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

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

NMFS Consultation Number: WCRO-2020-00655
ARN 151422WCR2020PR00029

Action Agencies: The National Marine Fisheries Service (NMFS)
Northwest Fisheries Science Center (NWFSC)
The United States Geological Survey (USGS)
The United States Fish and Wildlife Service (USFWS)

Affected Species and NMFS' 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 (*O. tshawytscha*)	Threatened	Yes	No	No	No
PS steelhead (*O. mykiss*)	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
Hood Canal summer-run (HCS) chum salmon (*O. keta*)	Threatened	Yes	No	No	No
Upper Columbia River (UCR) spring-run Chinook salmon (*O. tshawytscha*)	Endangered	Yes	No	No	No
Upper Columbia River (UCR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No

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?
Middle Columbia River (MCR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Snake River (SnkR) spring/summer-run (spr/sum) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Snake River (SnkR) fall-run Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Snake River Basin (SnkR) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Snake River (SnkR) sockeye salmon (*O. nerka*)	Endangered	Yes	No	No	No
Lower Columbia River (LCR) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Lower Columbia River (LCR) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Upper Willamette River (UWR) Chinook salmon (*O. tshawytscha*)	Threatened	Yes	No	No	No
Oregon Coast (OC) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
Southern Oregon/Northern California Coast (SONCC) coho salmon (*O. kisutch*)	Threatened	Yes	No	No	No
California Central Valley (CCV) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Central California Coast (CCC) steelhead (*O. mykiss*)	Threatened	Yes	No	No	No
Southern (S) eulachon (*Thaleichthys pacificus*)	Threatened	Yes	No	No	No
Southern Resident (SR) killer whale (*Orcinus orca*)	Endangered	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: March 27, 2020

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List of Acronyms

AMIP – Adaptive Management and Implementation Plan
ARIS – Adaptive Resolution Imaging Sonar
ARN – Administrative Record Number
BPA – Bonneville Power Administration
CA – California
C/H/R – Capture/Handle/Release
C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal
CC – California Coastal
CCC – Central California Coast
CDFW – California Department of Fish and Wildlife
CFR – Code of Federal Regulation
CH – Critical Habitat
CHART – Critical Habitat Analytical Review Teams
CR – Columbia River
CVS – Central Valley spring-run
CWT – Coded Wire Tag
DC – Direct Current
DFO – Department of Fisheries and Oceans
DIDSON – Dual Frequency Identification Sonar
DPS – Distinct Population Segment
DQA – Data Quality Act
EBMUD – East Bay Municipal Utility District
EFH – Essential Fish Habitat
ESA – Endangered Species Act
ESU – Evolutionarily Significant Unit
FR – Federal Register
HCS – Hood Canal summer-run
HUC5 – Hydrologic Unit Code (fifth-field)
ICTRT – Interior Columbia Technical Recovery Team
IDFG – Idaho Department of Fish and Game
IM – Intentional (Directed) Mortality
IPC – Idaho Power Company
ITS – Incidental Take Statement
KWIAHT – Center for the Historical Ecology of the Salish Sea (KWIAHT)
LCR – Lower Columbia River
LHAC – Listed Hatchery Adipose Clipped
LHIA – Listed Hatchery Intact Adipose
LLTK – Long Live the Kings
MCR – Middle Columbia River
MPG – Major Population Group
MSA – Magnuson-Stevens Fishery Conservation and Management Act
NFH – National Fish Hatchery
NMFS – National Marine Fisheries Service
NOAA – National Oceanic and Atmospheric Administration

NSF – Northwest Straits Foundation
NWFSC – Northwest Fisheries Science Center
O/H – Observe/Harass
OC – Oregon Coast
ODFW – Oregon Department of Fish and Wildlife
OL – Ozette Lake
OR – Oregon
PBF – Physical or Biological Features
PCE – Primary Constituent Element
PFMC – Pacific Fishery Management Council
PIT – Passive Integrated Transponder
PS – Puget Sound
PS/GB – Puget Sound/Georgia Basin
RBDD – Red Bluff Diversion Dam
RKM – River kilometer
RM – River mile
ROV – Remotely Operated Vehicle
RPM – Reasonable and Prudent Measure
S – Southern
SacR – Sacramento River
SAR – Smolt-to-Adult Ratio
SCUBA – Self Contained Underwater Breathing Apparatus
SnkR – Snake River
SONCC – Southern Oregon/Northern California Coast
SMURF – Standard Monitoring Units for the recruitment of Reef Fishes
spr/sum – spring/summer run
SR – Southern Resident
TRT – Technical Recovery Team
UCR – Upper Columbia River
USFWS – United States Fish and Wildlife Service
USGS –United States Geological Survey
UW – University of Washington
UWR – Upper Willamette River
VSP – Viable Salmonid Population
WA – Washington
WCR – West Coast Region
WDFW – Washington Department of Fish and Wildlife
WEIS – Wood Environment & Infrastructure Solutions
WFE – West Fork Environmental

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, as amended. It constitutes a review of sixteen scientific research permits proposed for issuance by NMFS under section 10(a)(1)(A) of the ESA and is based on information provided in the associated applications for the proposed permits, published and unpublished scientific information on the biology and ecology of listed salmonids 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 within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at the Protected Resources Division in Portland, OR.

