Table 11. Fifteen year trends for HCS chum salmon for two time series – 1990-2005 and 1999-2014 (NWFSC 2015).

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

Annual hatchery production goals can estimate juvenile listed hatchery HCS chum salmon abundance. Hatchery production varies from year to year due to several factors including funding, equipment failures, human error, disease, and availability of adult spawners. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggests that average production from past years is not a reliable indication of production in the coming years. For these reasons, production goals should equal abundance. The combined hatchery production goal for listed HCS chum salmon from Table 7 is 150,000 unmarked juvenile chum salmon.

Limiting Factors

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

Status Summary

Natural-origin spawner abundance has increased since their 1999 ESA-listing (64 FR 14508) and spawning abundance targets in both populations have been met in some years (NWFSC 2015). Productivity was quite low at the time of the last review (Ford 2011), though rates have increased in the last five years, and have been greater than replacement rates in the past two years for both populations. For each population, spatial structure and diversity viability parameters have increased and nearly meet the viability criteria. However, only two of eight individual spawning aggregates have viable performance. Despite substantive gains towards meeting viability criteria in the Hood

Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not meet all of the recovery criteria for population viability at this time (NWFSC 2015).

2.2.2.3 Puget Sound Steelhead

Description and Geographic Range

On August 9, 1996, NMFS determined that the PS steelhead DPS did not warrant listing (61 FR 41541). In response to a petition received on September 13, 2004, NMFS updated the species' status review. On May 7, 2007, NMFS listed PS steelhead—both natural-origin and some artificially-propagated fish—as a threatened species (72 FR 26722). NMFS concluded that the PS steelhead DPS was likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Six artificial propagation programs were listed as part of the DPS (79 FR 20802; Table 12), including: Green River Natural Program, White River Winter Steelhead Supplementation Program, Hood Canal Steelhead Supplementation Off-station Projects in the Dewatto, Skokomish, and Duckabush Rivers, and Lower Elwha Fish Hatchery Wild Steelhead Recovery Program. NMFS promulgated 4(d) protective regulations for PS steelhead on September 25, 2008 (73 FR 55451). The section 4(d) protections (and limits on them) apply to natural-origin and hatchery-origin PS steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

Table 12. Expected 2017 Puget Sound steelhead listed hatchery releases (WDFW 2017).

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

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

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

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

Spatial Structure and Diversity

Although Puget Sound DPS steelhead populations include both summer- and winter-run life-history types, winter-run populations predominate. For the PS steelhead DPS, Myers et al. (2015) identified three Major Population Groups (MPGs) and 32 Demographically Independent Populations (DIPs) composed of 27 winter-run and nine summer-run steelhead stocks (Table 13). Summer-run stock statuses are mostly unknown; however, most appear to be small, averaging less than 200 spawners annually (Hard et al. 2007). Summer-run stocks are primarily concentrated in the northern Puget Sound and the Dungeness River (Myers et al. 2015).

Table 13. PS steelhead historical Demographically Independent Populations (DIPs), runs, and estimated capacities (Myers et al. 2015).

Demographically Independent Populations	Run(s)	Population Capacity
Central and South Puget Sound MPG		
Cedar River	Winter	5,949 – 11,899
N Lake Washington/Lake Sammamish	Winter	5,268 – 10,536
Green River	Winter	19,768 – 39,537
Puyallup/Carbon River	Winter	14,716 – 29,432
White River	Winter	17,490 – 34,981
Nisqually River	Winter	15,330 – 30,660
South Puget Sound Tributaries	Winter	9,854 – 19,709
East Kitsap Peninsula Tributaries	Winter	1,557 – 3,115

Demographically Independent Populations	Run(s)	Population Capacity
	TOTAL	**89,932 – 179,869**
Hood Canal and Strait of Juan de Fuca MPG		
East Hood Canal Tributaries	Winter	1,270 – 2,540
South Hood Canal Tributaries	Winter	2,985 – 5,970
Skokomish River	Winter	10,030 – 20,060
West Hood Canal Tributaries	Winter	3,608 – 7,217
Sequim/Discovery Bays Independent Tributaries	Winter	512 – 1,024
Dungeness River	Summer; Winter	2,465 – 4,930
Strait of Juan de Fuca Independent Tributaries	Winter	728 – 1,456
Elwha River	Winter	7,116 – 14,231
	TOTAL	**28,714 – 57,428**
North Cascades MPG		
Drayton Harbor Tributaries	Winter	2,426 – 4,852
Nooksack River	Winter	22,045 – 44,091
SF Nooksack River	Summer	1,137 – 2,273
Samish River and Bellingham Bay Tributaries	Winter	3,193 – 6,386
Skagit River	Summer; Winter	64,775 – 129,551
Nookachamps Creek	Winter	1,231 – 2,462
Baker River	Summer; Winter	5,028 – 10,056
Sauk River	Summer; Winter	23,230 – 46,460
Stillaguamish River	Winter	19,118 – 38,236
Deer Creek	Summer	1,572 – 3,144
Canyon Creek	Summer	121 - 243
Snohomish/Skykomish River	Winter	21,389 – 42,779
Pilchuck River	Winter	5,193 – 10,386
NF Skykomish River	Summer	663 – 1,325
Snoqualmie River	Winter	16,740 – 33,479
Tolt River	Summer	321 - 641
	TOTAL	**188,182 – 376,364**
	GRAND TOTAL	**306,828 – 613,661**

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

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

Artificial propagation is a major factor affecting the genetic diversity of both summer- and winter-run steelhead in the Puget Sound DPS. Although offsite releases and releases of steelhead fry and parr have largely ceased in the DPS, annual hatchery steelhead smolt releases derived from non-local steelhead (Skamania summer-run steelhead) or domesticated steelhead originally found within the

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

Abundance and Productivity

Historical Puget Sound steelhead abundance is largely based on catch records. Catch records from 1889 to 1920 indicate that catch peaked at 163,796 steelhead in 1895. Using harvest rates of 30-50%, the estimated peak run size for Puget Sound would range from 327,592 to 545,987 fish. Myers et al. (2015) estimated historic PS steelhead abundance at 306,828 to 613,661 based upon geographic, hydrologic, and ecological characteristics (Table 13). In the 1980s, Light (1987) estimated the steelhead run size at approximately 100,000 winter-run and 20,000 summer-run steelhead. However, as many as 70% of the run were first generation hatchery fish (Hard et al. 2007). By the mid-1990s, Busby et al. (1996) estimated a total run of 45,000 (winter- and summer-run combined). Since then, DPS escapement (total spawners) has decreased to 17,363 (2000-2004), 15,926 (2005-2009), and 13,422 (2010-2014; Table 14).

Table 14. Abundance–five-year geometric means for adult (age 3+) natural-origin and total spawners (natural- and hatchery-origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NWFSC 2015).

Demographically Independent Populations	Geometric means					
	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Central and South Puget Sound MPG						
Cedar River	(321)	(298)	(37)	(12)	(4)	(-67)
Green River	1,566 (1,730)	2,379 (2,505)	1,618 (1,693)	(716)	(552)	(-23)
Nisqually River	1,201 (1,208)	759 (759)	394 (413)	278 (375)	(442)	(18)
N. Lake WA/Lake Sammamish	321 (321)	298 (298)	37 (37)	12 (12)	-	-
Puyallup/Carbon River	1,156 (1,249)	1,003 (1,134)	428 (527)	315 (322)	(277)	(-14)
White River	696 (696)	519 (519)	466 (466)	225 (225)	531 (531)	136 (136)
Hood Canal and Strait of Juan de Fuca MPG						
Dungeness River	356 (356)	-	38 (38)	24 (25)	-	-
East Hood Canal Tribs.	110 (110)	176 (176)	202 (202)	62 (62)	60 (60)	-3 (-3)
Elwha River	206 (358)	127 (508)	(303)	-	(237)	-
Sequim/Discovery Bay Tribs	(30)	(69)	(63)	(17)	(19)	(12)
Skokomish River	385 (503)	359 (359)	205 (259)	351 (351)	(580)	(65)
South Hood Canl Tribs	89 (89)	111 (111)	103 (103)	113 (113)	64 (64)	-43 (-43)
Strait of Juan de Fuca Tribs	89 (89)	191 (191)	212 (212)	101 (101)	147 (147)	46 (46)
West Hood Canal Tribs	-	97 (97)	210 (210)	149 (174)	(74)	(-50)
North Cascades MPG						

Demographically Independent Populations	Geometric means					
	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Nooksack River	-	-	-	-	1,693 (1,745)	-
Pilchuck River	1,225 (1,225)	1,465 (1,465)	604 (604)	597 (597)	614 (614)	3 (3)
Samish River/ Bellingham Bay Tribs	316 (316)	717 (717)	852 (852)	534 (534)	846 (846)	58 (58)
Skagit River	7,189 (7,650)	7,656 (8,059)	5,424 (5,675)	4,767 (5,547)	(5,123)	(7)
Snohomish/Skykomish Rivers	6,654 (7,394)	6,382 (7,200)	3,230 (3,980)	4,589 (5,399)	(930)	(-83)
Snoqualmie River	1,831 (1,831)	2,056 (2,056)	1,020 (1,020)	944 (944)	680 (680)	-28 (-28)
Stillaguamish River	1,078 (1,078)	1,024 (1,166)	401 (550)	259 (327)	(392)	(20)
Tolt River	112 (112)	212 (212)	119 (119)	73 (73)	105 (105)	44 (44)

Steelhead are most abundant in the North Cascades MPG, with the Skagit and Nooksack rivers supporting the two largest winter-run steelhead DIPs (Table 15). The Snohomish/Snoqualmie DIP used to support the second largest DIP for the DPS, but this DIP has declined by 83% during the last five years (NWFSC 2015). Currently, neither the Central and South Puget Sound MPG nor the Hood Canal and Strait of Juan de Fuca MPG DIPs have averaged greater than 600 spawners annually.

Table 15. Abundance of PS steelhead spawner escapements (natural-origin and hatchery-production combined) from 2012-2016 (pers. comm., A. Marshall, WDFW, July 13, 2017).

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

Demographically Independent Populations	Spawners	Expected Number of Outmigrants[b]
Snoqualmie River	824	93,730
Stillaguamish River	476	54,145
Tolt River	70	7,963
TOTAL	**18,257**	**2,076,734**

[a] Geometric mean of post fishery spawners.
[b] Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant.
[c] Hatchery-origin steelhead not included in abundance estimate

The average abundance (2012-2016) for the PS steelhead DPS is 18,257 adult spawners (natural-origin and hatchery-production combined). Escapement data, the percentage of females in the population, and fecundity can estimate juvenile PS steelhead abundance. For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (9,129 females), 31.95 million eggs are expected to be produced annually. With an estimated survival rate of 6.5% (Ward and Slaney 1993), the DPS should produce roughly 2.08 million natural-origin outmigrants annually (Table 15).

Linear regressions of smoothed log natural-origin spawner abundance were applied to PS steelhead DIPs for two 15-year time series trend analyses (1990-2005 and 1999-2014) (NWFSC 2015). For the 1990-2005 time series, trends were negative for 12 of 17 DIPs; and for the 1999-2014 time series, seven of eight DIPs had negative trends (Table 16). Only the Samish River/Bellingham Bay tributaries DIP had a positive trend for both time series (NWFSC 2015).

Table 16. Fifteen year trends for PS steelhead for two time series – 1990-2005 and 1999-2014 (NWFSC 2015).

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

Demographically Independent Populations	1990-2005		1999-2014	
	Trend	95% CI	Trend	95% CI
Nooksack River	-	-	-	-
Pilchuck River	-0.04	(-0.06, -0.02)	-0.02	(-0.05, 0.01)
Samish River/Bellingham Bay Tribs	0.04	(0.02, 0.07)	0.02	(-0.01, 0.05)
Skagit River	-0.02	(-0.04, 0)	-	-
Snohomish/Skykomish Rivers	-0.05	(-0.08, -0.03)	-	-
Snoqualmie River	-0.03	(-0.06, -0.01)	-0.05	(-0.08, -0.02)
Stillaguamish River	-0.09	(-0.11, -0.06)	-	-
Tolt River	0.01	(-0.02, 0.04)	-0.02	(-0.06, 0.01)

Juvenile listed hatchery PS steelhead estimates come from the annual hatchery production goals. Hatchery production varies from year to year due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggests that average production from previous years is not a reliable estimate for future production. For these reasons, we will use production goals to estimate abundance. The combined production goal for listed PS steelhead hatchery stocks is 223,730 adipose-fin-clipped and non-clipped juveniles (Table 12).

Limiting Factors

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

Status Summary

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

2.2.2.4 Ozette Lake Sockeye Salmon

Description and Geographic Range

On March 25 1999, NMFS listed the OL sockeye salmon as a threatened species (64 FR 14528). The ESU includes all naturally spawned sockeye salmon originating from the Ozette River and Ozette Lake and its tributaries. Also, sockeye salmon from two artificial propagation programs: the Umbrella Creek Hatchery Program; and the Big River Hatchery Program (79 FR 20802). The Umbrella Creek and Big River sockeye salmon hatchery programs (Table 17) were developed in 1982 to augment the beach spawning population and are limited to releases through 2012, at which time it will be reevaluated (Ford 2011). Under the final listing in 2005, the section 4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

Table 17. Expected 2018 Ozette Lake juvenile sockeye salmon hatchery releases (WDFW 2017).

Subbasin	Artificial propagation program	Brood year	Clipped Adipose Fin	Intact Adipose Fin
Hoh-Quillayute	Stony Creek	2017	45,750	137,250
	Umbrella Creek	2017	-	122,000
Total Annual Release Number			**45,750**	**259,250**

The vast majority of sockeye salmon spawn in lake inlet or outlet streams or in lakes themselves. The offspring of these "lake-type" sockeye salmon use the lake environment for juvenile rearing for one, two, or three years and then migrate to sea. However, some populations of sockeye salmon spawn in rivers without juvenile lake rearing habitat. The offspring of these spawners rear for one or two years in riverine habitats ("river-type" sockeye salmon), or migrate to sea as sub-yearlings after only a few months and therefore rear primarily in saltwater ("sea-type" sockeye salmon) (Gustafson et al. 1997). The duration of time spent in the ocean is the same for all three spawning types—adult sockeye salmon return to the natal spawning habitat after one to four years in the ocean.

Ozette Lake sockeye salmon are lake-type sockeye salmon. Adult sockeye salmon enter Ozette Lake through the Ozette River from April to early August, and hold three to nine months in the lake before spawning in late October through January. Ozette Lake sockeye salmon spawn in lakeshore upwelling areas and in tributaries. Eggs and alevins remain in gravel redds until the fish emerge as fry in spring. Fry then migrate immediately to the limnetic zone where the fish rear. After one year of rearing, Ozette Lake sockeye salmon emigrate seaward as age 1+ smolts in late spring. The majority of Ozette Lake sockeye salmon return to the lake as age 3+ adults and after holding in the lake spawn as four-year-old fish.

Kokanee are populations of *O. nerka* that become resident in the lake environment over long periods of time. Occasionally, a proportion of the juveniles in an anadromous sockeye salmon population will remain in the lake environment their entire lives and will be observed on the spawning grounds together with their anadromous siblings. Ricker (1938) defined the terms "residual sockeye" and "residuals" to identify these resident, non-migratory progeny of anadromous sockeye salmon parents.

Chamberlain (1907, p. 40) reported that "dwarf sockeye" were present in Ozette Lake around the turn of the century, and it is likely that kokanee were present prehistorically in Ozette Lake. Between 5,000 and 10,000 kokanee spawn in small tributaries to Ozette Lake. Dlugokenski et al. (1981, p. 34) reported that kokanee spawn not only in tributaries, but also spawn interspersed with sockeye salmon on the lakeshore in mid-November to early December.

Spatial Structure and Diversity

The OL sockeye salmon ESU is composed of one historical population, with substantial substructuring of individuals into multiple spawning aggregations. The primary existing spawning aggregations occur in two beach locations—Allen's and Olsen's beaches, and in two tributaries, Umbrella Creek and Big River (both tributary-spawning groups were initiated through a hatchery introduction program). In addition, mature adults have been located at other beach locations within the lake (e.g., Umbrella Beach, Ericson's Bay, Baby Island, and Boot Bay); but whether spawning occurred in those locations is not known (Good et al. 2005). Similarly, occasional spawners are found sporadically in other tributaries to the lake, but not in as high numbers or as consistently as in Umbrella Creek.

As initial broodstock, the Umbrella Creek spawning aggregation was started through collections of lake-spawning adults; and in recent years, all broodstock has been collected from returning adults to Umbrella Creek (Good et al. 2005). There is some disagreement as to the extent to which sockeye salmon spawned historically in tributaries to the lake (Gustafson et al. 1997), but it is clear that multiple beach-spawning aggregations of sockeye salmon occurred historically and that genetically distinct kokanee currently spawn in large numbers in all surveyed lake tributaries (except Umbrella Creek and Big River). The two remaining beach-spawning aggregations are probably fewer than the number of aggregations that occurred historically, but it is unknown how many subpopulations occurred in the ESU historically.

Diversity is the variety of life histories, sizes, and other characteristics expressed by individuals within a population. As stated previously, the OL sockeye salmon ESU once had two life history patterns: tributary spawners and beach spawners. Although there are numerous anecdotal accounts of historical tributary spawning, a series of intense basin-wide surveys in the late 1970s and early 1980s found only beach spawners. The loss of tributary spawning aggregations represents a loss of an important life history type that may have been genetically distinct from beach spawning aggregations. Depleted run-sizes and the loss of tributary spawning aggregations prompted managers to initiate a re-introduction and supplementation program in three of the Ozette Lake tributaries (e.g. Umbrella Creek, Big River, and Crooked Creek).

With the first broodstock collection in 1983, the Umbrella Creek spawning aggregation was established using a combination of brood stock collected at Olsen's and Allen's Beaches (PSTRT 2007). After OL sockeye salmon were listed in 1999, the hatchery program has been managed to protect the genetic diversity of beach spawning aggregations. Since 2000, broodstock collection has been restricted to natural origin tributary spawners, and juvenile sockeye salmon from the program have been outplanted in Umbrella Creek and Big River. Observations of sockeye salmon spawning in Big River during the winter of 1998 before any hatchery out-planting suggests that sockeye salmon strayed into new habitats, potentially in an attempt to colonize new environments. The expected duration of the tributary hatchery programs is 12 years, or three sockeye salmon generations, per release site. These programs should improve the ESU's diversity by extending the range of spatial distribution, which may, in turn, contribute to life history diversity and increase the resiliency of the population (NMFS 2003).

Based upon variation in peak spawn timing and genetic differences observed in tissue samples experts have argued that the beach spawning aggregations may be separate populations (Haggerty et al. 2009). However, Hawkins (2004) found that there was very little genetic structure among the sockeye salmon spawning aggregations at Olsen's Beach, Allen's Beach, and Umbrella Creek. Hawkins (2004) found cohort lineages along the predominant 4-year brood cycle to be closely related independent of sampling locations.

Sockeye and kokanee salmon are known to interact during the fresh-water rearing phase of the sockeye salmon, which coincides with nearly the entire life history phase of kokanee. Genetic evidence analyzed by Hawkins (2004) indicates that hybridization between sockeye and kokanee salmon appears to have been occurring before 1991 and continues to be persistent between the two populations. However, the genetic mixing between sockeye salmon and kokanee is of low enough frequency to maintain the large genetic differences observed between the two populations (Hawkins 2004).

Abundance and Productivity

Historical abundance estimates of OL sockeye salmon come from weir counts and harvest records. The earliest attempt to quantify the size of the OL sockeye salmon run occurred in 1924-1926 when the U.S. Fish and Wildlife Service (FWS) installed and operated a counting weir downstream from the lake's outlet in the Ozette River (Haggerty et al. 2009). However, the weir deployment missed the early part of the run; and weir counts did not account for the number of sockeye salmon harvested. Between 1948 and 1976, the Washington Department of Fisheries collected harvest data but no escapement data. Estimates made from these data sets indicate a maximum escapement of a few thousand sockeye salmon in 1926 and a peak harvest of more than 17,000 in 1949 (Gustafson et al. 1997). However, in some years the total run size may have been more than 1949's peak-recorded harvest. Blum (1988) speculated that before the 1940s, the OL sockeye salmon run-size exceeded 50,000 fish.

After the Makah Tribe's annual OL sockeye salmon harvest peaked at 17,000 in 1949 (WDF 1955), harvest declined sharply thereafter and ceased altogether in 1974. In an effort to protect and increase the spawning sockeye salmon abundance, all ceremonial and subsistence tribal fishing ended in 1982. Despite the cessation of harvest, OL sockeye salmon runs never rebounded.