1.2 Consultation History

The West Coast Region's (WCR's) Protected Resources Division (PRD) received 16 applications for permits to conduct scientific research in Washington, Oregon, Idaho and California (see dates below; Table 1):

- 10 applications were to renew existing permits
- 1 application was to modify an existing permit, and
- 5 applications were for new permits.

Because the permit requests are similar in nature and duration and are expected to affect many of the same listed species, we combined them into a single consultation pursuant to 50 CFR 402.14(c).

The affected species are:

- Chinook salmon
    - Puget Sound (PS)
    - Upper Columbia River (UCR) spring-run
    - Snake River (SnkR) spring/summer run
    - Snake River (SnkR) fall-run

    - Lower Columbia River (LCR)
    - Upper Willamette River (UWR)
- Coho salmon
    - Lower Columbia River (LCR)
    - Oregon Coast (OC)
    - Southern Oregon/Northern California Coast (SONCC)
- Chum salmon
    - Hood Canal summer-run (HCS)
- Sockeye salmon
    - Snake River (SnkR)
- Steelhead
    - Puget Sound (PS)
    - Upper Columbia River (UCR)
    - Middle Columbia River (MCR)
    - Snake River Basin (SnkR)
    - California Central Valley (CCV)
    - Central California Coast (CCC)
- Southern DPS Eulachon
- Puget Sound.Georgia Basin Bocaccio (PS/GB)
- Puget Sound/ Georgia Basin yelloweye rockfish (PS/GB)

The proposed actions also have the potential to affect Southern Resident (SR) killer whales and their critical habitat by diminishing the whales' prey base. We concluded that the proposed activities are not likely to adversely affect SR killer whales or their critical habitat and the full analysis for that conclusion is found in the "Not Likely to Adversely Affect" Determination section (2.11).

Table 1. The Applications (and their Associated Applicants) Considered in this Biological Opinion.

Permit Number	Applicant
1339-5M	Columbia River Intertribal Fish Commission (CRITFC)
14772-4R	Oregon Department of Fish and Wildlife (ODFW)
15205-4R	KWIAHT Center for the Historical Ecology of the Salish Sea (KWIAHT)
15230-3R	West Fork Environmental (WFE)
17062-6R	NMFS NW Fisheries Science Center (NWFSC)
17761-2R	East Bay Municipal Utility District (EBMUD)
18696-4R	Idaho Power Company (IPC)
18852-2R	U.S. Fish and Wildlife Service (USFWS)
18906-2R	Northwest Straits Foundation (NSF)
19013-2R	Long Live the Kings (LLTK)
19386-2R	Wood Environment & Infrastructure Solutions (WEIS)
23567	Stillwater Sciences

Permit Number	Applicant
23600	University of Washington (UW)
23629	U.S. Geological Survey (USGS)
23633	U.S. Fish and Wildlife Service (USFWS)
23637	Oregon Department of Fish and Wildlife (ODFW)

We received a request (1339-5M) from CRITFC to modify the existing permit on November 18, 2019. Requested edits and alterations were discussed, addressed, and the application was completed on December 10, 2019.

We received a request (14772-2R) from the ODFW to renew the existing permit on September 12, 2019. Requested edits and alterations were discussed, addressed, and the application was completed on November 29, 2019.

We received a permit renewal request (15205-4R) from KWIAHT on March 11, 2019. No edits were required, and the application was deemed complete on December 5, 2019.

We received a permit renewal request (15230-3R) from WFE on March 21, 2019. Requested edits were sent on December 5, 2019, addressed, and the application was completed on January 3, 2020.

We received a permit renewal request (17062-6R) from NWFSC on September 13, 2019. Requested edits were sent on December 12, 2019, addressed, and the application was completed on December 13, 2019.

We received a permit renewal request (17761-2R) from East Bay Municipal Utility District, Fisheries and Wildlife Division on March 28, 2019. Requested edits were sent, addressed, and the application was completed on January 23, 2020.

We received a request (18696-4R) from the Idaho Power Company to renew the existing permit on November 12, 2019. Requested edits and alterations were discussed, addressed, and the application was completed on November 18, 2019.

We received a request (18852-2R) from the USFWS to renew the existing permit on January 2, 2020. Requested edits and alterations were discussed and addressed and the application was completed on January 24, 2020.

We received a permit renewal request (18906-2R) from NSF on March 19, 2019. No edits were required, and the application was deemed completed on December 13, 2019.

We received a permit renewal request (19013-2R) from LLTK on September 25, 2019. Requested edits were sent on December 13, 2019, addressed, and the application was completed on January 13, 2020.

We received a permit renewal request (19386-2R) from WEIS on March 21, 2019. No edits were required, and the application was deemed completed on December 30, 2019.

We received a new permit request (23567) from Stillwater Sciences on November 13, 2019. Requested edits were sent, addressed, and the application was completed on January 23, 2020.

We received a new permit request (23600) from UW on December 10, 2019. Requested edits were sent on December 27, 2019, addressed, and the application was completed on January 13, 2020.