In 1977, the FWS, USGS, and the Makah Tribe installed a counting weir in the Ozette River, near the lake's outlet. The methods used to enumerate and estimate Lake Ozette sockeye salmon run sizes changed several times between 1977 and the present. Methods ranged from nighttime weir counts (1977-1981), 24-hour counts (1982, 1984, 1986), visual – hour counts with an underwater video camera (1998-2003). In 1998, the operation period expanded to include earlier starting and later ending dates. The changes in 1998 allowed for a more complete count of all fish passing the weir. It is likely that counts for previous years underestimated total spawner abundance, but the magnitude of this bias is unknown. Since 2004, survey data appears to be scantly and of poor quality with the Makah Tribe not making any total spawning estimates for these years. Beginning in 2011, dual frequency identification sonar (ARIS) surveys began along the main spawning beaches in Lake Ozette to estimate OL sockeye salmon abundance (Haggerty and Makah Fisheries Management 2013). Due to predation problems at the Ozette River weir and poor visibility at the spawning beaches, the ARIS surveys were chosen; and after a few years of data calibration, the goal is to remove the weir from the Ozette River (NMFS 2016b). From 2012 onward, all abundance data are preliminary and have not been published. From 2007 through 2011, the current average run size is 2,321 adult spawners (2,143 natural-origin and 178 hatchery origin spawners; Table 18) for the ESU.

Table 18. Five-year geometric means (2007-2011) for adult natural-origin and hatchery-origin spawners for the OL sockeye salmon ESU (NWFSC 2015).

Year	Ozette Lake[a]		Umbrella Creek		Total	
	Natural-origin Spawners	Hatchery-origin Spawners	Natural-origin Spawners	Hatchery-origin Spawners	Natural-origin Spawners	Hatchery-origin Spawners
2007	692	0	42	7	734	7
2008	443	44	1,430	234	1,873	278
2009	1,031	127	3,037	574	4,068	701
2010	791	51	3,056	270	3,847	321
2011	1,597	120	503	237	2,100	357
ESU Average					**2,143**	**178**

[a] Ozette Lake spawners include all OL sockeye salmon except for those counted at the Umbrella Creek weir.

Escapement data, the percentage of females in the population, and fecundity can estimate juvenile OL sockeye salmon abundance. Fecundity estimates for the ESU average 3,050 eggs per female (Haggerty et al. 2009), and the proportion of female spawners is assumed to be 50% of escapement. By applying fecundity estimates to the expected escapement of females (both natural-origin and hatchery-origin spawners – 1,161 females), the ESU is estimated to produce approximately 3.54 million eggs annually. Analyzing data from1991 to 2007 for the Lake Washington sub-basin, McPherson and Woodey (2009) found an average egg-to-fry survival rate of 13.5% (range 1.9-32.0%). Assuming a similar 13.5% egg-to-fry survival for Lake Ozette, the ESU should produce roughly 477,836 natural outmigrants annually.

Spawning habitat capacity estimates for beach and tributary habitats (combined) range from 90,000 to 120,000 adult OL sockeye salmon (PSTRT 2007). These estimates use a relatively low spawning density target of one female per three sq. meters of suitable habitat. However, historical spawning density may have been as high as one female/sq. meter, which would triple the capacity estimates. Nonetheless, the most recent five-year average for natural origin adult sockeye salmon escapement is only 2.4% of the lower estimate (2,143/90,000).

Listed hatchery sockeye salmon abundance is from the annual hatchery production goals. Hatchery production varies from year to year due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. The uncertainty in funding and the inability to predict equipment failures, human error, and disease suggests that an average production from past years is not a reliable indication of production in the coming years. For these reasons, abundance is assumed to be equal to the production goals. The combined hatchery production goal for listed OL sockeye salmon is 305,000 juveniles (Table 26).

Limiting Factors

The limiting factors continue to be loss of adequate and quantity of spawning and rearing habitat, predation and disruption of natural predator-prey relationships, and introduction of non-native fish and plant species (Good et al. 2005). Significant habitat concerns, particularly regarding spawning beach conditions, hydrologic patterns that are legacy effects of streamside timber practices and large wood removal, which will take decades to ameliorate without affirmative restoration activities (NMFS 2016b). The low productivity of the beach spawning aggregation(s) is a continuing concern that will require corrective habitat measures on the part of the co-managers and the Olympic National Park in order for viability benefits to accrue. Further, the current operation and management of the weir at Ozette Lake currently constrains sockeye salmon migration and delays both upstream and downstream fish passage, which results in increased fish and mammal predation by northern pikeminnow, harbor seal, and river otter on migrating juvenile and/or adult sockeye salmon as they encounter the weir. Also, climate change also portends increasing frequency of detrimental conditions similar to those experienced throughout 2015 (NMFS 2016b).

Status Summary

Abundance of OL sockeye salmon has not changed substantially from the last status review (NWFSC 2015). The quality of data continues to hamper efforts to assess more recent trends and spatial structure and diversity although this situation is improving (NWFSC 2015). Overall, the biological risk was determined to have not changed between the 2005, 2010, and 2015 status reviews (Ford 2011; NWFSC 2015).

2.2.2.5 Southern Eulachon

Description and Geographic Range

On March 16, 2010, NMFS listed the Southern DPS of 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. Because these freshets rapidly move eulachon eggs and larvae to estuaries, it is believed that eulachon imprint and home to an estuary into which several rivers drain rather than individual spawning rivers (Hay and McCarter 2000). From December to May, eulachon typically enter the Columbia River system with peak entry and spawning during February and March (Gustafson et al. 2010). They spawn in the lower Columbia River mainstem and multiple tributaries of the lower Columbia River.

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

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

Spatial Structure and Diversity

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

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

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

Abundance and Productivity

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

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

Similar abundance declines have occurred in the Fraser and other coastal British Columbia rivers (Hay and McCarter 2000, Moody 2008). Over a three-generation time of 10 years (1999-2009), the overall Fraser River eulachon population biomass has declined by nearly 97% (Gustafson et al. 2010). In 1999, the biomass estimates were 418 metric tons[4]; and by 2010, had dropped to just 4 metric tons (Table 17). 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[5] effects and random genetic and demographic effects (Gustafson et al. 2010). Under SARA, Canada designated the Fraser River population as endangered in May 2011 due to a 98% decline in spawning stock biomass over the previous 10 years (COSEWIC 2011a). From 2013 through 2017, the Fraser River eulachon spawner population estimate is 1,968,688 adults (Table 19).

Table 19. Southern DPS eulachon spawning estimates for the lower Fraser River, British Columbia (data from http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/herring-hareng/herspawn/pages/river1-eng.html).

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

[a] Estimated population numbers are calculated as 11.2 eulachon per pound.
[b] Five-year geometric mean of eulachon biomass estimates (2013-2017).

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

[4] The U.S. ton is equivalent to 2,000 pounds and the metric ton is equivalent to 2,204 pounds.
[5] 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.

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 Washington Department of Fish and Wildlife (WDFW) began eulachon biomass surveys similar to those conducted on the Fraser River. From 2013 through 2015, eulachon abundance increased with a peak of over 84.2 million eulachon spawners in 2014. Since that 2014 peak, eulachon numbers have decreased annually with the lowest spawner run total, since the surveys began in 2011, of 8.15 million in 2017 (Langness 2017). From 2013 through 2017, the estimated eulachon spawner estimate for the Columbia River and its tributaries is 32,968,415 eulachon spawning adults (Table 20).

Table 20. Southern DPS eulachon spawning estimates for the lower Columbia River and its tributaries (unpublished data, R. Gustafson, NWFSC, June 8, 2017; Langness 2017).

Year	Biomass Estimate (metric tons)	Estimated spawner population[a]
2011	723	17,860,400
2012	810	20,008,600
2013	1,845	45,546,700
2014	3,412	84,243,100
2015	2,330	57,525,700
2016	877	21,654,800
2017	330	8,148,600
2013-2017[b]	**1,598**	**32,968,415**

[a] Estimated population numbers are calculated as 11.2 eulachon per pound.
[b] Five-year geometric mean of mean eulachon biomass estimates (2013-2017).

In Northern California, no long-term eulachon monitoring programs exist. In the Klamath River, large eulachon spawning aggregations once regularly occurred but eulachon abundance has declined substantially (Fry 1979, Moyle et al. 1995, Larson and Belchik 1998, Hamilton et al. 2005). Recent reports from Yurok Tribal fisheries biologists have revealed small runs of adult eulachon ranging from 7 (2011) to ~1,000 (2014) individuals in presence/absence surveys using seines and dip nets (Gustafson et al. 2016).

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 spawner estimate from the Columbia and Fraser rivers is 34.94 million eulachon.

Limiting Factors

Climate Change

Climate change impacts on ocean habitat are the most serious threat to persistence of the S 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).

Commercial and Recreational Harvest

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

In British Columbia, the Fraser River supports the only commercial eulachon fishery that is within the range of the southern DPS. This fishery has been essentially closed since 1997, only opening briefly in 2002 and 2004 when only minor catches were landed (DFO 2008, Gustafson et al. 2016).

Shrimp Fishery Bycatch

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

Other Factors

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

Status Summary

Adult spawning abundance of the southern DPS of eulachon has clearly increased since the listing occurred in 2010 (Gustafson et al. 2016). The improvement in estimated abundance in the Columbia

River, relative to the time of listing, reflects both changes in biological status and improved monitoring. The documentation of eulachon returning to the Naselle, Chehalis, Elwha, and Klamath rivers over the 2011–2015 also likely reflects both changes in biological status and improved monitoring. Although eulachon abundance in monitored populations has generally improved, especially in the 2013–2015 return years, recent poor ocean conditions and the likelihood that these conditions will persist into the near future suggest that population declines may be widespread in the upcoming return years (Gustafson et al. 2016). Since the 2014 eulachon spawner peak, eulachon runs have decreased each year with the 2017 Columbia River run being the smallest since the eulachon surveys began in 2011 (pers. comm., R. Gustafson, June 8, 2017).

2.2.2.6 Puget Sound/Georgia Basin Bocaccio and Yelloweye Rockfish

Description and Geographic Range

On April 27, 2010, NMFS listed the PS/GB DPS of bocaccio as endangered and PS/GB DPS of yelloweye rockfish as threatened (75 FR 22276). The geographic range of the listed PS/GB DPS rockfish is Puget Sound, Georgia Basin, Strait of Georgia, and Strait of Juan de Fuca east of Victoria Sill. The Victoria Sill, running from east of Port Angeles to Victoria, is a submerged terminal moraine that restricts water flow through the Strait of Juan de Fuca (Masson 2002). Puget Sound, a fjord system of submerged glacier valleys formed during a previous ice age, is an estuary located in northwest Washington State and covers an area of about 2,330 square km (900 square miles), including 4,000 km (2,500 miles) of shoreline. The Georgia Basin is a large fjord estuary situated between southern Vancouver Island and the mainland Washington State and British Columbia coasts. Puget Sound can be subdivided into five interconnected basins separated by shallow sills: (1) the San Juan/Strait of Juan de Fuca Basin (also referred to as "North Puget Sound"), (2) Main Basin, (3) Whidbey Basin, (4) South Puget Sound, and (5) Hood Canal. Each basin differs in features such as temperature regimes, water residence and circulation, biological conditions, depth profiles and contours, species, and habitats (Drake et al. 2010). We will use the term 'Puget Sound Proper' to refer to all of these basins except North Puget Sound.

Bocaccio

NMFS has determined that the PS/GB DPS of bocaccio is currently in danger of extinction throughout all of its range. Bocaccio are one of 28 rockfish species that reside in Puget Sound (Palsson et al. 2009). Bocaccio are elongate, laterally compressed fish with very large mouths (Love et al. 2002). Their appearance often varies among individuals, with several common color variations.

Bocaccio life-history includes a larval/pelagic juvenile stage followed by a nearshore juvenile stage, and sub-adult and adult stages. In contrast to the majority of bony fishes, rockfish fertilize their eggs internally, and the young are extruded as larvae. Bocaccio produce from 20,000 to 2,298,000 eggs; and as bocaccio grow and age, the number of young produced per female increases (Love et al. 2002). Larval release timing varies throughout the geographic range. Along the Washington state coast, female bocaccio release larvae between January and April (Love et al. 2002). Larvae are observed under free-floating algae, seagrass, and detached kelp (Shaffer et al. 1995, Love et al. 2002) but are also distributed throughout the water column (Weis 2004). Larvae can make small local movements to pursue food immediately after birth (Tagal et al. 2002), but are likely passively distributed with prevailing currents. Bocaccio larvae are planktivores that feed on larval krill, diatoms, and dinoflagellates (Love et al. 2002). Unique oceanographic conditions within Puget Sound proper (sills regulating water exchange from one basin to the next) likely result in most larvae staying within the basin where they are released (e.g., the South Sound) rather than being broadly dispersed (Drake et al. 2010).

Most bocaccio remain pelagic for 3.5 months prior to settling in shallow areas, although some may remain pelagic as long as 5.5 months. Several weeks after settlement, fish move to deeper waters, and settle onto shallow nearshore waters in rocky or cobble substrates with or without kelp (Love et al. 1991, 2002). These habitat features offer a beneficial mix of warmer temperatures, food, and refuge from predators (Love et al. 1991). Young-of-the-year are often found in shallow, nearshore waters over rocky bottoms associated with algae, within and near kelp canopies, and in 18 to 30 m deep waters associated with rocky reefs and high relief areas (Feder et al. 1974, Carr 1983, Sakuma and Ralston 1995, Johnson 2006, Love and Yoklavich 2008). Pelagic juveniles are opportunistic feeders, taking fish larvae, copepods, krill, and other prey. Larger juveniles and adults are primarily piscivores, eating other rockfishes, hake, sablefish, anchovies, lanternfishes, and squid. Chinook salmon, terns, and harbor seals predate upon smaller bocaccio (Love et al. 2002).

Bocaccio mature between ages three and eight years, at lengths from 32 cm to 61 cm (Wyllie-Echeverria 1987, Love et al. 2002). Evidence suggests that bocaccio may begin to mature at earlier ages in declining populations (MacCall 2002). Sub-adult and adult bocaccio typically utilize habitats with moderate to extreme steepness, complex bathymetry, and rock and boulder-cobble complexes (Love et al. 2002). Within Puget Sound proper, bocaccio have been documented in areas of high relief rocky and non-rocky substrates such as sand, mud, and other unconsolidated sediments (Washington 1977, Miller and Borton 1980). Bocaccio have large home ranges, move long distances, and spend time suspended in the water column (Love et al. 2002). Adult bocaccio inhabit waters from 12-478 m while being most common at depths of 50 to 250 m (Feder et al. 1974, Orr et al. 2000, Love et al. 2002). Some adults are semi-pelagic and form schools above rocky areas, while some are non-schooling, solitary benthic individuals (Yoklavich et al. 2000). Solitary bocaccio have been associated with large sea anemones, as well as under ledges and in crevices of isolated rock outcrops (Yoklavich et al. 2000). Though difficult to age, adults may live as long as 54 years (Drake et al. 2010). Their natural annual mortality is approximately eight percent (Palsson et. al 2009).

Yelloweye Rockfish

NMFS has determined that the PS/GB yelloweye rockfish is likely to become in danger of extinction in the foreseeable future throughout all of its range. The yelloweye rockfish life-history includes a larval/pelagic juvenile stage followed by a nearshore juvenile stage, and sub-adult and adult stages. Yelloweye rockfish may store sperm for several months until fertilization occurs, commonly between September and April, though fertilized individuals may be found year-round, depending on location (Wyllie-Echeverria 1987). In Puget Sound, yelloweye rockfish are believed to fertilize eggs during the winter to summer months and give birth in early spring to late summer (Washington et al. 1978). Fecundity ranges from 1.2 to 2.7 million eggs, considerably more than many other rockfish species (Love et al. 2002). Although yelloweye rockfish are generally thought to spawn once a year (MacGregor 1970), a Puget Sound study offered evidence of at least two spawning periods per year (Washington et al. 1978).

Larvae can make small local movements to pursue food immediately after birth (Tagal et al. 2002), but are likely passively distributed with prevailing currents. Larvae are observed under free-floating algae, seagrass, and detached kelp (Shaffer et al. 1995, Love et al. 2002) but are also distributed throughout the water column (Weis 2004). Unique oceanographic conditions within Puget Sound proper (sills regulating water exchange from one basin to the next) likely result in most larvae staying within the basin where they are released (e.g., the South Sound) rather than being broadly dispersed (Drake et al. 2010). Larval yelloweye rockfish remain pelagic for up to three months.

When yelloweye rockfish reach sizes of 2.5 to 10 cm (1 to 4 in.), they settle primarily in shallow, high relief zones, caves, crevices and areas with sponge gardens (Richards et al. 1985, Love et al. 1991). Juveniles have been documented as shallow as 15 m and generally move deeper as they get older (Love et al. 2002). Though not typically occupying intertidal waters (Love et al. 1991, Studebaker et al. 2009), juvenile yelloweye rockfish eventually settle in 30 to 40 m (98 to 131 ft.) of water near the upper depth range of adults (Yamanaka and Lacko 2001).

Yelloweye rockfish are among the largest rockfish, weighing up to 11 kg (25 lbs.) and are easily recognizable by their bright yellow eyes and red-orange color (Love et al. 2002). Yelloweye rockfish reach 50 percent maturity at sizes around 40 to 50 cm (16 to 20 in.) and ages of 15 to 20 years (Rosenthal et al. 1982, Yamanaka and Kronlund 1997). Sub-adult and adult yelloweye rockfish typically utilize habitats with moderate to extreme steepness, complex bathymetry, and rock and boulder-cobble complexes (Love et al. 2002). As they grow and move to deeper waters, adults utilize rocky, high relief areas that include caves, crevices, rocky pinnacles, and boulder fields (Carlson and Straty 1981, Richards 1986, Love et al. 1991, O'Connell and Carlisle 1993, Yoklavich et al. 2000). Within Puget Sound proper, yelloweye rockfish have been documented in areas of high relief rocky and non-rocky substrates such as sand, mud, and other unconsolidated sediments (Washington 1977, Miller and Borton 1980). In waters less than 90 m deep, adult yelloweye rockfish were observed at a mean depth of 45.8 m (Johnson et al. 2003). Overall, yelloweye rockfish adults are most commonly found between 40 to 250 m (131 to 820 ft.) and have small home ranges (Orr et al. 2000, Love et al. 2002).

Yelloweye rockfish adults do not move much and are generally considered to be relatively site-attached (Coombs 1979, DeMott 1983). Yelloweye rockfish are generally solitary, demersal residents with small home ranges but can be found infrequently in aggregations (Coombs 1979, DeMott 1983, Love et al. 2002). They are opportunistic feeders, targeting different food sources during different phases of their life history, with the early life stages having typical rockfish diets that include sand lance, gadids, flatfishes, shrimps, crabs, and gastropods (Love et al. 2002, Yamanaka et al. 2006). Due to their large sizes, they are able to handle much larger prey, including smaller yelloweye rockfish, and are preyed upon less frequently (Rosenthal et al. 1982). Yelloweye rockfish predators include salmon and orcas (Ford et al. 1998, Love et al. 2002). Yelloweye rockfish are among the longest lived rockfish, living up to at least 118 years (Love 1996, Love et al. 2002) with natural mortality rates estimated from 2 to 4.6 percent (Yamanaka and Kronlund 1997, Wallace 2007).

Spatial Structure and Diversity

A population's spatial structure depends on habitat quality, spatial configuration, and dynamics as well as dispersal characteristics of individuals within the population (McElhaney et al. 2000). In spatially and temporally varying environments, the three general reasons why diversity is important for species and population viability are: (1) diversity allows a species to use a wider array of environments, (2) it protects a species against short-term spatial and temporal changes in the environment, and (3) genetic diversity provides the raw material for surviving long-term environmental changes.

Bocaccio

Prior to contemporary fishery removals, all major basins likely hosted PS/GB bocaccio populations (Washington 1977, Washington et al. 1978, Moulton and Miller 1987). Historically, they were most abundant in the Central and South Sound (Drake et al. 2010). In North Puget Sound, bocaccio have always been rare in recreational fishery surveys. In the Strait of Georgia, bocaccio have been documented in some inlets; but records are sparse, isolated, and often based on anecdotal reports (COSEWIC 2002). This wide distribution allowed bocaccio to utilize the full suite of available habitats to maximize their abundance and demographic characteristics and, thereby, enhance their resilience (Hamilton 2008). This also enabled bocaccio to potentially exploit ephemerally good habitat conditions or, in turn, receive protection from smaller-scale and negative environmental fluctuations. These fluctuations may change prey abundance for various life stages and/or environmental characteristics that influence annual recruitment numbers. However, Puget Sound basin connectivity is naturally restricted by relatively shallow sills located at Deception Pass, Admiralty Inlet, the Tacoma Narrows, and in Hood Canal (Burns 1985) which most likely moderates rockfish larvae movement (Drake et al. 2010).

The steep reduction in PS/GB bocaccio abundance (and consequent fragmentation) has led to concerns about their viability (Drake et al. 2010). In the 1970’s, size-frequency distributions for bocaccio included a wide range of sizes, with recreationally caught individuals from 25 to 85 cm (9.8 to 33.5 in.) and a bi-modal distribution (most captured bocaccio were either 30 cm or 70 cm) (Drake et al. 2010). This broad size distribution suggests a spread of ages, with some successful recruitment over many years. In the 1980’s, a similar size range was still evident in the catch data, but the distribution was flat across length. By the 2000s, no bocaccio size distribution data were available. The temporal trend in bocaccio size distributions also suggests size truncation of the population, with larger fish becoming less common over time. So as the mature fish density has decreased, productivity may have also been impacted by Allee effects despite the propensity of some individuals to move long distances and potentially reestablish aggregations in formerly occupied habitat (Drake et al. 2010).

The BRT concluded there was no available information to support a conclusion of individual bocaccio populations within the DPS. The factors supporting that conclusion include: (1) similarity in age structure, (2) wide distribution of mature reproductive age adults, (3) widespread suitable habitat in a pattern that allows for movement, and (4) bocaccio adults are able to move over relatively long distances (75 FR 22276). Further, the potential loss of diversity for PS/GB bocaccio, in combination with their relatively low productivity, may result in a mismatch with habitat conditions and further reduce population viability (Drake et al. 2010). The unique oceanographic features and relative isolation of some of its basins may have led to unique adaptations, such as larvae release timing (Drake et al. 2010). Rockfish diversity characteristics include fecundity, larvae release timing, larvae condition, morphology, age at reproductive maturity, physiology, and molecular genetic characteristics. Leading factors affecting diversity include: (1) relatively small home ranges of juveniles and subadults (Love et al. 2002) and (2) low population size for all life stages. Results from a recent genetic study comparing bocaccio individuals from within the PS/GB DPS (n=2) to those outside the DPS (n=9) was insignificant due to insufficient sample size (Tonnes et al. 2016).

Yelloweye Rockfish

Prior to contemporary fishery removals, each major basin in the DPS likely hosted relatively large yelloweye rockfish populations (Washington 1977, Washington et al. 1978, Moulton and Miller 1987). This distribution allowed yelloweye rockfish to utilize the full suite of available habitats to maximize their abundance and demographic characteristics and, thereby, enhance their resilience (Hamilton 2008). This distribution also enabled them to potentially exploit ephemerally good habitat conditions or, in turn, receive protection from smaller-scale and negative environmental fluctuations. These fluctuations may change prey abundance for various life stages and/or may change environmental characteristics that influence annual recruit numbers. Yelloweye rockfish are probably most abundant within the San Juan Basin, but the likelihood of juvenile recruitment from this basin to adjacent basins is naturally low because of the generally retentive circulation patterns that.

The apparent steep reduction of ESA-listed rockfish in Puget Sound proper (and their consequent fragmentation) has led to concerns about the viability of these populations (Drake et al. 2010). Recreationally caught yelloweye rockfish in the 1970s spanned a broad size range. By the 2000s, fewer older fish in the population were observed (Drake et al. 2010). However, overall fish numbers in the database were also much lower, making it difficult to determine if clear size truncation occurred. With age truncation, the reproductive burden may have shifted to younger and smaller fish. This could alter larval release timing and condition, which may create a mismatch with habitat conditions and potentially reduce offspring viability (Drake et al. 2010).

Spatial distribution provides a protective measure from larger scale anthropogenic changes that damage habitat suitability, such as oil spills or hypoxia, which can occur within one basin but not necessarily the other basins. When localized depletion of rockfish occurs, it can reduce stock resiliency, especially when exacerbated by the natural hydrologic constrictions within Puget Sound (Levin 1998, Hilborn et al. 2003, Hamilton 2008). Combining this with limited adult movement, yelloweye rockfish population viability may be highly influenced by the probable localized loss of populations within the DPS, thus decreasing spatial structure and connectivity.

Rockfish diversity characteristics include fecundity, larvae release timing, larvae condition, morphology, age at reproductive maturity, physiology, and molecular genetic characteristics. The leading factors affecting diversity are the relatively small home ranges of juveniles and subadults (Love et al. 2002) and low population size of all life stages. Yelloweye rockfish spatial structure and connectivity are likely threatened by the apparently severe reduction of fish numbers throughout Hood Canal and South Puget Sound. At 2,330 square km, Puget Sound is a small geographic area compared with the entire yelloweye rockfish range in the northeastern Pacific.

Results from a recent genetic study comparing yelloweye rockfish individuals from within the PS/GB DPS (n=52) to those outside the DPS (n=52) provided multiple results (Tonnes et al. 2016). First, yelloweye rockfish in inland Canadian waters as far north as Johnstone Strait were genetically similar to those within the PS/GB DPS. Currently, these areas are not included within the boundaries of the DPS. Second, a significant genetic difference exists between individuals (1) outside the DPS and (2) within the DPS and north of the DPS in inland Canadian waters to as far north as Johnstone Strait. Lastly, individuals within Hood Canal are genetically differentiated from the rest of the DPS; thereby indicating a previous unknown degree of population differentiation within the DPS (Tonnes et al. 2016).

Abundance and Productivity

Short- and long-term abundance trends serve as primary risk indicators in natural populations. Trends may be calculated from a variety of quantitative data, including catch, catch per unit of effort (CPUE), and survey data. However, no single reliable historic or contemporary population estimate exists for PS/GB bocaccio and yelloweye rockfish (Drake et al. 2010). Despite this limitation, there is clear evidence all of these species' abundance has declined dramatically (Drake et al. 2010).

With historic fisheries reducing larger, older, more mature rockfish abundance, maternal effects can have a greater influence upon populations. Maternal effects for rockfish show up in numerous traits. Larger and older rockfish females, of various species, have higher weight-specific fecundity (larvae per unit of female weight) (Boehlert et al. 1982, Bobko and Berkeley 2004, Sogard et al. 2008). Several studies have shown that larger or older rockfish females release larvae earlier in the season when compared to smaller or younger females (Nichol and Pikitch 1994, Sogard et al. 2008). Larval birth timing can be crucial in terms of corresponding with favorable oceanographic conditions because most larvae are released on only one day each year, with a few exceptions in southern coastal populations (Washington et al. 1978). Further, larger or older females provide more nutrients to larvae by developing a larger oil globule released at parturition, which provides energy to the developing larvae (Berkeley et al. 2004, Fisher et al. 2007), and in black rockfish enhances early growth rates (Berkeley et al. 2004).

In 2008, WDFW conducted fishery-independent population abundance estimates using spatially and temporally limited research trawls, drop camera surveys, and underwater remotely operated vehicle (ROV) surveys (Pacunski et al. 2013). The trawl surveys were conducted on the bottom to assess marine fish abundance for a variety of species. The drop camera surveys sampled habitats less than 36.6 m (120 ft.), which is potential habitat for bocaccio juveniles. In the San Juan Basin, rocky habitats were mapped and a randomized survey of these areas assessing species assemblages and estimating abundances was conducted. The ROV surveys were conducted exclusively within these rocky habitats and represent the best available abundance estimates because of their survey area, number of transects, and stratification methods. WDFW conducted 200 transects and stratified each rocky habitat survey as either "shallower than" and "deeper than" 36.6 m (120 ft.). The total area surveyed within each stratum was calculated using the average transect width multiplied by the transect length. The mean densities were calculated by dividing the species counts within each stratum by the area surveyed. Population estimates were calculated by multiplying density estimates by the total survey area within each stratum (Pacunski et al. 2013). Additional ROV surveys by WDFW have been conducted in 2010, 2012, and 2013; but results from these surveys have not been published (Tonnes et al. 2016). In 2014, NMFS and WDFW began a rockfish habitat-stratified ROV survey in Puget Sound proper (NMFS 2017). This research enables an assessment of the population while also collecting important habitat information necessary to better characterize rockfish habitat

(NMFS 2017). Population estimates from these recent surveys have not been determined. Further, there are no estimates for juveniles for any of the PS/GB listed rockfish (Tonnes et al. 2016).

Bocaccio

Though bocaccio were never a predominant segment of the multi-species rockfish population within the Puget Sound/Georgia Basin (Drake et al. 2010), their present-day abundance is likely a fraction of their pre-contemporary fishery abundance. These trawls generally sampled over non-rocky substrates where bocaccio are less likely to occur compared to steep-sloped, rocky habitat (Drake et al. 2010). Based on these surveys, the WDFW estimates 4,606 bocaccio are present in the San Juan Islands basin of the DPS (Table 21). This estimate only includes the non-rocky habitats of the San Juan Island basin and, therefore, is likely to be a conservative estimate of the actual PS/GB bocaccio rockfish abundance.

Table 21. WDFW population estimates for bocaccio and yelloweye rockfish (Pacunski et al. 2013).

DPS	Survey Method	Population Estimate	
		North Sound	Puget Sound proper
PS/GB bocaccio	Bottom Trawl	Not Detected	Not Detected
	Drop Camera	Not Detected	Not Detected
	Remote Operated Camera	4,606 (San Juan Basin)	
	Total Population Estimate	**4,606**	
PS/GB yelloweye rockfish	Bottom Trawl	Not Detected	600
	Drop Camera	Not Detected	Not Detected
	Remove Operated Camera	47,407 (San Juan Basin)	
	Total Population Estimate	**47,407** [a]	

[a] The bottom trawl estimate is an incomplete estimate and is therefore not included in the total population estimate.

This information is limiting for PS/GB bocaccio. The total rockfish population in the Puget Sound region is estimated to have declined around three percent per year for the past several decades, which corresponds to an approximate 70 percent decline from the 1965 to 2007 time period (Drake et al. 2010). Relative to other rockfish species, bocaccio have declined in frequency in Puget Sound. Bocaccio declined from 4.63% of the total rockfish catch (1975-1979) to 0.24% of the total rockfish catch (1980-1989) (Drake et al. 2010). From 1996 to 2007, bocaccio were not observed in any of the 2,238 rockfish identified in the dockside surveys of the recreational catches. In a sample this large, the probability of observing at least one bocaccio would be 99.5% assuming it was at the same frequency (0.24%) as in the 1980s (Drake et al. 2010). In 2008 and 2009, some bocaccio were reported by recreational anglers in the Central Sound (WDFW 2011).

Though the bottom trawl and drop camera surveys did not detect bocaccio in Puget Sound proper, bocaccio have been historically present there and have been caught in recent recreational fisheries. Factors for the lack of bocaccio detections in Puget Sound proper include: (1) bocaccio populations are depleted, (2) the general lack of rocky benthic areas in Puget Sound proper may lead to bocaccio densities that are naturally less than the San Juan Basin, and (3) the study design or effort may not have been sufficiently powerful to detect bocaccio.

Productivity measures a population's growth rate through all or a portion of its life-cycle. Bocaccio life-history traits suggest generally low inherent productivity levels because they are long-lived, mature slowly, and have sporadic episodes of successful reproduction (Tolimieri and Levin 2005, Drake et al. 2010). PS/GB bocaccio have a very low intrinsic rate of population growth of 1.01, even in the absence of a targeted fishery (Tolimieri and Levin 2005).

Bocaccio populations do not follow consistent growth trajectories, and sporadic recruitment drives population structure (Drake et al. 2010). Productivity is driven by high fecundity and episodic recruitment events, largely correlated with rare climatic and oceanographic conditions. Tolimieri and Levin (2005) estimated that these environmental conditions occur only about 15% of the time. When these conditions occur, large year-classes may be produced, which can sustain the population during years of reproductive failure. Demographically, this species demonstrates some of the highest recruitment variability among rockfish species, with many years of failed recruitment being the norm (Tolimieri and Levin 2005). This so-called year class strength is present in some fishes but extreme in rockfish (Ralston and Howard 1995).

Yelloweye Rockfish

Yelloweye rockfish were 2.4 percent of the rockfish harvest in the North Sound during the 1960s, 2.1 percent of the harvest during the 1980s, and further decreased to an average of one percent from 1996 to 2002 (Palsson et al. 2009). In Puget Sound proper, yelloweye rockfish were 4.4 percent of the rockfish harvest during the 1960s, 0.4 percent during the 1980s, and 1.4 percent from 1996 to 2002 (Palsson et al. 2009). By the 2000s, evidence of fewer older fish in the population prevailed. Since overall fish numbers in the database were also much lower, it is difficult to determine if size truncation occurred.

In 2008, fishery-independent estimate surveys conducted by WDFW estimated that 47,407 yelloweye rockfish are present in the in the San Juan Islands basin (Table 21). Since this estimate only includes the San Juan Island basin, this estimate is considered a conservative estimate of actual PS/GB yelloweye rockfish abundance. Though yelloweye rockfish were detected via bottom trawl surveys in Puget Sound proper, we do not consider the WDFW estimate of 600 fish to be a complete estimate and were not included. Since juvenile yelloweye rockfish are less dependent on rearing in shallow nearshore environments than bocaccio, the drop camera surveys were not expected to result in any detections.

Productivity measures a population's growth rate through all or a portion of its life-cycle. Yelloweye rockfish life-history traits suggest generally low inherent productivity levels because they are long-lived, mature slowly, and have sporadic episodes of successful reproduction (Tolimieri and Levin 2005, Drake et al. 2010). Adult yelloweye rockfish typically occupy relatively small ranges (Love et al. 2002) and may not move to find suitable mates. So as the density of mature fish has decreased, productivity may have also been impacted by Allee effects. Further, past commercial and recreational fishing may have depressed the DPS to a threshold beyond which optimal productivity is unattainable (Drake et al. 2010). Also, historic over-fishing may have had dramatic impacts on population size or age structure.

Limiting Factors

Several factors, both population- and habitat-related, have caused the listed PS/GB rockfish to decline to the point that NMFS has listed them. Their low intrinsic productivity, combined with continuing threats from bycatch in commercial and recreational harvest, non-native species introductions, loss and degradation of habitat, and chemical contamination increase the extinction risk.

Over the last century in the Puget Sound and Georgia Basin, human activities have introduced a variety of toxins that may affect rockfish populations or their prey. Although few studies have investigated toxin effects on rockfish ecology or physiology, other Puget Sound fish have shown a substantial impact, including reproductive dysfunction of some sole species (Landahl et al. 1997). Contaminants such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and chlorinated pesticides appear in rockfish collected in urban areas (Palsson et al. 2009). Though the highest contamination levels occur in urban areas, toxins can be found in the tissues of fish throughout Puget Sound (West et al. 2001). Several urban embayments have high heavy metal and organic compound levels (Palsson et al. 2009). When organisms living or eating in these sediments are consumed, contaminants are transferred up the food web to higher level predators like rockfishes and a wider geographic area. Rockfish reproductive function is also likely affected by contaminants (Palsson et al. 2009) and other life-history stages may be as well (Drake et al. 2010). Also, Puget Sound water quality is impacted by sewage, animal waste, and nutrient inputs.

Present-day abundance is influenced by bycatch from several commercial and recreational fisheries. Though rockfish may no longer be retained in these fisheries, released fish are often injured or killed by barotrauma. Physoclist fish (such as rockfish) lack the duct connection to the esophagus (Hallacher 1974) and are dependent upon passive gas exchange through their blood in the *rete mirabile* within their swim bladders (Alexander 1966). This allows them to become buoyant at much deeper depths than physotome fish (such as salmon), but rendering them unable to offload gases quickly during a rapid ascent. So when rockfish are brought from depths greater than 18.3 m (60 ft.), rapid decompression occurs (Parker et al. 2006, Jarvis and Lowe 2008, Palsson et al. 2009). During rapid decompression, swim bladder gases expand exponentially which is further exasperated by temperature increases. This results in swim bladder expansion; reduction in body cavity space; and displacement, eversion, and/or injury to the heart, kidneys, stomach, liver, and other internal organs (Rogers et al. 2008, Pribyl et al. 2009, Pribyl et al. 2011). Further, expanding gas can rupture and escape from the swim bladder filling the orbital space behind the eyes, stretching the optic nerve, and causing exophthalmia (Rogers et al. 2008). Once on the surface, rockfish can become positively buoyant, being unable to return to their previous water depth, and make them susceptible to predation (Starr et al. 2002, Hannah et al. 2008, Jarvis and Lowe 2008).

Future climate-induced changes to rockfish habitat could alter their productivity (Drake et al. 2010). Harvey (2005) created a generic bioenergetic model for rockfish, showing that rockfish productivity is highly influenced by climate conditions. For instance, El Niño-like conditions generally lowered growth rates and increased generation time. The negative effect of the warm water conditions associated with El Niño appear to be common across rockfishes (Moser et al. 2000). Rockfish recruitment appears to be correlated at large scales. Field and Ralston (2005) hypothesized that such synchrony was the result of large-scale climate forcing. Exactly how climate influences rockfish in Puget Sound is unknown; however, given the general importance of climate to rockfish recruitment, it is likely that climate strongly influences the dynamics of ESA-listed rockfish population viability (Drake et al. 2010).

Status Summary

Bocaccio

PS/GB bocaccio likely exist at very low abundance; however, observations are rare. Results from a recent genetic study comparing bocaccio individuals from within the PS/GB DPS to those outside the DPS were inconclusive due to an insufficient sample size (Tonnes et al. 2016). Their low intrinsic productivity, combined with continuing threats from bycatch in commercial and recreational harvest, non-native species introductions, loss and degradation of habitat, and chemical contamination, increase the extinction risk. NMFS has determined that this DPS is currently in danger of extinction throughout all of its range; and in its 2016 status review (Tonnes et al. 2016), NMFS has recommended no change in the PS/GB bocaccio's endangered classification.

Yelloweye Rockfish

PS/GB yelloweye rockfish abundance is much less than it was historically. The fish face several threats including bycatch in commercial and recreational harvest, non-native species introductions, and habitat degradation. Results from a recent genetic study comparing yelloweye rockfish individuals from within the PS/GB DPS to those outside the DPS concluded that a significant genetic difference exists between individuals (1) outside the DPS and (2) within the DPS and north of the DPS in inland Canadian waters to as far north as Johnstone Strait (Tonnes et al. 2016). Further, individuals within Hood Canal are genetically differentiated from the rest of the PS/GB DPS; thereby indicating a previous unknown degree of population differentiation within the DPS (Tonnes et al. 2016). NMFS has determined that this DPS is likely to be in danger of extinction in the foreseeable future throughout all of its range; and in its 2016 status review (Tonnes et al. 2016), NMFS has recommended no change in the PS/GB yelloweye rockfish's threatened classification.

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[6]; the conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' critical habitat analytical review teams (CHARTs; NOAA Fisheries 2005) evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area

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

compared to other areas within the species' range, and the significance to the species of the population occupying that area. Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution of the population it served (e.g., a population at the extreme end of geographic distribution), or the fact that it serves another important role (e.g., obligate area for migration to upstream spawning areas).

2.2.3.1 Puget Sound Chinook Salmon

Critical habitat was designated for PS Chinook salmon on September 2, 2005, when NMFS published a final rule in the *Federal Register* (70 FR 52630). There are approximately 1,683 miles of stream habitats and 2,182 miles of nearshore marine habitats designated as critical habitat for PS Chinook salmon.

As part of the designation process, NMFS convened Critical Habitat Analytical Review Teams (CHART) to evaluate the current habitat status and identify habitat health threats. The Puget Sound CHART's assessment of habitat quality and identification of habitat threats is available on our website at:
http://www.westcoast.fisheries.noaa.gov/publications/protected_species/salmon_steelhead/critical_habitat/chart_report/2005_chart_ps_chinook.pdf. In determining the areas eligible for critical habitat designation, the PS CHART identified the essential PBFs for species conservation. PS Chinook salmon PBFs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. Of the stream habitats designated as critical habitat, there are 926 miles of spawning/rearing sites, 215 miles of rearing/migration sites, and 542 miles of migration corridors. The 2,182 miles of designated nearshore marine habitats also contain rearing and migration PBFs. There are 61 watersheds within the range of this ESU. Twelve watersheds received a low rating, nine received a medium rating, and 40 received a high rating of conservation value to the ESU. Nineteen nearshore marine areas also received a rating of high conservation value.