We first received a permit request (23629) from the USGS in October of 2019, but it was in the form of an application for an ESA section 4(d) authorization. After some back-and-forth, it was determined that the activity would need a section 10 scientific research permit and the application was submitted January 31, 2019. Subsequent edits were discussed and addressed and the application was completed on January 21, 2020.

We received a new permit request (23633) from the USFWS on December 18, 2019. Requested edits and alterations were discussed and addressed and the application was completed on December 23, 2019.

We received the request (23637) from the ODFW for the new permit on December 16, 2019. Requested edits and alterations were discussed and addressed and the application was completed on December 18, 2019.

Most of the requests were incomplete when originally submitted. We worked with the applicants to complete the applications, and published a notice in the Federal Register on January 30, 2020 asking for public comment on them (85 FR 5367). The public comment period closed on March 2, 2020 and formal consultation was initiated on the same date. A complete record of this consultation is maintained by the Protected Resources Division and kept on file in Portland, Oregon.

1.3 Proposed Federal 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). The proposed actions here are NMFS' issuance of sixteen scientific research permits pursuant to section 10(a)(1)(A) of the ESA for the associated activities proposed by CRITFC, ODFW, KWIAHT, WFE, NWFSC, EBMUD, IPC, USFWS, NSF, LLTK, WEIS, Stillwater Sciences, UW, and USGS. The permits would authorize researchers to take all the species listed on the front page of this document, except SR killer whales. "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.

We considered whether or not the proposed action would cause any other activities and determined that (*i)* it would not *or (ii)* it would cause the following activities.

Permit 1339-5M

The Nez Perce Tribe (NPT) under the authorization of the Columbia River Intertribal Fish Commission (CRITFC) is seeking to modify a permit that allows them to annually take adult and juvenile SnkR spring/summer Chinook salmon and SnkR steelhead while conducting research in a number of the tributaries to the Imnaha River. Currently, they conduct work in Cow, Lightning, Horse, Big Sheep, Camp, Little Sheep, Freezeout, Grouse, Crazyman, Mahogany, and Gumboot

Creeks; the Grande Ronde River (Joseph Creek, Wenaha and Minam rivers); the Clearwater River (South Fork Clearwater River and Lolo Creek); and the Snake River (Lower Granite Dam adult trap). The Imnaha and Grande Ronde Rivers are in northeastern Oregon, the Clearwater is in Idaho, and the work in the Snake River would take place in Washington. The NPT has been conducting this work for more than two decades in the Pacific Northwest. The NPT is seeking to modify the permit in one way: they would like to be able to capture a number of adult steelhead at temporary weirs in the Salmon River subbasin in Idaho—primarily at a small number of locations in the lower Salmon River below the town of Riggins.

The purpose of the research is to acquire information on the status (escapement abundance, genetic structure, life history traits) of juvenile and adult steelhead in the Imnaha, Grande Ronde, Clearwater, and Salmon River subbasins. The research would benefit the listed species by providing information on current status that fishery managers can use to determine if recovery actions are helping increase Snake River salmonid populations. Baseline information on steelhead populations in the Imnaha, Grande Ronde, and Clearwater River subbasins would also be used to help guide future management actions. Adult and juvenile salmon and steelhead would be observed, handled, and marked. The researchers would use temporary/portable picket and resistance board weirs and rotary screw traps to capture the fish and would then sample some of them for biological information (fin tissue and scale samples). They may also mark some of the fish with opercule punches, fin clips, dyes, and PIT, floy, and/or Tyvek disk tags. Adult steelhead carcasses would also be collected and sampled. The researchers do not intend to kill any of the fish being captured, but a small number may die as an unintended result of the activities.

Permit 14772-4R

The Oregon Department of Fish and Wildlife (ODFW) is seeking to renew a permit that currently allows it to take juvenile and adult OC coho salmon while studying fish abundance, distribution, and habitat preference in the Umpqua River. The ODFW would also study the distribution of non-native invasive species, interspecific competition, and predator-prey interactions. The information would benefit OC coho by helping to improve management plans. The researchers would use backpack and boat electrofishing equipment to capture the fish. Stunned fish would be recovered in a soft mesh dipnet and immediately put in an aerated holding tank. The fish would then be measured, weighed, recorded by species, and swiftly returned to the water. The researchers would avoid adult coho, but a few may be encountered. In the event that an adult coho is encountered, the ODFW would shut off the electrical current and allow the fish to swim away, and no more electrofishing would occur in that location. The researchers do not intend to kill any of the fish being captured, but a small number of juvenile coho may die as an unintended result of the activities.