PS Chinook salmon populations inhabit rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward. This includes rivers and streams flowing into Hood Canal, South Sound, North Sound, and the Strait of Georgia in Washington. This region experiences reduced rainfalls (50-120 cm) from the rainshadow effect of the Coast Mountains. The area is generally flat with high hills (600 m) at the southern margin of the ecoregion. Soils are composed of alluvial and lacustrine deposits. These deposits are glacial in origin north of Centralia, Washington. This area tends to have large groundwater resources, with groundwater from the bordering mountain ranges helping sustain river flows during drought periods. Peak river flow varies from December to June depending on the contribution of snowpack to surface runoff for each river system. Rivers tend to have sustained flows (five to eight months of flows at 50% of the peak or more), and low flows are generally 10-20% or more of the peak flows (Myers et al. 1998).

Douglas fir represents the primary subclimax forest species, with other coniferous species (lodgepole, western white, and ponderosa pines) locally abundant. Prairie, swamp, and oak, birch, or alder woodlands are also common. The land is heavily forested, and wood-cutting activities (including road building, etc.) contribute to soil erosion, river siltation, and river flow and temperature alteration. The region is heavily urbanized, and domestic and industrial wastes impact local water systems. Urban run-off and sewage treatment influence water quality west of the Cascade Mountains, with the exception of the Olympic Peninsula coastal and northern Puget Sound rivers. Glacial sediment also influences water quality, especially in the Skagit, North Fork Nooksack, Nisqually, and Puyallup/White River basins (Myers et al. 1998).

The PS CHART identified human activities that affect PBF quantity and quality. The major categories are (1) forestry; (2) grazing; (3) agriculture; (4) road building/maintenance; (5) channel modifications/diking; (6) urbanization; (7) sand and gravel mining; (8) dams; (9) irrigation impoundments and withdrawals; (10) river, estuary, and ocean traffic; and (11) wetland loss/removal. In addition to these, salmonid prey species harvest (e.g., herring, anchovy, and sardines) was found to affect nearshore marine PBFs. All of these activities affect PBFs by altering 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.

Habitat blockage and/or degradation occur throughout the PS Chinook salmon ESU range. In general, upper tributaries have been adversely affected by past forest practices, and lower tributaries and mainstem rivers have been degraded by agriculture and/or urbanization. Diking for flood control, draining and filling freshwater and estuarine wetlands, and sedimentation from timber harvests and urban development are cited as problems throughout the ESU (WDF et al. 1993). Blockages, water diversions, and shifts in flow regimes due to hydroelectric development and flood control projects are major habitat problems in several basins. Bishop and Morgan (1996) identified a variety of stream habitat limitations in the range of this species. These include: flow regime changes (all basins), sedimentation (all basins), high temperatures (Dungeness, Elwha, Green/Duwamish, Skagit, Snohomish, and Stillaguamish Rivers), streambed instability (most basins), estuarine loss (most basins), large woody debris loss (Elwha, Snohomish, and White Rivers), pool habitat loss (Nooksack, Snohomish, and Stillaguamish Rivers), and blockage or passage problems associated with dams or other structures (Cedar, Green/Duwamish, Snohomish, and White Rivers).

The Puget Sound Salmon Stock Review Group (PFMC 1997) extensively reviewed habitat conditions for several ESU stocks. They concluded that reductions in habitat quantity and quality have reduced PS Chinook salmon spawner numbers. Causes cited include tributary and mainstem habitat destruction, due to dams, and slough and side-channel habitat loss, due to diking, dredging, and hydromodification. They also noted habitat quality degradation due to land development activities.

2.2.3.2 Hood Canal Summer-run Chum Salmon

Critical habitat was designated for HCS chum salmon on September 2, 2005, when NMFS published a final rule in the *Federal Register* (70 FR 52630). There are approximately 79 miles of stream habitats and 377 miles of nearshore marine habitats designated as critical habitat for HCS chum salmon.

As part of the designation process, NMFS convened Critical Habitat Analytical Review Teams (CHART) to evaluate the current habitat status and identify habitat health threats. The Puget Sound CHART's assessment of habitat quality and identification of habitat threats is available on our

website at
http://www.westcoast.fisheries.noaa.gov/publications/protected_species/salmon_steelhead/critical_habitat/chart_report/2005_chart_hc_chum.pdf. In determining the areas eligible for critical habitat designation, the PS CHART identified the PBFs essential for species conservation. PBFs for HCS chum salmon are those sites and habitat components that support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. Designated critical habitat includes 34 miles of spawning/rearing sites, one mile of rearing/migration sites, 36 miles of migration corridors, and eight miles of unoccupied but essential habitat to ESU conservation. The 377 miles of designated nearshore marine habitats contain rearing and migration PBFs. There are 12 watersheds within the range of this ESU. Three watersheds received a medium rating and nine received a high rating of conservation value to the ESU. Five nearshore marine areas also received a rating of high conservation value.

The HCS chum salmon range from the Dungeness River (western boundary) clockwise around the Olympic Peninsula into and including Hood Canal. HCS chum salmon inhabit the Olympic Peninsula east of the Dungeness River including Discovery and Sequim Bays. Hood Canal is a 100-km-long, fjord-like, blind channel that extends to the west of Puget Sound. Beginning at the northern tip of the Kitsap Peninsula, the Canal runs southward along the eastern side of the Olympic Mountains, takes a sharp eastward turn at the hook-like Great Bend, and ends only a few kilometers from southern Puget Sound. The western shore is on the Olympic Peninsula, with river headwaters high in the Olympic Mountains. The eastern shore is on the Kitsap Peninsula, with rivers much gentler and without headwater snowpack. The Quilcene, Dosewallips, Duckabush, Hamma Hamma, and Skokomish Rivers on the western side of the Canal drain the eastern slope of the Olympic Mountains. These rivers tend to be steep, with cool water and high river flows even in summer. Big Beef Creek and the Dewatto, Tahuya, and Union Rivers drain the eastern shore of the Canal. They are smaller, lowland-type streams on the Kitsap Peninsula. The Kitsap Peninsula, part of a glacial drift plain that covers much of Puget Sound, consists of low rolling hills usually less than 154 m high. The streams have very low flow levels in late summer and early fall. The greater Hood Canal watershed is approximately 2,331 km^2.

The PS CHART identified human activities that affect PBF quantity and quality. The major categories are: (1) forestry; (2) agriculture; (3) road building/maintenance; (4) channel modifications/diking; (5) urbanization; (6) sand and gravel mining; (7) dams; (8) river, estuary, and ocean traffic; and (9) beaver removal. In addition to these, the harvest of salmonid prey species (e.g., herring, anchovy, and sardines) was found to affect nearshore marine PBFs. All of these activities affect PBFs by altering 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.

Stream channels and estuaries are, with few exceptions, moderately to highly degraded throughout the ESU. During the past 150 years, logging, road building, rural development, agriculture, water withdrawal, and channel manipulations (stream cleanout, dredging, and straightening) were common and widespread, especially within low gradient stream reaches utilized by summer chum salmon. Three quarters of the ESU’s watersheds contain simplified, degraded channels either completely lacking a forested riparian zone or surrounded by small diameter, deciduous-dominated forests. Most streams have degraded or reduced pool densities and large woody debris.

Over the past 150 years, development has occurred in nearly all estuaries within Hood Canal and the eastern Strait of Juan de Fuca. Degradation is severe in more than half of these estuaries with an additional 25% moderately degraded. Dikes, roads or causeways, remnant dikes or ditches, and fill are the primary causes of estuarine habitat degradation. In estuarine and nearshore areas, bulkheads, revetments, and impaired riparian corridors have reduced the amount of rearing habitat. Altered river and tidal dynamics have likely reduced estuarine food web productivity and, thus, the carrying capacity for chum salmon and other salmonids.

2.2.3.3 Puget Sound Steelhead

Critical habitat was designated for PS steelhead on February 24, 2016, when NMFS published a final rule in the Federal Register (81 FR 9252). There are approximately 2,031 miles of freshwater and estuarine habitat designated as critical habitat for PS steelhead.

As part of the designation process, NMFS convened a Puget Sound Critical Habitat Analytical Review Team (PS CHART) to evaluate the current habitat status and identify habitat health threats. The PS CHART's assessment of habitat quality and identification of habitat threats for PS steelhead is available on our website at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/steelhead/puget_sound/puget_sound_steelhead_proposed_critical_habitat_supporting_information.html. In determining the areas eligible for critical habitat designation, the PS CHART identified the essential PBFs for species conservation. PS steelhead PBFs are those sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, estuarine areas, and nearshore marine areas. There are 18 subbasins containing 66 watersheds within the range of this DPS. Nine watersheds received a low rating, 16 received a medium rating, and 41 received a high rating of conservation value to the DPS. Additionally, one unoccupied area in the upper Elwha River watershed was identified as essential for the conservation of the species and is being designated as critical habitat.

PS steelhead populations inhabit rivers and streams flowing into Puget Sound including the Straits of Juan De Fuca from the Elwha River, eastward. The Puget Sound region is in the rain shadow of the Olympic Mountains and therefore is drier than the Olympic Peninsula; most of the Puget Sound region averages less than 160 cm of precipitation annually. Puget Sound rivers generally have high relief in the headwaters and extensive alluvial floodplains in the lowlands. The area is generally flat with high hills (600 m) at the southern margin of the ecoregion. Geology and topography are dominated by the effects of the Cordilleran Ice Sheet as evidenced by glacial deposits (alluvial and lacustrine deposits) and the regional geomorphology (Busby et al. 1996). This area tends to have large groundwater resources, with groundwater from the bordering mountain ranges helping sustain river flows during drought periods. Peak river flow varies from December to June depending on the snowpack to surface runoff contribution for each river system. Rivers tend to have sustained flows (five to eight months of flows at 50% of the peak or more), and low flows are generally 10-20% or more of the peak flows (Myers et al. 1998).

Douglas fir represents the primary subclimax forest species, with other coniferous species (lodgepole, western white, and ponderosa pines) locally abundant. Prairie, swamp, and oak, birch, or alder woodlands are also common. The land is heavily forested, and wood-cutting activities (including road building, etc.) contribute to soil erosion, river siltation, and river flow and temperature alteration. The region is heavily urbanized, and domestic and industrial wastes impact local water systems. Urban run-off and sewage treatment influence water quality west of the Cascade Mountains, with the exception of the Olympic Peninsula coastal and northern Puget Sound rivers. Glacial sediment also influences water quality, especially in the Skagit, North Fork Nooksack, Nisqually, and Puyallup/White River basins (Myers et al. 1998).

The PS CHART identified human activities that affect PBF quantity and quality. The major categories are (1) forestry; (2) grazing; (3) agriculture; (4) road building/maintenance; (5) channel modifications/diking; (6) urbanization; (7) sand and gravel mining; (8) mineral mining; (9) dams; (10) irrigation impoundments and withdrawals; (11) river, estuary, and ocean traffic; (12) wetland loss/removal; (13) beaver removal; and (14) exotic/invasive species introductions. In addition to these, salmonid prey species harvest (e.g., herring, anchovy, and sardines) was found to affect nearshore marine PBFs. All of these activities affect PBFs by altering 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.

Dams have dramatically affected steelhead habitat use in a number of Puget Sound subbasins. In addition to eliminating accessible habitat, dams affect habitat quality by changing river hydrology, temperature profiles, downstream gravel recruitment, and large woody debris movement. Dams have impeded upstream access to historical steelhead habitat in the following systems: Middle Fork Nooksack River, Baker River, Cedar River, Green River, White River, Nisqually River basin, and North Fork Skokomish River. Trap and haul programs have made passage above the dams on the Baker River and White River possible. A smolt collection facility has allowed downstream passage possible on the Baker River. On the White River, downstream migrants pass directly through the dams. Overall, passage efficiency is higher for larger (yearling) smolts (e.g., coho and sockeye salmon and steelhead) that migrate near the surface than for subyearling smolts (Chinook, chum, and pink salmon).

Urban development has dramatically altered many of the lower reaches of rivers and their tributaries in Puget Sound. Urbanization has destroyed historical land cover and exchanged it for large areas of imperious surface (buildings, roads, parking lots, etc.). Wetland and riparian habitat loss has dramatically changed urban stream hydrology by increasing flood frequency and peak flows during storm events while decreasing groundwater-driven summer flows. Agricultural land development has altered the historical land cover and directly impacted river morphology, since much of this development occurs in river floodplains. Dike construction, bank hardening, and channelization have reduced river braiding and sinuosity. Constricting a river, especially during high flow events, increases the likelihood of gravel scour and the dislocation of rearing juveniles.

Habitat blockage and/or degradation occur throughout the PS steelhead DPS range. In general, upper tributaries have been adversely affected by past forest practices, and lower tributaries and mainstem rivers have been degraded by agriculture and/or urbanization. Diking for flood control, draining and filling freshwater and estuarine wetlands, and sedimentation from timber harvests and urban development are cited as problems throughout the DPS (WDF et al. 1993). Blockages, water diversions, and shifts in flow regimes due to hydroelectric development and flood control projects are major habitat problems in several basins. Bishop and Morgan (1996) identified a variety of stream habitat limitations in the range of this species. These include: flow regime changes (all basins), sedimentation (all basins), high temperatures (Dungeness, Elwha, Green/Duwamish, Skagit, Snohomish, and Stillaguamish Rivers), streambed instability (most basins), estuarine loss (most basins), large woody debris loss (Elwha, Snohomish, and White Rivers), pool habitat loss (Nooksack, Snohomish, and Stillaguamish Rivers), and blockage or passage problems associated with dams or other structures (Cedar, Green/Duwamish, Snohomish, and White Rivers).

2.2.3.4 Ozette Lake Sockeye Salmon

Critical habitat was designated for OL sockeye salmon on September 2, 2005, when NMFS published a final rule in the Federal Register (70 FR 52630). There are approximately 41 miles of stream habitats and 12 square miles of lake habitats designated as critical habitat for OL sockeye salmon. Critical habitat is defined as the stream channels within the designated stream reaches and extends laterally to the ordinary high-water line. In areas where ordinary high-water line has not been defined, the lateral extent is defined by the bankfull elevation. Critical habitat in lake areas is defined by the perimeter of the water body as displayed on standard 1:24,000 scale topographic maps or the elevation of ordinary high water, whichever is greater.

The freshwater habitat for this ESU is contained within a single watershed. In the final critical habitat designation for OL sockeye salmon NMFS excluded Indian Lands and other habitat areas where the benefits of exclusion outweighed the benefits of inclusion. NMFS excluded approximately <1 mile of stream because it overlaps with Indian lands. Approximately 2 miles of stream were excluded because they are covered by a habitat conservation plan.

As part of the designation process NMFS convened Critical Habitat Analytical Teams (CHART) to evaluate the current status of the habitat and identify threats to habitat health. The Puget Sound CHART's assessment of habitat quality and identification of habitat threats is available on our website at http://www.nwr.noaa.gov/Salmon-Habitat/Critical-Habitat/2005-Biological-Teams-Report.cfm. In determining what areas are eligible for critical habitat designation, the PS CHART identified the PBFs that are essential for the conservation of the species. PBFs for OL sockeye salmon are those sites and habitat components that support one or more life stages, including freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors. Of the areas designated as Critical Habitat, there are eight miles of spawning/rearing sites, 19 miles of rearing/migration sites, and 14 miles of migration corridors.

The PS CHART identified human activities that affect PBF quantity and quality. The major categories include, but are not limited to, forestry and introduction of exotic invasive plants. Both of these activities affect PBFs by altering one or more of the following: stream hydrology, lake surface elevation, geomorphology and sediment transport, temperature, dissolved oxygen, vegetation, soils, nutrients and chemicals, and physical habitat structure.

NMFS developed a multi-factor scoring system that the CHART used to determine conservation value ratings for each watershed or area. Because the freshwater spawning, rearing and migration PBF's for OL sockeye salmon are contained within a single watershed, the CHART determined that the Ozette Lake watershed should receive a high rating of conservation value to the ESU (NMFS 2005b). The CHART concurred that the quantity and current conditions of PBFs are lower than they were historically. However, the CHART also agreed that the watershed has a high potential to improve its PBFs either naturally or through active conservation/restoration.

2.2.3.5 Southern Eulachon

Critical habitat was designated for S eulachon on October 20, 2011, when NMFS published a final rule in the Federal Register (76 FR 65324). NMFS designated 16 specific areas as critical habitat within the states of 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; but no marine areas, including Puget Sound and the Strait of Juan de Fuca, were designated as critical habitat. Areas designated for critical habitat in Washington state include the Columbia River (from the mouth to Bonneville Dam), Grays River, Skamokawa Creek, Elochoman River, Cowlitz River, Toutle River, Kalama River, Lewis River, Quinault River, and Elwha River. The Tribal lands of Lower Elwha Tribe and Quinault Tribe are excluded from critical habitat designation.

As part of the designation process, NMFS evaluated the current status of the habitat and identified threats to habitat health. The assessment of habitat quality and identification of habitat threats is available on our website at http://www.westcoast.fisheries.noaa.gov/protected_species/eulachon/eulachon_critical_habitat.html . In determining what areas are eligible for critical habitat designation, the physical or biological features essential to the conservation of the southern DPS were analyzed as three major categories reflecting key life-history phases of eulachon. 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.

NMFS has identified numerous activities that may affect the physical and biological features essential to eulachon such that special management considerations or protection may be required. Major categories of such activities include: (1) dams and water diversions (i.e. Bonneville Dam, SRS structure – NF Toutle River); (2) dredging and disposal of dredged material (i.e. Cowlitz and Columbia rivers); (3) in-water construction or alterations; (4) pollution and runoff from point and non-point sources (i.e. agriculture, logging, urban); (5) tidal, wind, or wave energy projects; (6) port and shipping terminals; and (7) habitat restoration projects (i.e. salmon habitat restoration goals are different than those for eulachon). 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, flow, temperature and dissolved oxygen levels; erosion and sediment input/transport; physical habitat structure; vegetation; soils; nutrients and chemicals; fish passage; and estuarine/marine prey resources.

2.2.3.6 Puget Sound/Georgia Basin Bocaccio and Yelloweye Rockfish

Critical habitat was designated for PS/GB bocaccio and yelloweye rockfish on November 13, 2014, when NMFS published a final rule in the Federal Register (79 FR 68042). The critical habitat in the

U.S. is spread amongst five interconnected, biogeographic basins (San Juan/Strait of Juan de Fuca basin, Main basin, Whidbey basin, South Puget Sound, and Hood Canal) based upon presence and distribution of adult and juvenile rockfish, geographic conditions, and habitat features.

NMFS has designated 590.4 sq. miles (1,529 sq. km.) of nearshore habitat in Puget Sound, Washington as PS/GB bocaccio critical habitat. Nearshore critical habitat consists of underwater substrates such as sand, rock, and/or cobble compositions from extreme high water out to 30m deep (the limit of the photic zone in Puget Sound). This critical habitat supports kelp, enables forage opportunities and refuge from predators, and enables behavioral and physiological changes needed for juveniles to occupy deeper adult habitats. These nearshore habitats need to provide: (1) quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities and (2) water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

Further, NMFS has designated 414.1 sq. miles (1,072.5 sq. km.) of deepwater habitat in Puget Sound, Washington as PS/GB bocaccio and PS/GB yelloweye critical habitat. Deepwater critical habitat consists of benthic habitats or sites deeper than 30m that possess or are adjacent to areas of complex bathymetry consisting of rock and/or highly rugose habitat. This habitat is essential to conservation because these features support growth, survival, reproduction, and feeding opportunities by providing the structure for rockfish to avoid predation, seek food, and persist for decades. These deepwater habitats need to provide: (1) quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; (2) water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities; and (3) the type and amount of structure and rugosity that supports feeding opportunities and predator avoidance.

As part of the designation process, NMFS evaluated the current status of the habitat and identified threats to habitat health. The assessment of habitat quality and identification of habitat threats is available on our website at http://www.westcoast.fisheries.noaa.gov/protected_species/rockfish/critical_habitat_info.html. Benthic habitat degradation within these waters is a threat to listed rockfish and includes derelict fishing gear, eelgrass and kelp loss, non-native species introduction, and water quality degradation.

Derelict fishing gear is considered a threat to listed rockfish (75 FR 22276) with up to 117,000 derelict nets and pots estimated to lie beneath the waters of Puget Sound (WDFW, unpublished data). As of June 30, 2015, the Northwest Straits Initiative had removed 5,667 derelict fishing nets, 3,634 derelict crab pots, and 58 derelict shrimp pots from Puget Sound with over 460,000 animals found entangled in the derelict gear from waters less than 32 m deep (105 ft.) (data from www.derelictgear.org). Sixty-two fish species have been identified entangled in derelict nets including canary rockfish, Chinook salmon, and chum salmon (data from www.derelictgear.org). Most derelict gillnets were recovered from high-relief habitats featuring rocky ledges and boulders (Drake et al. 2010) which are habitats frequently used by subadult and adult rockfish (Love et al. 2002). Some derelict nets have a tendency to remain stretched open with piles of bones beneath the nets suggesting that entanglement and mortality rates may not decline to negligible rates (Drake et al. 2010). Gilardi et al. (2010) estimated from their Puget Sound study of derelict gillnets that 0.275 fish become entangled daily per net with a mean decomposition rate of 16.8 days and a mean drop-out rate of 31.6% during net recovery.