Permit 15205-4R

The KWIAHT Center for the Historical Ecology of the Salish Sea (KWIAHT) is seeking to renew for five years a research permit that currently allows them to take juvenile PS Chinook salmon. Sampling sites would occur offshore of Decatur, Lopez, and Waldron island beaches in the San Juan Island archipelago in Puget Sound (San Juan County, WA). The purpose of this research is to understand long-term changes in the food web that supports Salish Sea salmon populations that annually congregate in the San Juan Islands basin. Since 2010, this study has been analyzing trends in juvenile Chinook salmon, their prey species (sand lance and Pacific herring), and their changing environment (i.e., water temperatures). This research would benefit PS Chinook salmon by continuing to keep managers informed of the changes in the salmonids' environment and the impact those changes are having on juvenile wild Chinook salmon during their neritic life history stage. The researchers propose capturing fish using a beach seine. Once captured, the fish would be anesthetized and measured, and a tissue sample would be taken (sample scale and fin clip). The fishes' stomach contents would then be sampled by gastric lavage. The fish would then be returned to an aerated holding bucket until they are ready for release. The researchers do not propose to kill any of the listed salmonids being captured, but a small number may die as an unintended result of the activities.

Permit 15230-3R

West Fork Environmental, Inc. (WFE) is seeking to renew for five years a research permit that currently allows them to take juvenile PS Chinook salmon and PS steelhead on the South Fork of the Tolt River (Snoqualmie River sub-basin; King County, WA). The purpose of the study is to better understand the seasonal use of the Tolt River and its tributaries by juvenile PS steelhead prior to their outmigration. Since 2010, this study has increased our knowledge of size- and age-based movements in the upper reaches of the South Fork Tolt River. Further research would benefit PS steelhead by including an additional PIT-tag array to provide a better understanding of population-specific age structure, genetic structure, and movement patterns for both juveniles and returning adults. The WFE researchers propose capturing fish using backpack electrofishing and hook and line angling. The listed steelhead would be captured, anesthetized, measured, weighed, have a tissue sample taken (sample scale and fin clip), PIT tagged, and returned to an aerated holding bucket until they are ready for release. All other fish would be captured, identified to species, and released. The researchers do not propose to kill any of the listed salmonids being captured, but a small number may die as an unintended result of the activities.

Permit 17062-6R

The Northwest Fisheries Science Center (NWFSC) is seeking to renew for five years a research permit that currently allows them to take juvenile and adult PS Chinook salmon, PS steelhead, HCS chum salmon, and PS/GB bocaccio. The NWFSC research may also cause them to take adult S eulachon and juvenile and adult PS/GB yelloweye rockfish, for which there are currently no ESA take prohibitions. Sampling would take place throughout the Puget Sound, the Strait of Juan de Fuca, and Hood Canal, WA. The purposes of the study are to (1) determine how much genetic variation exists between coastal and PS/GB DPS bocaccio populations; (2) investigate how characteristics (patch size and level of nearby urbanization) of rocky reef habitats, kelp forests, and eelgrass beds affect the relative quality of these habitats as nursery habitat for rockfishes in Puget Sound; and (3) examine the trophic relationships of rockfish in Puget Sound and their reliance on productivity from rocky reef habitats, kelp forests, and eelgrass beds. Since 2012, this study has been collecting genetic samples from ESA-listed rockfish to determine whether or not the PS/GB DPS rockfish designations are supported. For yelloweye and canary rockfish, enough genetic information was collected to support the PS/GB DPS designation for yelloweye rockfish but suggested that canary rockfish in Puget Sound were not a unique DPS. For bocaccio, not enough individuals were captured to support a determination. Further research would benefit these ESA-listed rockfish by collecting more biological samples to better understand DPS/species uniqueness and their habitat (i.e., rocky reef, kelp forests, and eelgrass beds) interactions. The NWFSC proposes to capture fish by using (1) hook and line equipment at depths of 20–200 meters; (2) hand nets and spear guns while conducting SCUBA diving transects; and (3) anchored minnow traps and Standard Monitoring Units for the recruitment of Reef Fishes (SMURFs). For the hook and line fishing, captured fish would be reeled slowly to the surface to reduce the impacts of barotrauma. All captured ESA-listed rockfish would be measured, weighed, sexed, tissue sampled (caudal fin clip and dorsal musculature), floy tagged, and released to the water via rapid submersion techniques to reduce barotrauma. If a rockfish individual is captured dead or deemed nonviable, it would be retained for genetic analysis. All other ESA-listed fish would be released after capture. For the SCUBA diving transects, juvenile rockfish would be collected in a plastic bag and brought to the surface and sacrificed for full body analysis. For minnow traps and SMURFs, the traps would be brought to the surface, emptied into a tub of water, and the fish would be identified to species, enumerated, and sacrificed for full body analysis. The researchers do not propose to kill any adult listed fish being captured, but a small number may die as an unintended result of the activities.

Permit 17761-2R

The East Bay Municipal Utility District (EBMUD), Fisheries and Wildlife Division is seeking to renew for a five-years a permit that currently allows them to take juvenile and adult CCV steelhead in the lower Mokelumne River in the San Joaquin Valley, CA. Fish would be observed (video monitoring in the fish ladder, escapement surveys, snorkel surveys, and redd surveys), captured (boat and backpack electrofishing, rotary screw traps, fish ladder trap, fyke traps, beach seines, smolt bypass trap, hook and line, trawling), handled (anesthetize, weigh, measure, and check for marks or tags), and released. A subsample may be marked, tagged, and/or sampled for stomach content or biological tissue. The purpose of the research is to collect scientific data on anadromous and resident fish, and fish habitat on the lower Mokelumne River as part of an ongoing study to measure the success of the flow requirements and non-flow measures set forth in the 1998 Joint Settlement Agreement (JSA) between EBMUD, the U.S. Fish and Wildlife Service (USFWS), and the California Department of Fish and Game (CDFW). Data will also be used to develop and implement Hatchery and Genetics Management Plans for operation of the Mokelumne River Fish Hatchery's fall run Chinook salmon program and Central Valley steelhead program. The researchers are not proposing to kill any of the fish they capture, but a small number of individuals may be killed as an inadvertent result of the activities.