Kelp coverage is highly variable and has shown long-term declines in some regions, though some kelp beds have increased in areas where artificial substrate provides additional kelp habitat (Palsson et al. 2009). Kelp and eelgrass are stressed by light availability (e.g. turbidity), nutrient levels (e.g. water stratification, eutrophication), toxics (e.g. oil, metals, sulfides), and physical disturbance (e.g. propellers, boat wake) (Mumford 2007). Kelp and eelgrass habitats are important for larval and young juvenile rockfish (Love et al. 2002).

Non-indigenous species are an emerging threat to the native Puget Sound biotic habitat. *Sargassum muiticum*, an introduced brown algae common throughout much of Puget Sound, is a competitor of kelp and eelgrass (Mumford 2007). Several nonindigenous tunicate species, primitive marine animals with firm, flexible bodies enclosed in tough outer coverings, have been identified in Puget Sound. For example, the sea squirt, *Ciona savignyi*, originally found in one location in 2004 has spread to 86% of Hood Canal survey sites within two years (Puget Sound Action Team 2007). Invasive tunicates impacts on rockfish or their habitats is unknown, but results from other regions (e.g., Levin et al. 2002) suggest the potential for widespread impacts on rocky-reef fish populations.

Low dissolved oxygen levels have been an increasing concern. Since the mid-1990s, Hood Canal has seen persistent and increasing areas of low dissolved oxygen with recent fish kill events occurring in 2002, 2003, 2004, 2006, and 2010 (Newton et al. 2012). Typically, rockfish move out of areas with dissolved oxygen less than 2 mg/l; however, when low dissolved oxygen waters were quickly upwelled to the surface in 2003, about 26% of the rockfish population was killed (Palsson et al. 2009). In addition to Hood Canal, Palsson et al. (2009) reported those periods of low dissolved oxygen are becoming more widespread in waters south of Tacoma Narrows.

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, and steelhead in all sub-basins of Puget Sound. 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 and Puget Sound, accessible to listed Chinook salmon, chum salmon, coho salmon, sockeye salmon, steelhead, eulachon, and rockfish. Where it is possible to narrow the range of the research, the effects analysis would take that limited geographic scope into account when determining the proposed actions' impacts on the species and their critical habitat.

In all cases, the proposed research activities would take place in individually very 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 all the proposed actions would take place in designated critical habitat. More detailed habitat information (i.e., 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 HCS chum salmon, OL sockeye salmon, and PS Chinook salmon (70 FR 52630); S eulachon (76 FR 65324); PS/GB bocaccio and PS/GB yelloweye rockfish (79 FR 68042); and PS steelhead (81 FR 9252).

2.4 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for this opinion is therefore the result of the impacts that many activities (summarized below and in the species' status sections) have had on the various listed species' survival and recovery. The action area under consideration covers individual animals that could come from anywhere in the various listed species' entire ranges (see Section 2.3). As a result, the effects of these past activities on the species themselves (effects on abundance, productivity, etc.) cannot be tied to any particular population and are therefore displayed individually in the species status sections that precede this 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. In general, though, and with respect to the species' habitat, the environmental baseline is the culmination of these effects on the physical or biological features (PBFs) that are essential to the conservation of the species.

2.4.1 Summary for all Listed Species

2.4.1.1 Factors Limiting Recovery

The best scientific information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of west coast salmonids. NMFS' status reviews, Technical Recovery Team publications, and recovery plans for the listed species considered in this opinion identify several factors that have caused them to decline, as well as those that prevent them from recovering (many of which are the same). Very generally, these include habitat degradation and curtailment caused by human development and harvest and hatchery practices. NMFS' decision to list them identified a variety of factors that were limiting their recovery. None of these documents identifies scientific research as either a cause for decline or a factor preventing their recovery. See Table 22 for a summary of the major factors limiting recovery of the listed species considered in this opinion; more details can also be found in the individual discussions of the species' status.

Table 22. Major factors limiting recovery.

Major Factors	PS Chinook salmon	HCS chum salmon	PS steelhead	OL sockeye salmon	S eulachon	PS/GB bocaccio	PS/GB yelloweye rockfish
Degraded floodplain and in-river channel structure	•		•	•			
Riparian area degradation and loss of in-river large woody debris	•	•	•	•			
Degraded tributaries/river habitat conditions		•					

Major Factors	PS Chinook salmon	HCS chum salmon	PS steelhead	OL sockeye salmon	S eulachon	PS/GB bocaccio	PS/GB yelloweye rockfish
Reduced access to spawning/rearing habitat			•		•		
Degraded estuarine conditions and loss of estuarine habitat	•	•	•	•			
Excessive sediment in spawning gravels	•	•	•	•			
Degraded water quality	•		•	•	•	•	•
High water temperature	•		•				
Reduced streamflow in migration areas				•			
Predation on adults and juveniles		•		•	•	•	•
Chemical pollutants					•	•	•
Bycatch					•	•	•
Derelict Fishing Gear						•	•
Degradation of nearshore habitats	•					•	•
Climate change	•	•	•	•	•	•	•

For detailed information on how various factors have degraded PBFs, please see any of the following: Busby et al. 1996, Good et al. 2005, Drake et al. 2010, Gustafson et al. 2010, Ford 2011, NMFS 2016a, NMFS 2016b, NWFSC 2016, NMFS 2017, and sections 2.2.3.1-2.2.3.6.

Research Effects

Although not identified as a factor for decline or a threat preventing recovery, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed salmonids—whether intentionally or not. For the year 2018, NMFS has issued numerous research section 10(a)(1)(A) scientific research permits allowing lethal and non-lethal take of listed species, along with the state scientific research programs under ESA section 4(d) and tribal 4(d) research. Table 23 displays the total take for the ongoing research authorized under ESA sections 4(d) and 10(a)(1)(A).

Table 23. Take allotments for research on listed species in 2018.

Species	Life Stage	Origin[a]	Total Take	Percent of Abundance	Lethal Take	Percent of ESU/DPS killed
PS Chinook salmon[b]	Adult	LHAC	1,085	13.24563%	56	0.47630%
		LHIA	667		7	
		Natural	649	3.52468%	24	0.13034%
	Juvenile	LHAC	126,504	0.35045%	5,396	0.01495%

Species	Life Stage	Origin[a]	Total Take	Percent of Abundance	Lethal Take	Percent of ESU/DPS killed
		LHIA	156,114	2.17664%	2,664	0.03714%
		Natural	438,635	17.32939%	7,278	0.28754%
HCS chum salmon	Adult	LHIA	0	0.00000%	0	0.00000%
		Natural	2,011	7.87454%	32	0.12530%
	Juvenile	LHIA	135	0.09000%	3	0.00200%
		Natural	700,133	17.42522%	2,736	0.06809%
OL sockeye salmon	Adult	LHAC	5	2.80899%	0	0.00000%
		Natural	9	0.41997%	4	0.18665%
	Juvenile	LHAC	20	0.04372%	2	0.00437%
		Natural	15	0.00314%	2	0.00042%
PS steelhead[c]	Adult	LHAC	31	8.72542%	6	0.19718%
		LHIA	11		0	
		Natural	1,551		30	
	Juvenile	LHAC	4,400	3.99165%	100	0.09072%
		LHIA	751	0.66167%	12	0.01057%
		Natural	59,133	2.84740%	1,153	0.05552%
S eulachon[d]	Adult	Natural	35,658	0.10322%	33,026	0.09555%
	Juvenile	Natural	405		356	
PS/GB bocaccio[d]	Adult	Natural	19	1.73686%	11	0.54277%
	Juvenile	Natural	61		14	
PS/GB yelloweye rockfish[d]	Adult	Natural	69	0.28477%	31	0.09703%
	Juvenile	Natural	66		15	

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.
[b] Abundances for adult hatchery PS Chinook salmon are LHAC and LHIA combined.
[c] Abundances for all adult PS steelhead are combined
[d] Abundances for juvenile listed rockfish and eulachon are unknown; all take and mortalities will be analyzed as adults

Actual take levels associated with these activities are almost certain to be a good deal lower than the allowed levels. There are several reasons for this. First, the juvenile abundance estimates are deliberately designed to generate a conservative picture of abundance. Second, it is important to remember that estimates of lethal take for most of the proposed studies are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer juveniles would be killed by the research than stated. In fact, for the vast majority of scientific research permits, history has shown that researchers generally take far fewer salmonids than the allotted number of salmonids every year (14.19% of requested take and 12.31% of requested mortalities were used in ID, OR, and WA Section 10a1A permits from 2008 to 2016). Third, for salmonids, many of the fish that may be affected would be in the smolt stage, but others definitely would not be. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, the already small percentages were derived by (a) conservatively estimating the actual number of juveniles, (b) overestimating the number of fish likely to be killed, and (c) treating each dead juvenile fish as part of the same year class. Thus, the actual numbers of juvenile salmonids the research is likely to kill are undoubtedly smaller than the stated figures—probably something on the order of one eighth of the values given in the tables.

2.5 Effects of the Proposed Actions on the Species and Their Designated Critical Habitat

Under the ESA, "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 the Species

As discussed further below, the proposed research activities will have no measurable effects on the habitat of listed salmonids, eulachon, or rockfish. The actions are therefore not likely to measurably affect 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 the fish. Harassment caused by capturing, handling, and releasing fish generally leads to stress and other sub-lethal effects, but the fish do sometimes die from such treatment.

The following subsections describe the types of activities being proposed. Each is described in terms broad enough to apply to all the permits. The activities would be carried out by trained professionals using established protocols. The effects of the activities are well documented and discussed in detail below. No researcher would receive a permit unless the activities (e.g., electrofishing) incorporate NMFS' uniform, pre-established set of mitigation measures. These measures are described in Section 1.3 of this opinion. They are incorporated (where relevant) into every permit as part of the conditions to which a researcher must adhere.

Capture/handling

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

Electrofishing

Electrofishing is a process by which an electrical current is passed through water containing fish in order to stun them—thus making them easy to capture. It can cause a suite of effects ranging from simply disturbing the fish to actually killing them. The amount of unintentional mortality attributable to electrofishing varies widely depending on the equipment used, the settings on the equipment, and the expertise of the technician. 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 and 1995; Dalbey et al. 1996) because lower rates of spinal injury, 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).

NMFS' electrofishing guidelines (NMFS 2000) will be followed in all electrofishing surveys. 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, however, 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. Because of its greater potential to harm fish, and because NMFS has not published appropriate guidelines, boat electrofishing has not been given a general authorization under NMFS' ESA section 4(d) rules. In any case, all researchers intending to use boat electrofishing would use all means at their disposal to ensure that a minimum number of fish are harmed.

Gastric Lavage

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

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

Hook and Line

Fish that are caught and released alive as part of a research project may still die as a result of injuries or stress they experience during capture and handling. The likelihood of killing a fish varies widely, based on a number of factors including the gear type used, the species, the water conditions, and the care with which the fish is released.

The available information assessing hook and release mortality of adult steelhead suggests that hook and release mortality is low. 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. Data on summer-run steelhead and warmer water conditions are less abundant (Cramer et al. 1997). 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 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 natural or synthetic bait reduces juvenile steelhead mortality more than any other angling regulatory change. 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; 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 little difference (or inconclusive results) in the mortality of juvenile steelhead associated with using barbed versus barbless hooks, single versus treble hooks, and different hook sizes (Schill and Scarpella 1995; Taylor and White 1992; Mongillo 1984). However, some investigators believe that the use of barbless hooks reduces handling time and stress on hooked fish and adds to survival after release (Wydoski 1977). In summary, catch-and-release mortality of juvenile steelhead is generally less than 10% and approaches 0% 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 salmon 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 and gear type 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%). A large portion of the mortality in the Lindsay et al. (2004) study was related to deep hooking by anglers using prawns or sand shrimp for bait on two-hook terminal tackle. Other baits and lures produced higher rates of jaw hooking than shrimp, and therefore produced lower hooking mortality estimates. The Alaska study reported very low incidence of deep hooking by anglers using lures and bait while fishing for salmon.

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.

Rockfish barotrauma

Fish have two different types of swim bladders: physotome (open swim bladder) and physoclist (closed swim bladder). Physostome fish (such as salmonids) have a swim bladder connected to the esophagus via the pneumatic duct that allows them to gulp air to fill their swim bladder or quickly release the air when necessary. Physoclist fish (such as rockfish) lack the duct connection to the esophagus (Hallacher 1974) and are dependent upon passive gas exchange through their blood in the rete mirabile within their swim bladders (Alexander 1966). This allows them to become buoyant at much deeper depths than physotome fish, but they are unable to offload gases quickly during a rapid ascent.

For rockfish caught in waters deeper than 60 feet (18.3 m), the primary cause of injury and death is often barotrauma (NMFS 2017). During rapid decompression, swim bladder gases expand exponentially which is further exacerbated by temperature increases. This results in swim bladder expansion; reduction in body cavity space; and displacement, eversion, and/or injury to the heart, kidneys, stomach, liver, and other internal organs (Rogers et al. 2008, Pribyl et al. 2009, Pribyl et al. 2011). Further, expanding gas can rupture and escape from the swim bladder filling the orbital space behind the eyes, stretching the optic nerve, and causing exophthalmia (Rogers et al. 2008). Once on the surface, rockfish can become positively buoyant, meaning they are unable to return to their previous water depth become susceptible to predation (Starr et al. 2002, Hannah et al. 2008, Jarvis and Lowe 2008).

Methods for reducing barotrauma impacts on rockfish include handling rockfish below the surface, decreasing handling time at the surface, and rapidly submerging them to their capture depth (Parker et al. 2006, Hannah and Matteson 2007, Hannah et al. 2008). Hannah et al. (2008) observed that rockfish that failed to submerge either (1) did not attempt to submerge or only made weak attempts to do so or (2) vigorously attempted to submerge and failed, leading to his conclusion that buoyancy is not the sole cause of submergence failure. Starr et al. (2002) captured rockfish and brought them up to 20m below the surface (below the local thermocline) where divers surgically implanted sonic tags in rockfish, placed them in a recovery cage, and released them. Because they observed no mortalities or abnormal swimming when these methods were employed, Starr et al. (2002) deduced that reducing surface handling time appears to improve survivorship. Jarvis and Lowe (2008) noted a 78% survivorship rate after recompression for rockfish released within 10 minutes of landing, which increased to 83% when the fish were released within 2 minutes. Another method for increasing survival for captured rockfish involves rapidly submerging the rockfish after capture and handling. Though the rockfish do not avoid effects of barotrauma when handled in this manner, the immediate impacts of decompression will stop when they are returned to their capture depth. Hochhalter and Reed (2011) compared submergence success of yelloweye rockfish released at the surface and at depth in a mark-recapture study. Though 91% of the individuals showed external signs of barotrauma after capture, the 17-day survival rate was 98.8% after resubmergence, though survival was size-dependent. Yelloweye rockfish released at the surface successfully submerged only 22.1% of the time and had an unknown survivorship rate. In a different study, Hannah and Matteson (2007) researched nine different rockfish different species from six different sites off the Oregon coast. After being captured, rockfish were briefly handled (less than two minutes), placed in a release cage with a video camera, and returned to capture depth/neutral buoyancy. Release behavior was visually observed and scored for behavioral impairment. The behavioral effects of barotrauma appeared to be highly species-specific (probably due to anatomical differences among rockfish species) and health condition at the surface did not appear to be a good indicator of survivorship potential after recompression. In addition, barotrauma effects increase with capture depth.

Tissue Sampling / Marking

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 or severing individual fin rays (Welch and Mills 1981). 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.

Regardless, any time researchers clip or remove fins, it is necessary that the fish be handled. Therefore, the same safe and sanitary conditions required for tissue sampling operations also apply to tagging and marking activities.

2.5.2 Species-specific Effects of Each Permit

In previous sections, we estimated the annual abundance of adult and juvenile listed salmonids, eulachon, and rockfish. Since there are no measurable habitat effects, the analysis will consist primarily of examining directly measurable impacts on abundance. Abundance effects stand on their own and can be tied directly to productivity effects and less directly to structure and diversity effects. Examining the magnitude of these effects at the individual and, where possible, population levels is the best way to determine effects at the species level. Table 24 displays the estimated annual abundance of the listed species.

Table 24. Estimated annual abundance of ESA listed fish.

<table>
<tr><th rowspan="2">Species</th><th rowspan="2">Origin[a]</th><th colspan="2">Abundance</th></tr>
<tr><th>Adult</th><th>Juvenile</th></tr>
<tr><td rowspan="3">PS Chinook salmon</td><td>LHAC</td><td rowspan="2">13,227[b]</td><td>36,097,500</td></tr>
<tr><td>LHIA</td><td>7,172,240</td></tr>
<tr><td>Natural</td><td>18,413</td><td>2,531,163</td></tr>
<tr><td rowspan="2">HCS chum salmon</td><td>LHIA</td><td>1,935</td><td>150,000</td></tr>
<tr><td>Natural</td><td>25,538</td><td>4,017,929</td></tr>
<tr><td rowspan="3">PS steelhead</td><td>LHAC</td><td rowspan="3">18,257[c]</td><td>110,230</td></tr>
<tr><td>LHIA</td><td>113,500</td></tr>
<tr><td>Natural</td><td>2,076,734</td></tr>
<tr><td rowspan="3">OL sockeye salmon</td><td>LHAC</td><td rowspan="2">178[b]</td><td>45,750</td></tr>
<tr><td>LHIA</td><td>259,250</td></tr>
<tr><td>Natural</td><td>2,143</td><td>477,836</td></tr>
<tr><td>S eulachon[d]</td><td>Natural</td><td>34,937,103</td><td>-</td></tr>
<tr><td>PS/GB bocaccio[d]</td><td>Natural</td><td>4,606</td><td>-</td></tr>
<tr><td>PS/GB yelloweye rockfish[d]</td><td>Natural</td><td>47,407</td><td>-</td></tr>
</table>

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.
[b] Abundances for adult hatchery salmonids are LHAC and LHIA combined.
[c] Abundances for all adult PS steelhead are combined
[d] Abundances for juvenile listed rockfish and eulachon are unknown

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

Permit 10020-5R

As noted previously, issuing permit 10020-5R would authorize the COB to renew an existing permit that currently authorizes them to take juvenile and adult PS Chinook salmon and PS steelhead in Cemetery, Padden, Silver, and Squalicum creeks in Bellingham, WA. Using a smolt trap (V-shaped channel-spanning weirs with live boxes), the researchers would capture, anesthetize, identify to species, measure, take a tissue sample (to determine their origin), and allowed to recover in cool, aerated water before being released back to the stream. For natural-origin ESA listed salmonids, up to one adult PS steelhead and six juvenile salmonids (two PS Chinook salmon and four PS steelhead) may die as a result of the research. The requested take is laid out in Table 25.

Table 25. Proposed take under permit 10020-5R.

ESU/DPS	Life Stage	Origin	Take Action	Requested Take	Requested Mortality
PS Chinook salmon	Juvenile	LHAC	C/M,T,S/R	20	1/20
PS Chinook salmon	Juvenile	Natural	C/M,T,S/R	200	2/200
PS steelhead	Adult	Natural	C/M,T,S/R	50	1/50
PS steelhead	Juvenile	Natural	C/M,T,S/R	400	4/400

C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these losses, it is necessary to compare the numbers of fish killed to the total abundance numbers expected for the population and species. This research may kill the following percentages of listed fish abundances (Table 26).

Table 26. Comparison of possible lethal take to annual abundance at the population (Strait of Georgia sub-basin) and ESU/DPS scale for Permit 10020-5R.

ESU/DPS	Life Stage	Origin	Percent of Population	Percent of ESU/DPS
PS Chinook salmon	Juvenile	LHAC	<0.0001%	<0.0001%
PS Chinook salmon	Juvenile	Natural	0.0022%	<0.0001%
PS steelhead	Adult	Natural	0.1024%	0.0055%
PS steelhead	Juvenile	Natural	0.0036%	0.0002%

At the population level, the permitted activities may kill at most 0.1024% of any listed component (natural-origin adult PS steelhead). Other listed salmonid components impacted to lesser degrees, and only as juveniles, include natural-origin PS steelhead (0.0036%), natural-origin PS Chinook salmon (0.0022%), and listed hatchery adipose clipped PS Chinook salmon (<0.0001%). At the ESU/DPS levels, the permitted activities may kill at most 0.0055% of any listed component (natural-origin adult PS steelhead). Other listed salmonid components impacted to lesser degrees, and only as juveniles, include natural-origin PS steelhead (0.0002%) and natural-origin and listed hatchery adipose clipped PS Chinook salmon (<0.0001%). Overall, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity.

Moreover, it is possible that the impacts on listed species abundance are smaller than those laid out above. Over the past ten years (2008-2017), this project used only 9.86% of its authorized take (535 of 5,425) and 3.75% of its authorized mortalities (3 of 80). In response to this unused authorized take and mortalities, overall annual take was reduced by 50.4% (1,350 to 670) and mortalities by 55.6% (18 to 8) for this renewal when compared to the expiring permit.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of this study is to assess the effectiveness of habitat restoration activities within the City of Bellingham by documenting population trends for salmonids inhabiting these urban creeks. These restoration actions include native riparian and upland plantings, large woody debris and gravel augmentation, re-routing and re-structuring of degraded stream channel, and floodplain re-connection. Through long-term monitoring of these habitat restoration projects, project effectiveness can be assessed and its benefit upon the listed species analyzed. This research would benefit the affected species by informing future restoration designs, providing data to support future enhancement projects, and assess the status of salmonid populations in these urban systems.

Permit 16303-2R

As noted previously, issuing permit 16303-2R would authorize the USGS to renew an existing permit that currently authorizes them to take adult S eulachon, PS/GB bocaccio, and PS/GB yelloweye rockfish; juvenile HCS chum salmon and PS steelhead; and juvenile and adult PS Chinook salmon throughout the marine waters of Puget Sound, Hood Canal, and the Strait of Juan de Fuca (Washington state). The researchers would capture fish using mid-water trawls, hook and line (micro-trolling), beach seines, and purse seines. For the mid-water trawls, the fish would be identified to species, weighed, measured for length, tissue samples taken (fin clip and scales), and checked for coded wire tags (CWTs). For the other capture methods, the fish would be anesthetized, identified to species, checked for CWTs, measured to length, gastric lavaged, tissue samples taken (fin clip and scales), and released. For natural-origin salmonids, 13 adult/sub-adult and 1,520 juvenile PS Chinook salmon, 51 juvenile HCS chum salmon, and one juvenile PS steelhead may die as a result of the research. Further, an additional two PS/GB bocaccio, two PS/GB yelloweye rockfish, and 65 S eulachon, all adults, may die as a result of the research. The requested take is laid out in Table 27.

Table 27. Proposed take under permit 16303-2R.

ESU/DPS	Life Stage	Origin	Take Action	Requested Take	Requested Mortality
PS Chinook salmon	Adult	LHAC	C/H/R	180	16/180
PS Chinook salmon	Adult	LHIA	C/H/R	40	3/40
PS Chinook salmon	Adult	Natural	C/H/R	130	11/130
PS Chinook salmon	Juvenile	LHAC	C/M,T,S/R	7,000	0/7,000
PS Chinook salmon	Juvenile	LHAC	IM	5,500	5,500/5,500
PS Chinook salmon	Juvenile	LHIA	IM	1,150	1,150/1,150
PS Chinook salmon	Juvenile	Natural	C/M,T,S/R	2,000	20/2,000
PS Chinook salmon	Juvenile	Natural	IM	1,500	1,500/1,500
PS Chinook salmon	Sub-adult	LHAC	C/M,T,S/R	200	2/200
PS Chinook salmon	Sub-adult	LHIA	C/M,T,S/R	150	1/150
PS Chinook salmon	Sub-adult	Natural	C/M,T,S/R	200	2/200
HCS chum salmon	Juvenile	Natural	C/M,T,S/R	20	1/20
HCS chum salmon	Juvenile	Natural	IM	50	50/50
PS steelhead	Juvenile	LHAC	C/M,T,S/R	30	1/30
PS steelhead	Juvenile	Natural	C/M,T,S/R	30	1/30
S eulachon	Adult	Natural	C/H/R	105	65/105
PS/GB bocaccio	Adult	Natural	C/H/R	4	2/4
PS/GB yelloweye rockfish	Adult	Natural	C/H/R	4	2/4

C/H/R – Capture/Handle/Release; C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal; IM – Intentional Mortality

For this project, the fish mortality rate is expected to range from high to low depending upon the capture method. The mid-water trawl capture method has the highest mortality rate. Juvenile salmon shift to deeper marine waters throughout the year, which results in fish size and species composition continuously changing across marine water depths. This necessitates capture methods that can work at varying water depths. For the past twenty years, this project has used mid-water trawls to study abundance, growth, prey items, survival, and movements of juvenile salmon and other species from the water's surface to 60 m deep. For mid-water trawls, juvenile salmonids and eulachon suffer lethal injuries due to crushing and descaling, none are expected to survive. Adult salmon are larger and better able to survive (historically, about 10% mortality rate in this study). Rockfish are extremely susceptible to barotrauma, thus a moderate mortality rate is expected (about 50%). To combat barotrauma, rockfish would be returned to the water via rapid submersion to their capture depths. For the other capture methods, the majority of the fish that would be captured are expected to receive no adverse physiological, behavioral, nor reproductive effects from the capture methods. For the seining activities, all juvenile, hatchery-origin, CWT fish captured would be intentionally sacrificed to determine their origins. To determine the overall effects of these losses, it is necessary to compare the numbers of fish that may be killed to the total abundance numbers expected for the population and species. This research may kill the following percentages of the juvenile and adult abundances (Table 28).

Table 28. Comparison of possible lethal take to annual abundance at ESU/DPS scale for Permit 16303-2R.

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
PS Chinook salmon	Adult/Sub-adult	LHAC/LHIA	0.1663%
PS Chinook salmon	Adult/Sub-adult	Natural	0.0706%
PS Chinook salmon	Juvenile	LHAC	0.0152%
PS Chinook salmon	Juvenile	LHIA	0.0160%
PS Chinook salmon	Juvenile	Natural	0.0601%
HCS chum salmon	Juvenile	Natural	0.0013%
PS steelhead	Juvenile	LHAC	0.0009%
PS steelhead	Juvenile	Natural	<0.0001%
S eulachon[a]	Adult	Natural	0.0002%
PS/GB bocaccio[a]	Adult	Natural	0.0434%
PS/GB yelloweye rockfish[a]	Adult	Natural	0.0042%

Since take activities would occur throughout the Puget Sound region where all populations could be present, the effect of that take cannot be examined at the population level. At the ESU/DPS levels, the permitted activities may kill at most 0.1663% of any listed component (listed hatchery-produced adult/sub-adult PS Chinook salmon). Other adult/sub-adult ESA-listed components, all of which are natural-origin, impacted to a lesser degree include PS Chinook salmon (0.0706%), PS/GB bocaccio (0.0434%), PS/GB yelloweye rockfish (0.0042%), and S eulachon (0.0002%). Further, juvenile ESA-listed components impacted to a lesser degree include natural-origin (0.0601%), listed hatchery intact adipose (0.0160%), and listed hatchery adipose clipped (0.0152%) PS Chinook salmon; natural-origin HCS chum salmon (0.0013%); and listed hatchery adipose clipped (0.0009%) and natural-origin (<0.0001%) PS steelhead. Therefore, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity.

Moreover, it is possible that the impacts on listed species abundance are smaller than those laid out above. Over the past four years (2013-2016), this project used only 22.39% of its authorized take (18,749 of 83,740) and 30.47% of its authorized mortalities (10,941 of 35,908). In response to this unused authorized take and mortalities, overall annual take was reduced by 12.4% (20,935 to 18,343) and mortalities by 6.7% (8,977 to 8,377) for this renewal when compared to the expiring permit.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of this study is to examine salmonid stage-specific growth, bioenergetics, competition, and predation during the critical early marine growth period. Additionally, unlisted salmonid species, herring, and other forage fish species would be studied for the potential effects from temporal-spatial food supply, temperature, competition, and predation. This research provides essential empirical information, analysis and modeling for determining mechanisms that affect growth and survival of salmon in various regions of the Salish Sea. This research would benefit the affected species by quantifying key factors limiting survival and production of Chinook salmon, which can guide restoration efforts (e.g. water quality) to mechanistically address processes that impact marine mortality.

Permit 17258-2R

As noted previously, issuing permit 17258-2R would authorize the WDNR to renew an existing permit that currently authorizes them to take juvenile PS Chinook salmon, HCS chum salmon, PS steelhead, and OL sockeye salmon throughout the streams of Clallam, Jefferson, and Grays Harbor counties in western Washington state. Using backpack electrofishing equipment and minnow traps, the researchers would capture, identify to species, and release fish. Up to six listed, natural-origin salmonids (two of each species) may die as a result of the research. The requested take is laid out in Table 29.

Table 29. Proposed take under permit 17258-2R.

ESU/DPS	Life Stage	Origin	Take Action	Requested Take	Requested Mortality
PS Chinook salmon	Juvenile	LHAC	C/H/R	33	2/33
PS Chinook salmon	Juvenile	Natural	C/H/R	33	2/33
HCS chum salmon	Juvenile	Natural	C/H/R	33	2/33
PS steelhead	Juvenile	LHAC	C/H/R	33	2/33
PS steelhead	Juvenile	Natural	C/H/R	33	2/33
OL sockeye salmon	Juvenile	LHAC	C/H/R	11	1/11
OL sockeye salmon	Juvenile	Natural	C/H/R	11	1/11

C/H/R – Capture/Handle/Release

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these losses, it is necessary to compare the numbers of fish killed to the total abundance numbers expected for the population and species. This research may kill the following percentages of listed fish abundances (Table 30).

Table 30. Comparison of possible lethal take to annual abundance at the ESU/DPS scale for Permit 17258-2R.

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
PS Chinook salmon	Juvenile	LHAC	<0.0001%
PS Chinook salmon	Juvenile	Natural	<0.0001%
HCS chum salmon	Juvenile	Natural	<0.0001%
PS steelhead	Juvenile	LHAC	0.0018%
PS steelhead	Juvenile	Natural	<0.0001%
OL sockeye salmon	Juvenile	LHAC	0.0044%
OL sockeye salmon	Juvenile	Natural	0.0004%

Since take activities would occur throughout the Puget Sound region where all populations could be present, the effect of that take cannot be examined at the population level. At the ESU/DPS level, the permitted activities may kill at most 0.0044% of any listed component (listed hatchery adipose clipped juvenile OL sockeye salmon). Other listed salmonid components impacted to a lesser degree, and only as juveniles, include listed hatchery adipose clipped PS steelhead (0.0018%); natural-origin OL sockeye salmon (0.0004%); and natural-origin and listed hatchery adipose clipped PS Chinook salmon, natural-origin HCS chum salmon, and natural-origin PS steelhead (<0.0001%). Overall, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity.

Moreover, it is possible that the impacts on listed species abundance are smaller than those laid out above. Over the past four years (2013-2016), this project used none of the authorized take nor mortalities. No changes to authorized take or mortality levels occurred for this renewal.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of the research is to determine potential fish presence or absence in streams located on WDNR-managed lands in order to support a region-wide program of road maintenance and abandonment. WDNR identifies candidate streams for electrofishing as those with potential road-related barriers to fish passage and are typed as fish-bearing based on physical criteria but are suspected to not to support fish. This research would benefit the affected species by determining which streams with road-related passage barriers contain listed fish and, thus, allow WDNR to focus its resources on road improvements that would best help those species.

Permit 17798-2R

As noted previously, issuing permit 17798-2R would authorize the NWFSC to renew an existing permit that currently authorizes them to take juvenile PS Chinook salmon and PS steelhead and adult S eulachon in several bays and estuaries in Puget Sound (Washington State). Using beach seines, the researchers would capture and sacrifice 40 PS Chinook salmon juveniles (prioritizing hatchery produced over natural-origin) for whole body analysis. All excess Chinook salmon and other species would be released. Up to 321 listed, natural-origin juvenile salmonids (1 PS steelhead, 320 PS Chinook salmon) and two listed S eulachon may die as a result of the research. The requested take is laid out in Table 31.

Table 31. Proposed take under permit 17798-2R.

ESU/DPS	Life Stage	Origin	Take Action	Requested Take	Requested Mortality
PS Chinook salmon	Juvenile	LHAC	C/H/R	140	0/140
PS Chinook salmon	Juvenile	LHAC	IM	520	520/520
PS Chinook salmon	Juvenile	Natural	C/H/R	140	0/140
PS Chinook salmon	Juvenile	Natural	IM	320	320/320
PS steelhead	Juvenile	Natural	C/H/R	70	1/70
S eulachon	Adult	Natural	C/H/R	5	2/5

C/H/R – Capture/Handle/Release; IM – Intentional Mortality

The majority of the captured steelhead and eulachon are expected to recover with no adverse physiological, behavioral, nor reproductive effects. However, up to 57% of the requested Chinook salmon take captured for this research would be sacrificed for whole body analysis. For this study, whole genome and molecular analyses of Chinook salmon would be conducted on various tissues, which would allow for identification of gene pathways and robust mechanism-based diagnostic indices for CEC toxicity, thus requiring the directed mortalities. To determine the effects the research may have, it is necessary to compare the numbers of fish killed to the total abundance numbers expected for these species at the population and ESU/DPS levels. This research may kill the following percentages of listed fish abundances (Table 32).

Table 32. Comparison of possible lethal take to annual abundance at the ESU/DPS scale for Permit 17798-2R.

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
PS Chinook salmon	Juvenile	LHAC	0.0014%
PS Chinook salmon	Juvenile	Natural	0.0126%
PS steelhead	Juvenile	Natural	<0.0001%
S eulachon	Adult	Natural	<0.0001%

Since take activities would occur throughout the Puget Sound region where all populations could be present, the effect of that take cannot be examined at the population level. At the ESU/DPS levels, the permitted activities may kill at most 0.0126% of any listed component (juvenile natural-origin PS Chinook salmon). Other listed components impacted to a lesser degree include listed hatchery adipose clipped PS Chinook salmon (0.0014%) and natural-origin juvenile PS steelhead and S eulachon (<0.0001%). Therefore, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity.

Moreover, it is possible that the impacts on listed species abundance are smaller than those laid out above. Over the past four years (2013-2016), this project used only 9.94% of its authorized take (475 of 4,780) and 6.97% of its authorized mortalities (235 of 3,372 requested mortalities). No changes to authorized take or mortality levels occurred for this renewal.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of the research is to assess the bioaccumulation and toxic effects of CECs in Chinook salmon. Because Puget Sound contains a number of sites with multiple chemicals and various source inputs, traditional toxicological approaches do not adequately identify specific compounds that contribute to toxicity and ecosystem degradation. NWFSC's approach incorporates multi-analyte analysis of CEC with molecular and physiological approaches that will identify bioaccumulative CEC in ecologically sensitive indicator species and determine the impacts of these exposures on endocrine function and growth. The research would benefit the listed species by identifying degraded estuaries, studying how CECs impact Chinook salmon, and providing information that can be used to mitigate and improve listed species habitat.

Permit 17839-2R

As noted previously, issuing permit 17839-2R would authorize the USFS to renew an existing permit that currently authorizes them to take juvenile PS Chinook salmon and PS steelhead in the Nooksack, Sauk, Skagit, and Stillaguamish river drainages of western Washington. Using minnow and feddes traps, the researchers would capture, handle, and release fish. Up to four listed, natural-origin juvenile salmonids (two of each species) may die as a result of the research. The requested additional take is laid out in Table 33.

Table 33. Proposed take under Permit 17839-2R.

ESU/DPS	Life Stage	Origin	Take Action	Requested Take	Requested Mortality
PS Chinook salmon	Juvenile	LHAC	C/H/R	45	1/45
PS Chinook salmon	Juvenile	Natural	C/H/R	45	1/45
PS steelhead	Juvenile	Natural	C/H/R	45	1/45

C/H/R – Capture/Handle/Release

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these losses, it is necessary to compare the numbers of fish killed to the total abundance numbers expected for the population and species. This research may kill the following percentages of listed fish abundances (Table 34).

Table 34. Comparison of possible lethal take to annual abundance at the ESU/DPS scale for Permit 17839-2R.

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
PS Chinook salmon	Juvenile	LHAC	<0.0001%
PS Chinook salmon	Juvenile	Natural	<0.0001%
PS steelhead	Juvenile	Natural	<0.0001%

Since take activities would occur in multiple sub-basins in the northern Puget Sound, the effect of that take cannot be examined at the population level. At the ESU/DPS level, the permitted activities may kill at most less than 0.0001% of any juvenile listed component (listed hatchery adipose clipped and natural-origin PS Chinook salmon and natural-origin PS steelhead). Therefore, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity.

Moreover, it is possible that the impacts on listed species abundance are smaller than those laid out above. Over the past four years (2013-2016), this project used only 2.38% of its authorized take (19 of 800) and none of the requested mortalities occurred. In response to this unused authorized take and mortalities, overall annual take was reduced by 32.5% (200 to 135) and mortalities did not change for this renewal when compared to the expiring permit.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of the research is to expand distributional knowledge of the Salish sucker, a species listed as endangered in Canada since 2005 by the Species At Risk Act (SARA). Tissue samples would also be collected from captured Salish suckers for genetic analysis to determine their genetic separation from the longnose sucker – a species that they are considered to be diverging from. The USFS identifies the Salish Sucker as a "strategic" species. Though not considered "sensitive" nor needing to be addressed in Biological Evaluations, "strategic" species are poorly described (i.e., distribution, habitat, threats, or taxonomy) making their conservation status unclear. The research would benefit the listed species by providing information on their distribution. The main benefactor of this research is the Salish sucker whose status is not well understood in the United States.

Permit 17851-3R

As noted previously, issuing permit 17851-3R would authorize the CWI to renew an existing permit that currently authorizes them to take listed juvenile PS Chinook salmon, HCS chum salmon, and PS steelhead and adult S eulachon in the Elwha River estuary (Washington state). Using a beach seine, the researchers would capture, identify to species, handle, measure, and release fish. Up to 75 listed, natural-origin juvenile salmonids (55 PS Chinook salmon, 18 HCS chum salmon, and two PS steelhead) and eight adult S eulachon may die as a result of the research. The requested take is laid out in Table 35.

Table 35. Proposed take under Permit 17851-3M.

ESU/DPS	Life Stage	Origin	Take Action	Requested Take	Requested Mortality
PS Chinook salmon	Juvenile	LHAC	C/H/R	600	6/600
PS Chinook salmon	Juvenile	Natural	C/H/R	5,500	55/5,500
HCS chum salmon	Juvenile	Natural	C/H/R	1,800	18/1,800
PS steelhead	Juvenile	LHAC	C/H/R	120	2/120
PS steelhead	Juvenile	Natural	C/H/R	200	2/200
S eulachon	Adult	Natural	C/H/R	300	8/300

C/H/R – Capture/Handle/Release

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these losses, it is necessary to compare the numbers of fish killed to the total abundance numbers expected for the population and species. This research may kill the following percentages of listed salmonid abundances (Table 36).

Table 36. Comparison of possible lethal take to annual abundance at the population (Dungeness-Elwha sub-basin) and ESU/DPS scale for Permit 17851-3R.

ESU/DPS	Life Stage	Origin	Percent of Population	Percent of ESU/DPS
PS Chinook salmon	Juvenile	LHAC	0.0024%	<0.0001%

ESU/DPS	Life Stage	Origin	Percent of Population	Percent of ESU/DPS
PS Chinook salmon	Juvenile	Natural	0.3144%	0.0022%
HCS chum salmon[a]	Juvenile	Natural	-	0.0004%
PS steelhead	Juvenile	LHAC	0.0200%	0.0018%
PS steelhead	Juvenile	Natural	0.0064%	<0.0001%
S eulachon[a]	Adult	Natural	-	<0.0001%

[a] Abundance is unknown at the population level for this subbasin.

At the population level, the permitted activities may kill at most 0.3144% of any listed component (juvenile PS Chinook salmon). Other listed components impacted to a lesser degree, and only as juveniles, include listed hatchery adipose clipped PS steelhead (0.0200%), natural-origin PS steelhead (0.0064%), and listed hatchery adipose clipped PS Chinook salmon (0.0024%). For this sub-basin, natural-origin HCS chum salmon and S eulachon population abundances are unknown. At the ESU/DPS level, the permitted activities may kill at most 0.0022% of any listed component (juvenile natural-origin PS Chinook salmon). Other listed components impacted to a lesser degree include listed hatchery adipose clipped juvenile PS steelhead (0.0018%); natural-origin juvenile HCS chum salmon (0.0004%); and listed hatchery adipose clipped juvenile PS Chinook salmon, natural-origin juvenile PS steelhead, and natural-origin adult S eulachon (<0.0001%). Therefore, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity.