Permit 18696-4R

The Idaho Power company is seeking to renew for five years a research permit that currently allows them to annually capture juvenile and adult SnkR fall-run and SnkR spring/summer run Chinook salmon, SnkR sockeye and SnkR steelhead. The researchers are targeting juvenile white sturgeon in Lower Granite Reservoir, Idaho. The researchers currently use small-mesh gill nets and d-ring nets to capture white sturgeon. They also employ a benthic (near-bottom) trawl in Lower Granite Reservoir and do some gill-netting upstream from that reservoir. The gill net fishing would continue to take place at times (October and November) and in areas (the bottom of the reservoir and river) that have purposefully been chosen to have the least possible impact on listed fish. When the nets are pulled to the surface, listed species would immediately be released (including by cutting the net, if necessary) and allowed to return to the reservoir. The d-ring fishing would take place in June and July, but the same restrictions (immediately releasing listed fish, etc.) would still apply. The purpose of the research is to document sturgeon survival in early life stages in the mainstem Snake River. The research targets a species that is not listed, but the research would benefit listed salmonids by generating information about the habitat conditions near and in Lower Granite Reservoir and by helping managers develop conservation plans for the species that inhabit those areas. The researchers are not proposing to kill any of the fish they capture, but a small number of individuals may be killed as an inadvertent result of the activities.

Permit 18852-2R

The U.S. Fish and Wildlife Service (USFWS) Mid-Columbia River Fishery Resource Office is seeking to renew for five years a research permit that currently allows them to annually capture juvenile and adult UCR spring-run Chinook salmon and steelhead, and juvenile MCR steelhead. Sampling would take place throughout the Yakima, Wenatchee, Entiat, Methow and Okanogan river basins in WA. The researchers currently use backpack electrofishing, hand/dip nets, and hook and line to capture fish. The purpose of this project is to (1) determine the distribution and status of Pacific lamprey, bull trout, and other native fish species, and (2) implement and assess recovery actions associated with passage at existing structures and at lamprey passage engineered structures. During this research, non-target species, including Chinook salmon and steelhead will be released with minimal handling. In some study areas, Chinook salmon and steelhead may be anesthetized and identified to species, measured, and scanned for PIT tags. The research targets Pacific lamprey and bull trout, but the research would benefit listed salmonids by providing presence/absence data and helping inform habitat restoration actions. The researchers are not proposing to kill any of the fish they capture, but a small number of individuals may be killed as an inadvertent result of the activities.

Permit 18906-2R

The Northwest Straits Foundation (NSF) is seeking to renew for five years a research permit that currently allows them to take juvenile PS Chinook salmon and PS steelhead. The researchers may also take adult S eulachon, for which there are currently no ESA take prohibitions. Sampling would take place at up to 30 sites in the eastern Puget Sound from Saratoga Passage (in the south) to Fidalgo Bay (to the north) (Island and Skagit counties, WA). The purpose of the study is to monitor ecosystem response to restoration efforts (pre- and post-) and determine their effectiveness at reestablishing habitat as a natural functioning ecosystem. The research would benefit the listed species by determining the effectiveness of these restoration efforts and applying them to future efforts which directly benefits listed salmon by increasing habitat. The NSF proposes capturing fish using a beach seine. Fish would be captured, identified to species, measured, and released. The researchers do not propose to kill any of the listed fish being captured, but a small number may die as an unintended result of the activities.

Permit 19013-2R

Long Live the Kings (LLTK) is seeking to renew for five years a research permit that currently allows them to take juvenile HCS chum salmon, PS Chinook salmon, and PS steelhead in the Hamma Hamma River (Mason County, WA). The purpose of the study is to assess the long-term effects and effectiveness of PS steelhead supplementation when utilizing low-impact, innovative wild steelhead supplementation techniques in streams throughout the Hood Canal region. Further research would benefit the listed species by determining what legacy effects the PS steelhead hatchery program have had on natural steelhead populations (abundance, genetic diversity, life history diversity). The researchers propose capturing fish using a rotary screw trap. PS steelhead would be captured, anesthetized, weighed, measured, have a tissue sample taken (sample scale and fin clip), and returned to an aerated holding bucket until they are ready for release. All other fish will be captured, identified to species, and released downstream of the trap. The researchers do not propose to kill any of the listed salmonids being captured, but a small number may die as an unintended result of the activities.