Moreover, it is possible that the impacts on listed species abundance are smaller than those laid out above. Over the past four years (2013-2016), this project used only 11.43% of its authorized take (3,541 of 30,975) and none of the requested mortalities occurred. No changes to authorized take or mortality levels occurred for this renewal.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of this study is to research the nearshore restoration response to the Elwha River dam removals with an emphasis on ecological function of nearshore habitats for juvenile salmon and forage fish. This study provides information on how watersheds recover after dam removals and how well fish populations recover. The research would benefit listed species by providing a long term continuous dataset on the nearshore use of key salmonid species before, during, and after the dam removals on the Elwha River.

Permit 18001-3R

As noted previously, issuing permit 18001-3R would authorize the PCDPWU to renew an existing permit that currently authorizes them to take juvenile PS Chinook salmon and PS steelhead in the waterways of Pierce County, Washington. Using seines, dip-netting, minnow traps, fyke nets, hook and line, and backpack electrofishing, the researchers would capture, handle, and release fish. Up to four listed, natural-origin juvenile salmonids (one PS Chinook salmon and three PS steelhead) may die as a result of the research. The requested take is laid out in Table 37.

Table 37. Proposed take under Permit 18001-3R.

ESU	Life Stage	Origin	Take Action	Requested Take	Requested Mortality
PS Chinook salmon	Adult	LHAC	C/H/R	8	0/8
PS Chinook salmon	Adult	Natural	C/H/R	7	0/7
PS Chinook salmon	Juvenile	LHAC	C/H/R	60	2/60
PS Chinook salmon	Juvenile	Natural	C/H/R	60	1/60
PS steelhead	Adult	Natural	C/H/R	10	0/10
PS steelhead	Juvenile	Natural	C/H/R	120	3/120

C/H/R – Capture/Handle/Release

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these losses, it is necessary to compare the numbers of fish killed to the total abundance numbers expected for the population and species. This research may kill the following percentages of listed salmonid abundances (Table 38).

Table 38. Comparison of possible lethal take to annual abundance at the population (Nisqually and Puyallup sub-basins) and ESU/DPS scale for Permit 18001-3R.

ESU	Life Stage	Origin	Percent of Nisqually sub-basin Population	Percent of Puyallup sub-basin Population	Percent of ESU/DPS
PS Chinook salmon	Juvenile	LHAC	<0.0001%	<0.0001%	<0.0001%
PS Chinook salmon	Juvenile	Natural	**	0.0011%	<0.0001%
PS steelhead	Juvenile	Natural	0.0012%	0.0030%	0.0001%

** No lethal take was requested for this listed component in this sub-basin.

For the Nisqually sub-basin population, the permitted activities may kill at most 0.0012% of the natural-origin juvenile PS steelhead component and <0.0001% of the listed hatchery adipose clipped PS Chinook salmon component. For the Puyallup sub-basin population, the permitted activities may kill at most 0.0030% of any listed component (natural-origin juvenile PS steelhead). Other listed components impacted to a lesser degree, and only as juveniles, include natural-origin (0.0011%) and listed hatchery adipose clipped (<0.0001%) PS Chinook salmon. At the ESU/DPS level, the permitted activities may kill at most 0.0001% of any listed component (natural-origin juvenile PS steelhead). Other listed components impacted to a lesser degree, and only as juveniles, include natural-origin and listed hatchery adipose clipped PS Chinook salmon (both at <0.0001%). Overall, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity.

Moreover, it is possible that the impacts on listed species abundance are smaller than those laid out above. Over the past four years (2013-2016), this project has used none of its authorized take nor mortalities. No changes to authorized take or mortality levels occurred for this renewal.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of the research is to determine the distribution and diversity of anadromous fish species in the waterbodies adjacent to and within the county's levee system. The surveys would help establish listed salmonid presence in waterbodies about which (1) there is currently little or inconclusive data and (2) could be used to assess the impacts proposed projects may have upon the listed species. The research would benefit the listed species by helping Pierce County assess its best management practice program and in-water work timing windows to minimize project harm to listed fish.

Permit 20313

As noted previously, issuing permit 20313 would authorize the NWFSC take adult PS/GB bocaccio and PS/GB yelloweye rockfish and sub-adult PS Chinook salmon in the Puget Sound near the San Juan Islands (Washington state). Using hook and line, the researchers would scan salmonids for CWTs, measure for length, take tissue samples (scales and fin clips), and release the fish. Hatchery-origin Chinook salmon would also be anesthetized and gastric lavaged. Fifty adipose-clipped, hatchery-origin sub-adult Chinook salmon would be sacrificed for obtaining otolith samples for analysis of movement patterns and early growth history. Up to one listed, natural-origin sub-adult PS Chinook salmon and two listed adult rockfish (one of each species) may die as a result of the research. The requested take is laid out in Table 39.

Table 39. Proposed take under Permit 20313.

ESU	Life Stage	Origin	Take Action	Requested Take	Requested Mortality
PS Chinook salmon	Sub-adult	LHAC	C/M,T,S/R	100	0/100
PS Chinook salmon	Sub-adult	LHAC	IM	50	50/50
PS Chinook salmon	Sub-adult	LHIA	C/M,T,S/R	40	1/40
PS Chinook salmon	Sub-adult	Natural	C/M,T,S/R	25	1/25
PS/GB bocaccio	Adult	Natural	C/H/R	2	1/2
PS/GB yelloweye rockfish	Adult	Natural	C/H/R	2	1/2

C/H/R – Capture/Handle/Release; C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal; IM – Intentional Mortality

The majority of the captured Chinook salmon are expected to recover with no adverse physiological, behavioral, nor reproductive effects. However, up to 23% of the requested Chinook salmon take captured for this research would be sacrificed for otolith analysis (and only LHAC). For this study, otolith microchemistry would be used to determine resident Chinook salmon movement among coarse habitat features (San Juan Islands, Puget Sound, Strait of Georgia, and Pacific Ocean) and over a broad time-scale (e.g., summer vs winter). For listed rockfish, they are extremely susceptible to barotrauma, thus a moderate mortality rate is expected (about 50%). To combat barotrauma, rockfish would be returned to the water via rapid submersion to their capture depths. To determine the effects the research may have, it is necessary to compare the numbers of fish killed to the total abundance numbers expected for these species at the population and ESU/DPS levels. This research may kill the following percentages of listed fish abundances (Table 40).

Table 40. Comparison of possible lethal take to annual abundance at the ESU/DPS scale for Permit 20313.

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
PS Chinook salmon	Sub-adult	LHAC/LHIA	0.3856%
PS Chinook salmon	Sub-adult	Natural	0.0054%
PS/GB bocaccio	Adult	Natural	0.0217%
PS/GB yelloweye rockfish	Adult	Natural	0.0021%

Since take activities would occur in the Puget Sound where all populations could be present, the effect of that take cannot be examined at the population level. At the ESU/DPS level, the permitted activities may kill at most 0.3856% of any listed component (sub-adult listed hatchery PS Chinook salmon). Even though this is a higher than usual lethal take for any listed component, these are hatchery fish who would have been further subjected to fisheries and hatcheries and are being sacrificed in lieu of natural-origin PS Chinook salmon. Other listed components impacted to a lesser degree include natural-origin adult PS/GB bocaccio (0.0217%), natural-origin sub-adult PS Chinook salmon (0.0054%), and natural-origin adult PS yelloweye rockfish (0.0021%). Therefore, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity. Since approved research projects rarely use all of the take and mortalities authorized to them, it is possible that the impacts could be even smaller than those laid out above.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of the research is to assess the role of Chinook salmon residency relative to salmon recovery, including growth, movement patterns, and population structure. These efforts serve as the foundation for evaluating the relative contribution of residents to the broader ESU and the implications of this behavior type to salmon recovery both locally and throughout the region. This research would benefit the affected species by understanding which populations contribute to the resident PS Chinook salmon population in the San Juan Islands and determining the relationship between the resident life-history type and overall marine survival.

Permit 20451-2R

As noted previously, issuing permit 20451-2R would authorize the UW to renew an existing permit that currently authorizes them to take juvenile and adult OL sockeye salmon in Lake Ozette (northwest Washington state). Using minnow traps, hoop nets, gill nets, trammel nets, and hook and line, the researchers would capture, handle, and release fish. Up to one listed, natural-origin juvenile OL sockeye salmon may die as a result of the research. The requested take is laid out in Table 41.

Table 41. Proposed take under Permit 20451-2R.

ESU	Life Stage	Origin	Take Action	Requested Take	Requested Mortality
OL sockeye salmon	Adult	Natural	C/H/R	9	0/9
OL sockeye salmon	Juvenile	Natural	C/H/R	60	1/60

C/H/R – Capture/Handle/Release

Because the majority of the fish that would be captured are expected to recover with no adverse physiological, behavioral, nor reproductive effects, the true effects of the proposed action considered herein are best seen in the context of the fish that are likely to be killed. To determine the effects of these losses, it is necessary to compare the numbers of fish killed to the total abundance numbers expected for the population and species. This research may kill the following percentage of juvenile listed salmonid abundances (Table 42).

Table 42. Comparison of possible lethal take to annual abundance at the ESU scale for Permit 20451-2R.

ESU	Life Stage	Origin	Percent of ESU
OL sockeye salmon	Juvenile	Natural	0.0002%

Since the OL sockeye salmon is only composed of one population, analysis at the ESU and population level is the same. At the ESU/population level, the permitted activities may kill at most 0.0002% of the natural, juvenile OL sockeye salmon component. Therefore, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measureable effect on their spatial structure or diversity.

Moreover, it is possible that the impacts on listed species abundance are smaller than those laid out above. For this project, only one annual report has been submitted (2016); and none of the authorized take nor mortalities occurred. No changes to authorized take or mortality levels occurred for this renewal.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of this study is to investigate the interactions of native predators (i.e., northern pikeminnow, sculpin) and non-native predators (i.e. largemouth bass, yellow perch) with Olympic mudminnow, a state sensitive species. The project will characterize the threats to Olympic mudminnow presented by interactions (competition and predation) with non-native species through analysis of diet and stable isotopes, determine the importance of aquatic and terrestrial resources to mudminnow diet, and the extent of diet overlap with potential competitors (e.g., juvenile perch and bass). The research would benefit the listed species because OL sockeye salmon are similarly threatened by the same predators.

2.5.3 Effects on Critical Habitat

Full descriptions of effects of the proposed activities are found in the previous section. In general, the activities would be (1) electrofishing, (2) capturing fish with angling equipment, traps, and nets of various types, (3) collecting biological samples from live fish, and (4) collecting deceased fish for biological sampling. All of these techniques are minimally intrusive in terms of their effect on habitat because they would involve very little, if any, disturbance of streambeds or adjacent riparian zones. None of the activities will measurably affect any habitat 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.

2.6 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). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the 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 vs. cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described in the environmental baseline (Section 2.3).

Future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could impact listed species or their habitat. Government actions are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the action area which encompasses numerous government entities exercising various authorities, make any analysis of cumulative effects difficult and speculative. For more information on the various efforts being made at the local, tribal, state, and national levels to conserve PS Chinook salmon and other listed salmonids, see any of the recent status reviews, listing *Federal Register* notices, and recovery planning documents, as well as recent consultations on issuance of section 10(a)(1)(A) research permits, the Puget Sound Salmon Recovery Plan (SSDC 2007), and NMFS (2006).

Because the action area falls within navigable waters, the vast majority of future actions in the region will undergo section 7 consultation with one or more of the Federal entities with regulatory jurisdiction over water quality, flood management, navigation, or hydroelectric generation. In almost all instances, proponents of future actions will need government funding or authorization to carry out a project that may affect salmon or its habitat; and therefore, the effects such a project may have on salmon and steelhead will be analyzed when the need arises.

In developing this biological opinion, we considered several efforts being made at the local, tribal, state, and national levels to conserve listed salmonids—primarily final recovery and efforts laid out in the Status review updates for Pacific salmon and steelhead listed under the Endangered Species Act (NMFS 2016a and b). 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 (like that in this opinion) before they are allowed to proceed.

Non-Federal actions are likely to continue affecting listed species. The cumulative effects in the action area are difficult to analyze because of this opinion's 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, based on the trends identified in the baseline, the adverse cumulative effects are likely to increase. From 1960 through 2016, the population in Puget Sound has increased from 1.77 to 4.86 million people (Source: http://www.ofm.wa.gov/). During this population boom, urban land development has eliminated hydrologically mature forest and undisturbed soils resulting in significant change to stream channels (altered stream flow patterns, channel erosion) which eventually results in habitat simplification (Booth et al. 2002). Combining this population growth with over a century of resource extraction (logging, mining, etc.), Puget Sound's hydrology has been greatly changed and has created a different environment than what Puget Sound salmonids evolved in (Cuo et al. 2009). Scholz et al. (2011) has documented adult coho salmon mortality rates of 60-100% for the past decade in urban central Puget Sound streams that are high in metals and petroleum hydrocarbons especially after stormwater runoff. In addition, marine water quality factors (e.g. climate change, pollution) are likely to continue to be degraded by various human activities that will not undergo consultation. 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 NMFS can consider them "reasonably foreseeable" in its analysis of cumulative effects. Thus, the most likely cumulative effect is that the habitat in the action area is likely to continue to be degraded with respect to its ability to support the listed salmonids.

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 as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes 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). They are also made in consideration of the other scientific research and monitoring that has been authorized through 4(d) and Section 10(a)(1)(A) permits and may affect the various listed species. The reasons we integrate the proposed take in the nine permits considered here with the take from other research authorizations are that they are similar in nature, and we have good information on what the effects are. Thus, it is possible to determine the overall effect of all research in the region on the species considered here. The following three tables, therefore, (a) combine the proposed take for all the permits considered in this opinion for all components of each species (Table 43), (b) add the take proposed by the researchers in this opinion to the take that has already been authorized in the region (Table 44), and then (c) compare those totals to the estimated annual abundance of each species under consideration (Table 45).

Table 43. Total requested take for the permits and percentages of the ESA listed species for permits covered in this Biological Opinion.

Species	Life Stage	Origin[a]	Total Take	Percent of Abundance	Lethal Take	Percent of ESU/DPS killed
PS Chinook salmon[b]	Adult	LHAC	538	5.80631%	68	0.55190%
		LHIA	230		5	
		Natural	362	1.96600%	14	0.07603%
	Juvenile	LHAC	13,968	0.03870%	6,083	0.01685%
		LHIA	1,150	0.01603%	1,150	0.01603%
		Natural	9,798	0.38709%	1,902	0.07514%
HCS chum salmon	Adult	LHIA	0	0.00000%	0	0.00000%
		Natural	0	0.00000%	0	0.00000%
	Juvenile	LHIA	0	0.00000%	0	0.00000%
		Natural	1,903	0.04736%	71	0.00177%
OL sockeye salmon	Adult	LHAC	0	0.00000%	0	0.00000%
		Natural	9	0.41997%	0	0.00000%
	Juvenile	LHAC	11	0.02404%	1	0.00219%
		Natural	71	0.01486%	2	0.00042%
PS steelhead[c]	Adult	LHAC	0	0.32864%	0	0.00548%
		LHIA	0		0	
		Natural	60		1	
	Juvenile	LHAC	183	0.16602%	5	0.00454%
		LHIA	0	0.00000%	0	0.00000%
		Natural	898	0.04324%	15	0.00072%
S eulachon[d]	Adult	Natural	410	0.00117%	75	0.00021%
	Juvenile	Natural	0		0	
PS/GB bocaccio[d]	Adult	Natural	6	0.13026%	3	0.06513%
	Juvenile	Natural	0		0	
PS/GB yelloweye rockfish[d]	Adult	Natural	6	0.01266%	3	0.00633%
	Juvenile	Natural	0		0	

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.
[b] Abundances for adult hatchery salmonids are LHAC and LHIA combined.
[c] Abundances for all adult PS steelhead are combined
[d] Abundances for juvenile listed rockfish and eulachon are unknown; all take and mortalities will be analyzed as adults

Table 44. Total expected take of the ESA listed species for scientific research and monitoring already approved for 2018.

Species	Life Stage	Origin[a]	Total Take	Percent of Abundance	Lethal Take	Percent of ESU/DPS killed
PS Chinook salmon[b]	Adult	LHAC	1,085	13.24563%	56	0.47630%
		LHIA	667		7	
		Natural	649	3.52468%	24	0.13034%
	Juvenile	LHAC	126,504	0.35045%	5,396	0.01495%
		LHIA	156,114	2.17664%	2,664	0.03714%
		Natural	438,635	17.32939%	7,278	0.28754%
HCS chum salmon	Adult	LHIA	0	0.00000%	0	0.00000%
		Natural	2,011	7.87454%	32	0.12530%
	Juvenile	LHIA	135	0.09000%	3	0.00200%
		Natural	700,133	17.42522%	2,736	0.06809%
OL sockeye salmon	Adult	LHAC	5	2.80899%	0	0.00000%

Species	Life Stage	Origin[a]	Total Take	Percent of Abundance	Lethal Take	Percent of ESU/DPS killed
		Natural	9	0.41997%	4	0.18665%
	Juvenile	LHAC	20	0.04372%	2	0.00437%
		Natural	15	0.00314%	2	0.00042%
PS steelhead[c]	Adult	LHAC	31	8.72542%	6	0.19718%
		LHIA	11		0	
		Natural	1,551		30	
	Juvenile	LHAC	4,400	3.99165%	100	0.09072%
		LHIA	751	0.66167%	12	0.01057%
		Natural	59,133	2.84740%	1,153	0.05552%
S eulachon[d]	Adult	Natural	35,658	0.10322%	33,026	0.09555%
	Juvenile	Natural	405		356	
PS/GB bocaccio[d]	Adult	Natural	19	1.73686%	11	0.54277%
	Juvenile	Natural	61		14	
PS/GB yelloweye rockfish[d]	Adult	Natural	69	0.28477%	31	0.09703%
	Juvenile	Natural	66		15	

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.
[b] Abundances for adult hatchery salmonids are LHAC and LHIA combined.
[c] Abundances for all adult PS steelhead are combined
[d] Abundances for juvenile listed rockfish and eulachon are unknown; all take and mortalities will be analyzed as adults

Table 45. Total expected take of the ESA listed species for scientific research and monitoring already approved for 2018 plus the permits covered in this Biological Opinion.

Species	Life Stage	Origin[a]	Total Take	Percent of Abundance	Lethal Take	Percent of ESU/DPS killed
PS Chinook salmon[b]	Adult	LHAC	1,623	19.05194%	124	1.02820%
		LHIA	897		12	
		Natural	1,011	5.49069%	38	0.20638%
	Juvenile	LHAC	140,472	0.38915%	11,479	0.03180%
		LHIA	157,264	2.19268%	3,814	0.05318%
		Natural	448,433	17.71648%	9,180	0.36268%
HCS chum salmon	Adult	LHIA	0	0.00000%	0	0.00000%
		Natural	2,011	7.87454%	32	0.12530%
	Juvenile	LHIA	135	0.09000%	3	0.00200%
		Natural	702,036	17.47258%	2,807	0.06986%
OL sockeye salmon	Adult	LHAC	5	2.80899%	0	0.00000%
		Natural	18	0.83994%	4	0.18665%
	Juvenile	LHAC	31	0.06776%	3	0.00656%
		Natural	86	0.01800%	4	0.00084%
PS steelhead[c]	Adult	LHAC	31	9.05406%	6	0.20266%
		LHIA	11		0	
		Natural	1,611		31	
	Juvenile	LHAC	4,583	4.15767%	105	0.09526%
		LHIA	751	0.66167%	12	0.01057%
		Natural	60,031	2.89064%	1,168	0.05624%
S eulachon[d]	Adult	Natural	36,068	0.10440%	33,101	0.09576%
	Juvenile	Natural	405		356	
PS/GB bocaccio[d]	Adult	Natural	25	1.86713%	14	0.60790%
	Juvenile	Natural	61		14	

Species	Life Stage	Origin[a]	Total Take	Percent of Abundance	Lethal Take	Percent of ESU/DPS killed
PS/GB yelloweye rockfish[d]	Adult	Natural	75	0.29742%	34	0.10336%
	Juvenile	Natural	66		15	

[a] LHAC=Listed Hatchery Adipose Clipped, LHIA = Listed Hatchery Intact Adipose.
[b] Abundances for adult hatchery salmonids are LHAC and LHIA combined.
[c] Abundances for all adult PS steelhead are combined
[d] Abundances for juvenile listed rockfish and eulachon are unknown; all take and mortalities will be analyzed as adults

Salmonids

Juvenile life-stage

For juvenile salmonids, the total amount of estimated natural-origin, lethal take for the proposed research would be 1,902 PS Chinook salmon, 71 HCS chum salmon, 2 OL sockeye salmon, and 15 PS steelhead. This is the maximum amount of natural-origin salmonid take contemplated in this biological opinion; if the various permits are granted and exercised, a lesser amount of take is expected to actually occur. Eight of the nine permits in this biological opinion are renewals, and the ninth permit does not request any juvenile salmonid take. Since five of these permits kept their lethal take unchanged and three permits reduced their lethal take request, the overall juvenile listed salmonid lethal take analyzed here is less than what NMFS approved in the previous biological opinion (WCR-2017-7147).