Permit 19386–2R

The Wood Environment & Infrastructure Solutions, Inc. (WEIS) 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 Lower Duwamish River waterway (King County, WA). Under a Consent Decree settled through U.S. District Court (Western District of Washington), The Boeing Company agreed to construct two habitat restoration projects near Boeing Plant 2 in the Lower Duwamish Waterway to restore and create offchannel and riparian habitats in an area where they have been largely eliminated due to channelization and industrialization. The purpose of this study is to determine if fish, including ESA listed juvenile salmonids, are using the newly created/restored habitat. This is a planned ten-year study, and this renewal would cover the last five years of the study. This research would benefit the affected species by informing future restoration designs as well as providing data to support future enhancement projects. The researchers propose to capture fish using fyke nets during the spring salmonid outmigration (March through June). Fish would be anaesthetized, identified to species, measured for length, allowed to recover, and released. The researchers do not propose to kill any of the listed fish being captured, but a small number may die as an unintended result of the activities.

Permit 23567

Stillwater Sciences is seeking a five-year research permit to take juvenile CCC steelhead in Rector Creek in Napa County, CA. Sampling would be for a period of 1 week during both the Spring (March-June) and again during Fall (September-October) in 2020, followed by repeat surveys in 2021–2024. The purpose of this study is to assess instream flow needs in Rector Creek. The license to operate Rector Dam does not include specific instream flow release requirements; however, California Fish and Game Code Section 5937 requires the owner or operator of any dam to allow sufficient flow to pass through or over the dam to keep fish downstream of the dam in good condition. Data will be collected to assess species composition, distribution, abundance, age-class distribution, and individual fish condition (size, growth rate, and presence of disease, parasites, or lesions) to evaluate the condition of fish in Rector Creek downstream of Rector Dam. Results of this study will be used to refine the conditions of the Rector Creek release schedule to improve habitat conditions for fish species downstream. Fish survey methods used will include direct observation using multi-pass snorkeling methods, beach seining, dip-netting, and single-pass backpack electrofishing. These methods will follow standard guidelines to reduce injury to steelhead and other native fish species. The researchers do not propose to kill any of the listed fish being captured, but a small number may die as an unintended result of the activities.

Permit 23600

The University of Washington (UW) is seeking a three-year research permit to annually take juvenile and adult PS Chinook salmon, PS steelhead, HCS chum salmon, and PS/GB bocaccio throughout the Puget Sound and the Strait of Juan de Fuca, WA. The UW 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 study is to investigate the ecology and movement of broadnose sevengill shark (*Notorhynchus cepedianus*) and bluntnose sixgill shark (*Hexanchus griseus*) and to assess their potential to serve as sentinels for deep ocean ecosystems. This research would benefit the affected species by providing a better understanding of the marine ecosystem of Puget Sound and the Pacific Ocean. The UW proposes to capture fish using longline fishing gear. Targeted shark species would be tagged (satellite and acoustic), sampled (blood, fin clip, and muscle tissue biopsy), measured, and released. ESA-listed rockfish would be tissue sampled (fin clip), floy tagged, and released to the water via rapid submersion techniques to reduce barotrauma. If a rockfish individual is captured dead or deemed nonviable, it would be retained for genetic analysis. ESA-listed salmonids would either be immediately released or held an aerated livewell until they are ready for release. The researchers do not propose to kill any of the listed fish being captured, but a small number may die as an unintended result of the activities.

Permit 23629

The U.S. Geological Survey (USGS) is seeking a 5-year permit to annually take juvenile and adult UWR Chinook salmon in the Willamette (Coast Fork and Middle Fork), North and South Santiam, and McKenzie rivers; and adult and juvenile SONCC coho in the Upper Rogue River in OR. The purpose of this study is to evaluate contaminants, particularly mercury in reservoirs/lakes and the relationships between contaminants in sediment and biota, water quality, and fish tissue mercury concentrations. Researchers will capture fish with backpack and boat electrofishing, hook and line, gill nets, beach seines and minnow traps. Captured listed fish will be quickly handled and released. A subset of other fish will be anesthetized, tissue sampled, allowed to recover and released. This research will benefit listed species by providing information to assess factors that influence contaminant exposure and allow researchers to evaluate contaminant exposure, bioaccumulation, and effects in aquatic ecosystems. The researchers do not intend to kill any listed fish, but a small number some may die as an inadvertent result of the proposed activities.

Permit 23633

The USFWS is seeking a five-year permit to capture juveniles from several species of native lamprey in Abernathy Creek, WA. The researchers would use backpack electrofishing units to capture the lamprey. Because the researchers are targeting lamprey, the electrofishing units would be operated at very low setting—settings that generally have very little effect on salmonids. Nonetheless, if the researchers do encounter any juvenile LCR coho, those fish would be dip-netted, quickly enumerated, and returned to the creek downstream of the electrofishing team without further handling. Though the listed fish are not the target of the research, they would nonetheless benefit from the information to be gained. The researchers are collecting data on an important indicator of habitat health, and they are doing it in an area that has been designated as an "intensively monitored watershed"—which means that managers will easily be able to use any information the researchers gather help recover listed salmonids elsewhere in the lower Columbia River. The researchers do not intend to kill any listed fish, but a small number some may die as an inadvertent result of the proposed activities.

Permit 23637

The Oregon Department of Fish and Wildlife (ODFW) is seeking a five-year permit to tag—with acoustic tags—adult MCR steelhead at Bonneville Dam on the Columbia River and monitor their subsequent migration patterns and routes. The fish would be taken and tagged as they pass through the Bonneville Dam adult fish facility. Captured adult steelhead would be anesthetized, held in an oxygenated, river-temperature tank, and implanted with an acoustic transmitter once they are fully anesthetized and deemed ready. Following their recovery from anesthesia, tagged adult steelhead would be released immediately upstream of the adult fish trap and allowed to proceed up the fish ladder to cross Bonneville Dam. The fish would then be tracked by acoustic receiver arrays in upstream reservoirs and dams and at a location near the confluence of the Columbia and John Day Rivers.

The research is intended to generate information about adult MCR steelhead migration and, in particular, it is intended to help managers address the question of why so many steelhead that originate in the John Day River tend to swim past that river and continue up the Columbia River when they return as adults. Currently, approximately 60% of the returning steelhead overshoot the John Day River when they return as adults. If managers can figure out why that is the case and develop measures to reduce that percentage (i.e., help the fish find their way back to their spawning grounds), it could potentially greatly increase their survival and, therefore, vastly improve spawning success and overall steelhead numbers in the John Day River. The researchers do not intend to kill any of the fish being tagged, but some may die as an inadvertent result of the capturing and tagging activities.

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 the NMFS' WCR 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 (°F) 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°F.

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) (NMFS 2000).

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 the APPS permit website where downloadable forms can also be found. 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 provide 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 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.

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] Herein, the NMFS determined that the proposed action of issuing sixteen scientific research permits, individually or in aggregate:

- May adversely affect PS, UCR, SnkR spring/summer run, SnkR fall-run, LCR, and UWR Chinook salmon; LCR, OC, and SONCC coho salmon; HCS chum salmon; SnkR sockeye salmon; PS, UCR, MCR, SnkR, CCV and CCC steelhead, S eulachon, PS/GB bocaccio, and PS/GB yelloweye rockfish; but would not jeopardize their continued existence.
- Is not likely to adversely affect SR killer whales or their designated critical habitat . This conclusion is documented in the "Not Likely to Adversely Affect" Determinations section (Section 2.11).

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably 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 CFR402.02). 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 as a whole for the conservation of a listed species" (50 CFR 402.02).

The critical habitat designations for many of the species considered here use the term primary constituent element (PCE) or essential features. The 2016 critical habitat regulations (50 CFR

[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."

424.12) replaced 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.

The 2019 regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the regulations (84 FR 44977), that definition does not change the scope of our analysis and in this opinion we use the terms "effects" and "consequences" interchangeably.

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

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their habitat using an exposure-response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly 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, or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- 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.

Climate Change

Climate change is likely to play an increasingly important role in determining the abundance and distribution of ESA-listed species and the conservation value of designated critical habitats in the Pacific Northwest. These changes will not be spatially homogeneous across the Pacific Northwest. The largest hydrologic responses are expected to occur in basins with significant snow accumulation, where warming decreases snow pack, increases winter flows, and advances the timing of spring melt (Mote et al. 2014, Mote 2016). Rain-dominated watersheds and those with significant contributions from groundwater may be less sensitive to predicted changes in climate (Tague et al. 2013, Mote et al. 2014).

During the last century, average regional air temperatures in the Pacific Northwest increased by 1-1.4°F as an annual average, and up to 2°F in some seasons (based on average linear increase per decade; Abatzoglou et al. 2014, Kunkel et al. 2013). Warming is likely to continue during the next century as average temperatures are projected to increase another 3 to 10°F, with the largest increases predicted to occur in the summer (Mote et al. 2014). Decreases in summer precipitation of as much as 30% by the end of the century are consistently predicted across climate models (Mote et al. 2014). Precipitation is more likely to occur during October through March, less during summer months, and more winter precipitation will be rain than snow (ISAB 2007, Mote et al. 2013, Mote et al. 2014). Earlier snowmelt will cause lower stream flows in late spring, summer, and fall, and water temperatures will be warmer (ISAB 2007, Mote et al. 2014). Models consistently predict increases in the frequency of severe winter precipitation events (i.e., 20-year and 50-year events), in the western United States (Dominguez et al. 2012). The largest increases in winter flood frequency and magnitude are predicted in mixed rain-snow watersheds (Mote et al. 2014).

Overall, about one-third of the current cold-water salmonid habitat in the Pacific Northwest is likely to exceed key water temperature thresholds by the end of this century (Mantua et al. 2009). Higher temperatures will reduce the quality of available salmonid habitat for most freshwater life stages (ISAB 2007). Reduced flows will make it more difficult for migrating fish to pass physical and thermal obstructions, limiting their access to available habitat (Mantua et al. 2010; Isaak et al. 2012). Temperature increases shift timing of key life cycle events for salmonids and species forming the base of their aquatic foodwebs (Crozier et al. 2011, Tillmann and Siemann 2011, Winder and Schindler 2004). Higher stream temperatures will also cause decreases in dissolved oxygen and may also cause earlier onset of stratification and reduced mixing between layers in lakes and reservoirs, which can also result in reduced oxygen (Meyer et al. 1999, Winder and Schindler 2004, Raymondi et al. 2013). Higher temperatures are likely to cause several species to become more susceptible to parasites, disease, and higher predation rates (Crozier et al. 2008; Wainwright and Weitkamp 2013; Raymondi et al. 2013).