PS Chinook salmon – Overall, these numbers represent a very small fraction of the expected juvenile abundances and will kill at most 0.07514% of the natural-origin component, 0.01685% of the listed hatchery adipose clipped component, and 0.01603% listed hatchery intact adipose of the PS Chinook salmon component (Table 43). Eight permits requested take of PS Chinook salmon with permit 16303-2R requesting 90% of the take (8,220 of 9,135 – listed hatchery and natural-origin components combined). Most of this take is due to the use of variable depth trawl net surveys throughout Puget Sound, which result in a 100% mortality rate of juvenile salmonids due to crushing and descaling. These surveys have been ongoing since 1997 by the CDFO in coordination with surveys by the NWFSC to research salmon biology along the West Coast of North America. Overall, the amount of take (baseline plus research from this biological opinion) represents a very small fraction of the expected juvenile abundances and will be, at most, 0.36268% natural-origin, 0.05318% listed hatchery intact adipose, and 0.03180% listed hatchery adipose clipped PS Chinook salmon (Table 45).

HCS chum salmon – Overall, these numbers represent a very small fraction of the expected juvenile abundance and will kill at most 0.00177% of the natural-origin HCS chum salmon component (Table 43). The applicants requested no take of listed hatchery intact adipose HCS chum salmon. Three permits request take of HCS chum salmon with permit 16303-2R requesting 71.8% of the take (51 of 71) due to the reasons as outlined above. Overall, the amount of take (baseline plus research from this biological opinion) represents a very small fraction of the expected juvenile abundances and will be, at most, 0.06986% natural-origin component of HCS chum salmon (Table 45).

OL sockeye salmon – Overall, these numbers represent a very small fraction of the expected juvenile abundances and will kill at most 0.00219% of the listed hatchery adipose clipped component and 0.00042% of the natural-origin OL sockeye salmon component (Table 43). Only two permits

(17258-2R and 21451-2R) requested take of OL sockeye salmon. Both requests are for incidental take due to the capture methods (various nets, hook and line, and backpack electrofishing) with an overall mortality rate of 3.7% (three of the requested 82 take being lethal). Overall, the amount of take (baseline plus research from this biological opinion) represents a very small fraction of the expected juvenile abundances and will be, at most, 0.00656% listed hatchery adipose clipped and 0.00084% natural-origin OL sockeye salmon (Table 45).

PS steelhead – Overall, these numbers represent a very small fraction of the expected juvenile abundances and will kill at most 0.00454% of the listed hatchery adipose clipped component and 0.00072% of the natural-origin PS steelhead component (Table 43). Seven permits requested take of PS steelhead with all the requests being for incidental take due to the capture methods (various nets/seines/traps, smolt traps, hook and line, and backpack electrofishing) with an overall mortality rate of 1.9% (20 of the requested 1,081 take will kill fish). Overall, the amount of take (baseline plus research from this biological opinion) represents a very small fraction of the expected juvenile abundances and will be, at most, 0.09526% listed hatchery adipose clipped and 0.05624% natural-origin PS steelhead (Table 45).

Adult life-stage

For adult salmonids, the total amount of estimated natural-origin, take for the proposed research would be 14 PS Chinook salmon and one PS steelhead; the applicants requested no take of HCS chum salmon or OL sockeye salmon. This is the maximum amount of take contemplated in this biological opinion; if the various permits are granted and exercised, a lesser amount of take is expected to actually occur.

PS Chinook salmon – Overall, these numbers represent a very small fraction of the expected adult abundances and will kill at most 0.55190% of the listed hatchery component (intact and adipose fin clipped combined) and 0.07603% of the natural-origin PS Chinook salmon component (Table 43). Of the three permits that requested adult PS Chinook salmon take, only two permits requested take to kill fish – 16303-2R and 20313. For permit 16303-2R, most of this take is due to the use of variable depth trawl net surveys throughout Puget Sound, which is expected to result in a 10% mortality rate of adult salmonids due to crushing and descaling. Due to their larger size, adult salmon are better able to survive capture via trawl net than juvenile salmonids. For permit 20313, most of the take is intentional and targets adipose-clipped adults for whole body analysis. Overall, the amount of take (baseline plus research from this biological opinion) represents a very small fraction of the estimated adult abundances and will be, at most, 1.02820% of the listed hatchery component and 0.20638% of the natural-origin PS Chinook salmon component (Table 45).

PS steelhead – Overall, the amount of take represents a very small fraction of the expected adult abundance and will kill at most 0.00548% of all adult PS steelhead (listed hatchery and natural-origin components combined) (Table 43). Of the two permits that requested adult PS steelhead take that will kill fish, only one permit (10020-5R) requested take (one unintentional mortality). Total take (baseline plus research from this biological opinion) represent a very small fraction of the estimated adult abundances and will be, at most, 0.20266% of all PS steelhead adults (Table 45).

Summary

When combined with scientific research and monitoring permits already approved (Section 10 (a)(1)(A) and state/tribal 4(d) permits) (Table 44), the total amounts of take and mortalities are extremely low (Table 45). Moreover, it is likely that the impacts on abundance and productivity of the listed species considered in this opinion are smaller than those laid out above. For the vast majority of scientific research permits, history has shown that researchers generally take far fewer salmonids than the allotted number every year (14.19% of requested take and 12.31% of requested mortalities were used in ID, OR, and WA Section 10a1A permits from 2008 to 2016). Thus, the activities contemplated in this opinion would add only very small fractions to those already low numbers.

Thus, as Tables 43-45 demonstrate, all the mortalities, even taken together, represent a very small fraction of the various species' abundances. Nonetheless, and for a number of reasons, the displayed percentages are in reality almost certainly much smaller than even the small figures stated. First, the juvenile abundance estimates are conservative estimates of the total number of juvenile salmonids. Second, it is important to remember that estimates of take that kill fish are purposefully inflated to account for potential accidental deaths; and it is, therefore, very likely that fewer juveniles will be killed by the research than stated. As mentioned in the previous paragraph, approximately one-seventh of the authorized take (e.g., capture, collect, etc.) and one-eighth of the authorized lethal take for these research programs occurred between 2008 through 2016. Third, many of the fish that may be killed would be smolts but not all fish. These latter would simply be described as "juveniles," which means they may actually be yearlings, parr, or even fry: life stages represented by multiple spawning years and many more individuals than reach the smolt stage—perhaps as much as an order of magnitude more. Therefore, the already small percentages of take considered in this opinion are based on (a) a conservative estimate of the actual number of juveniles, (b) overestimating the number of fish likely to be killed, (c) treating each dead juvenile fish as part of the same year class, and (d) the number of juvenile salmonid fishes killed only represent a very small fraction of each species' abundance — measured as adult-equivalent fish (i.e., smolts that return as adult fish to the spawning grounds). Thus, the actual numbers of juvenile salmonids the research is likely to kill are undoubtedly smaller than the stated figures—probably something on the order of one eighth of the values given in the tables.

Rockfish and Eulachon

For listed rockfish and eulachon, all the mortalities, even taken together, represent very small fractions of the various species' abundances. Since no directed mortality is requested for any of these permits within this biological opinion, it is important to remember that lethal take estimates exist only to account for potential accidental deaths. In addition, there is no known juvenile abundance estimates for listed rockfish or eulachon species, so all life-stages are analyzed as adults (which will result in overestimates of the impact to the species). Further, there is no hatchery component to these listed DPSs, so all analyses of these DPSs are for natural-origin fish. All requested take in this biological opinion for these DPSs are for the adult life-stage, so the juvenile life-stage will not be analyzed here.

Adult life-stage

PS/GB bocaccio – Overall, these numbers represent a very small fraction of the expected adult abundance and will kill at most 0.06513% of the PS/GB bocaccio DPS (Table 43). Two permits (16303-2R and 20313) requested take [total take (fish killed) of three adults]. Overall, the amount of take (baseline plus research from this biological opinion) represents a very small fraction of the estimated adult abundances and will be, at most, 0.60790% of the PS/GB bocaccio DPS (Table 45).

PS/GB yelloweye rockfish – Overall, these numbers represent a very small fraction of the expected adult abundance and will kill at most 0.00633% of the PS/GB yelloweye rockfish DPS (Table 43). Two permits (16303-2R and 20313) requested take [total take (fish killed) of three adults]. Overall, the amount of take (baseline plus research from this biological opinion) represents a very small fraction of the estimated adult abundances and will be, at most, 0.10336% of the PS/GB yelloweye rockfish DPS (Table 45).

S eulachon – Overall, these numbers represent a very small fraction of the expected adult abundance and will kill at most 0.00021% of the S eulachon DPS (Table 43). Three permits requested take of S eulachon with permit 16303-2R requesting 87% of the take due to the reasons as outlined in the above juvenile PS Chinook salmon section. Overall, the amount of take (baseline plus research from this biological opinion) represents a very small fraction of the estimated adult abundances and will be, at most, 0.09576% of the S eulachon DPS (Table 45).

Summary

When combined with scientific research and monitoring permits already approved (Section 10 (a)(1)(A) and state/tribal 4(d) permits) (Table 44), the total amounts of take are low (Table 45). Moreover, it is likely that the impacts on abundance and productivity of the listed species considered in this opinion are smaller than those laid out above. For the vast majority of scientific research permits, history has shown that researchers generally take fewer rockfish than their allotted number every year (18.82% of the requested take and 0.62% of the requested mortalities were used in WA Section 10a1A permits from 2009 to 2016). For S eulachon, history has shown that researchers generally also take fewer eulachon than the allotted number every year (25.63% of the requested take and 26.03% of the requested mortalities were used in OR and WA Section 10a1A permits from 2009 to 2016).

Thus, as Tables 43-45 demonstrate, all the mortalities, even taken together, represent a very small fraction of the various species' abundances. Nonetheless, and for a number of reasons, the displayed percentages are in reality almost certainly much smaller than even the small figures stated. It is important to remember that estimates of lethal take for most of the proposed studies are purposefully inflated to account for potential accidental deaths; and it is, therefore, very likely that fewer individuals would be killed by the research than stated. As mentioned in the previous paragraphs, approximately one-hundredth of the authorized rockfish mortalities and one-quarter of the authorized eulachon mortalities for these research programs occurred between 2009 through 2016. Thus, the detrimental effect of the research activities contemplated in this opinion—even when they are added to the effects already contemplated in the region—are expected to be minimal. Because these effects are so small, the actions would have only a slight negative effect on the species' abundance and productivity. And because that slight impact is in most cases distributed throughout the entire listing units, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. Moreover, as shown in each permit description, all the research actions are expected to generate lasting benefits for the listed fish.

Critical Habitat

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

Summary

As noted in the sections on species status, no listed species currently has all its biological requirements being met. Their status is such that there must be a substantial improvement in the environmental conditions of their habitat and other factors affecting their survival if they are to begin to approach recovery. While the proposed research activities would in fact have some negative effect on each of the species' abundance, in all cases, this effect would be miniscule, the activity has not been identified as a threat, and the benefit from the research must be taken into account. In addition, while the future impacts of cumulative effects are uncertain at this time, they are likely to continue to be negative. Nonetheless, in no case would the proposed actions exacerbate any of the negative cumulative effects discussed (habitat alterations, etc.); and in all cases, the research may eventually help to limit adverse effects by increasing our knowledge about the species' requirements, habitat use, and abundance. The effects of climate change are also likely to continue to be negative. However, given the proposed actions' short time frames and limited areas, those negative effects, while somewhat unpredictable, are too small to be effectively gauged as an additional increment of harm over the time span considered in this analysis. Moreover, the actions would in no way contribute to climate change (even locally), and in any case the proposed actions would actually help monitor the effects of climate change by noting stream temperatures, flows, marine conditions, etc. So while we can expect both cumulative effects and climate change to continue their negative trends, it is unlikely that any of the proposed actions would have any additive impact to the pathways by which those effects are realized (e.g., a slight reduction in salmonid abundance would have no effect on increasing stream temperatures or continuing land development).

To this picture, it is necessary to add the increment of effect represented by the proposed actions. Our analysis shows that the proposed research activities would have slight negative effects on each species' abundance and productivity (and probably some negative effects on diversity and structure—ones that are so small that we cannot even measure them at this point). However, those abundance and productivity reductions are so small as to have no more than a negligible effect on the species' survival and recovery. In all cases, even the worst possible effect on abundance would be small fractions of one percent, the activity has never been identified as a threat, and the research is designed to benefit the species' survival in the long term.

For more than a decade, research and monitoring activities conducted on anadromous salmonids in the Pacific Northwest have provided resource managers with a wealth of important and useful information regarding anadromous fish populations. For example, juvenile fish trapping efforts have enabled the production of population inventories, PIT-tagging efforts have increased the knowledge of anadromous fish migration timing and survival, and fish passage studies have provided an enhanced understanding of how fish behave and survive when moving past dams and through reservoirs. By issuing research authorizations—including these being contemplated in this opinion—NMFS has allowed information to be acquired that has enhanced resource managers' abilities to make more effective and responsible decisions to sustain anadromous salmonid populations, mitigate adverse impacts on endangered and threatened salmon and steelhead, and implement recovery efforts. The resulting information continues to improve our knowledge of the respective species' life histories, specific biological requirements, genetic make-up, migration timing, responses to human activities (positive and negative), and survival in the rivers and ocean. And that information, as a whole, is critical to the species' survival.

Therefore, we expect the detrimental effects on the species are expected to be minimal and those impacts would only be seen in terms of slight reductions in abundance and productivity. And because these reductions are so slight, the actions—even in combination—would have no appreciable effect on the species' diversity or distribution. Moreover, the actions are expected to provide lasting benefits for the listed fish, and all habitat effects would be negligible.

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 PS Chinook salmon, HCS chum salmon, PS steelhead, OL sockeye salmon, S eulachon, PS/GB bocaccio, and PS/GB yelloweye rockfish. or destroy or adversely modify its designated critical habitat.

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 ITS.

In this instance, and for the actions considered in this opinion, there is no incidental take at all. The reason for this is that all the take contemplated in this document would be carried out under permits that allow the permit holders to directly take the animals in question. The actions are considered to be direct take rather than incidental take because in every case their actual purpose is to take the animals while carrying out a lawfully permitted activity. Thus, the take cannot 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

This concludes formal consultation for "Consultation on the Issuance of Nine ESA Section 10(a)(1)(A) Scientific Research Permits affecting Salmon, Steelhead, Eulachon, and Rockfish in the West Coast Region."

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 ITS 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.

In the context of this opinion, there is no incidental take anticipated and the reinitiation trigger set out in (1) is not applicable. If any of the direct take amounts specified in this opinion's effects analysis section (2.5) 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' concurrence with a determination that an action "is not likely to adversely affect" listed species or critical habitat is based on our finding that the effects are expected to be discountable, insignificant, or completely beneficial. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs; discountable effects are those that are extremely unlikely to occur; and beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat.

Southern Resident Killer Whales Determination

The Southern Resident (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 2008a).

NMFS published the final rule designating critical habitat for SR killer whales on November 29, 2006 (71 FR 69054). Critical habitat includes approximately 2,560 square miles of inland waters including Puget Sound, but does not include areas with water less than 20 feet deep relative to extreme high water. The physical or biological features (PBFs) of SR killer whale critical habitat are: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

SR killer whales spend considerable time in the Georgia Basin from late spring to early autumn, with concentrated activity in the inland waters of Washington State around the San Juan Islands, and then move south into Puget Sound in early autumn. Pods make frequent trips to the outer coast during this season. In the winter and early spring, SR killer whales move into the coastal waters along the outer coast from Southeast Alaska south to central California (NMFS 2008a, Hilborn et al. 2012). Half of the research activities included in the proposed actions would occur in freshwater areas where SR killer whales do not occur; and therefore, the proposed action may only indirectly affect SR killer whales by reducing their prey. The remainder of the research would occur in the critical habitat of SR killer whales (i.e. Puget Sound, Pacific Ocean) but direct interactions among the vessels and their capture equipment would be of an extremely low likelihood, therefore the potential for effects is discountable. This opinion would not authorize marine mammal take, nor has such take ever been observed in the past when similar activities were conducted in the action area. As a whole, the proposed action would only have discountable effects on marine mammals.

SR killer whales consume a variety of fish and one species of squid, but salmon, and Chinook salmon in particular, are their primary prey (review in NMFS 2008a). Ongoing and past diet studies of SR killer whales conduct sampling during spring, summer and fall months in inland waters of Washington State and British Columbia (i.e., Ford and Ellis 2006; Hanson et al. 2010; ongoing research by NWFSC). Genetic analysis of these samples indicate that when SR killer whales are in inland waters from May to September, they consume Chinook salmon stocks that originate from regions including the Fraser River (including Upper Fraser, Mid Fraser, Lower Fraser, N. Thompson, S. Thompson and Lower Thompson), Puget Sound (N. and S. Puget Sound), the Central BC Coast, W. and E. Vancouver Island, and Central Valley California (Hanson et al. 2010). Other research and analysis provides additional information on the age of prey consumed (Hanson unpubl. data, as summarized in Ward et al. unpubl. report), confirming that SR killer whales predominantly consume larger (i.e. older) Chinook salmon when in inland waters (May through September).

The proposed actions may affect SR killer whales indirectly by reducing availability of their primary prey, Chinook salmon. As described in the effects analysis for salmonids, up to 1,902 juvenile and 14 adult natural-origin Chinook salmon may be killed during proposed research activities.

Take of juvenile salmonids could affect prey availability to the whales in future years throughout their range, including designated critical habitat in inland waters of Washington. For the Puget Sound, average smolt to adult survival of both naturally produced and hatchery Chinook salmon is 1%. If one percent of the 1,902 juvenile Chinook salmon taken by research activities were to survive to adulthood, this would translate to the effective loss of 19 adult Chinook salmon per year across a 3-5 year period after the research activities occurred (i.e., by the time these juveniles would have grown to be adults and available prey of killer whales). Additionally, these take estimates are 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 smaller than the stated figure.

Given the total quantity of prey available to SR killer whales throughout their range, this reduction in prey is extremely small, and although measurable is not anticipated to be different than zero by multiple decimal places (based on NMFS previous analysis of the effects of salmon harvest on SR killer whales; e.g., NMFS 2008b). Because the reduction is so small, there is also a very low probability that any of the juvenile Chinook salmon killed by the research activities would have later (in 3-5 years' time) been intercepted by the killer whales across inland waters of their range in the absence of the research activities. Therefore, the anticipated take of salmonids associated with the proposed actions would result in an insignificant reduction in adult equivalent prey resources for 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 33 adult equivalent natural-origin Chinook salmon (1,902 juveniles and 14 adults) 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. With eight of these nine permit applications in this biological opinion being renewals, 28 of the 33 adult equivalent natural-origin Chinook salmon mortalities (14 adults and 1,418 juveniles) are not new mortalities but were originally part of the baseline and are now being renewed. Proposed research activities would have discountable effects on the water quality or passage PBFs for SR killer whales.

Therefore, NMFS finds that potential adverse effects of the proposed research on SR killer whales are discountable or 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. This opinion 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

This ESA section 7 consultation on the issuance of the ESA section 10(a)(1)(A) research permit concluded that the actions will not jeopardize the continued existence of any species. Therefore, the funding/action agencies may carry out the research actions and NMFS may permit them. Pursuant to the MSA, NMFS determined that no conservation recommendations were needed to conserve EFH.

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.

August 9, 1996 (61 FR 41541). Proposed Rule: Endangered and Threatened Species: Proposed Endangered Status for Five ESUs of Steelhead and Proposed Threatened Status for Five ESUs of Steelhead in Washington, Oregon, Idaho, and California.

March 25, 1999 (64 FR 14508). Final Rule: Endangered and Threatened Species: Threatened Status for Two ESUs of Chum Salmon in Washington and Oregon.

March 25, 1999 (64 FR 14528). Final Rule: Endangered and Threatened Species: Threatened Status for Ozette Lake Sockeye Salmon in Washington

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.

May 11, 2007 (72 FR 26722). Final Rule: Endangered and Threatened Species: Final Listing Determination for Puget Sound Steelhead.

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November 13, 2014 (79 FR 68042). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for the Puget Sound/Georgia Basin Distinct Population Segments of Yelloweye Rockfish, Canary Rockfish and Bocaccio.

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 15, 2017 (82 FR 52884). Notice: Endangered and Threatened Species; Take of Anadromous Fish.

5.2 Literature Cited

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