As more basins become rain-dominated and prone to more severe winter storms, higher winter stream flows may increase the risk that winter or spring floods in sensitive watersheds will damage spawning redds and wash away incubating eggs (Goode et al. 2013). Earlier peak stream flows will also alter migration timing for salmon smolts, and may flush some young salmon and steelhead from rivers to estuaries before they are physically mature, increasing stress and reducing smolt survival (McMahon and Hartman 1989; Lawson et al. 2004).

In addition to changes in freshwater conditions, predicted changes for coastal waters in the Pacific Northwest as a result of climate change include increasing surface water temperature, increasing but highly variable acidity, and increasing storm frequency and magnitude (Mote et al. 2014). Elevated ocean temperatures already documented for the Pacific Northwest are highly likely to continue during the next century, with sea surface temperature projected to increase by 1.0-3.7ºC (1.8-6.7ºF) by the end of the century (IPCC 2014). Habitat loss, shifts in species' ranges and abundances, and altered marine food webs could have substantial consequences to anadromous, coastal, and marine species in the Pacific Northwest (Tillmann and Siemann 2011, Reeder et al. 2013).

In California, average summer air temperatures are expected to increase according to modeling of climate change impacts (Lindley et al. 2007). Heat waves are expected to occur more often, and heat wave temperatures are likely to be higher (Hayhoe et al. 2004). Total precipitation in California may decline, critically dry years may increase (Lindley et al. 2007, Schneider 2007). Events of both extreme precipitation and intense aridity are projected for California, increasing climactic volatility throughout the state (Swain et al. 2018). Snow pack is a major contributor to stored and distributed water in the state (Diffenbaugh et al. 2015), but this important water source is becoming increasingly threatened. The Sierra Nevada snow pack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled (Luers et al. 2006). California wildfires are expected to increase in frequency and magnitude, with 77% more area burned by 2099 under a high emission scenario model (Westerling 2018). Vegetative cover may also change, with decreases in evergreen conifer forest and increases in grasslands and mixed evergreen forests. The likely change in amount of rainfall in Northern and Central Coastal California streams under various warming scenarios is less certain, although as noted above, total rainfall across the state is expected to decline.

For the California North Coast, some models show large increases in precipitation (75 to 200 percent) while other models show decreases of 15 to 30 percent (Hayhoe et al. 2004). Many of these changes are likely to further degrade salmonid habitat by, for example, reducing stream flows during the summer and raising summer water temperatures (Williams et al. 2016). Estuaries may also experience changes detrimental to salmonids. Estuarine productivity is likely to change based on alterations to freshwater flows, nutrient cycling, and sedimentation (Scavia et al. 2002). In marine environments, ecosystems and habitats important to salmonids are likely to experience changes in temperatures, circulation and chemistry, and food supplies (Feely et al. 2004, Brewer 2008, Osgood 2008, Turley 2008), which would be expected to negatively affect marine growth and survival of listed fish. The projections described above are for the mid- to late-21st Century. In shorter time frames, climate conditions not caused by the human addition of carbon dioxide to the atmosphere are more likely to predominate (Cox and Stephenson 2007, Smith et al. 2007).
Moreover, as atmospheric carbon emissions increase, increasing levels of carbon are absorbed by the oceans, changing the pH of the water. Acidification also impacts sensitive estuary habitats, where organic matter and nutrient inputs further reduce pH and produce conditions more corrosive than those in offshore waters (Feely et al. 2012, Sunda and Cai 2012).

Global sea levels are expected to continue rising throughout this century, reaching likely predicted increases of 10-32 inches by 2081-2100 (IPCC 2014). These changes will likely result in increased erosion and more frequent and severe coastal flooding, and shifts in the composition of nearshore habitats (Tillmann and Siemann 2011, Reeder et al. 2013). Estuarine-dependent salmonids such as chum and Chinook salmon are predicted to be impacted by significant reductions in rearing habitat in some Pacific Northwest coastal areas (Glick et al. 2007). Historically, warm periods in the coastal Pacific Ocean have coincided with relatively low abundances of salmon and steelhead, while cooler ocean periods have coincided with relatively high abundances, and therefore these species are predicted to fare poorly in warming ocean conditions (Scheuerell and Williams 2005; Zabel et al. 2006). This is supported by the recent observation that anomalously warm sea surface temperatures off the coast of Washington from 2013 to 2016 resulted in poor coho and Chinook salmon body condition for juveniles caught in those waters (NWFSC 2015). Changes to estuarine and coastal conditions, as well as the timing of seasonal shifts in these habitats, have the potential to impact a wide range of listed aquatic species (Tillmann and Siemann 2011, Reeder et al. 2013).

The adaptive ability of these threatened and endangered species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions will likely reduce long-term viability and sustainability of populations in many of these ESUs (NWFSC 2015). New stressors generated by climate change, or existing stressors with effects that have been amplified by climate change, may also have synergistic impacts on species and ecosystems (Doney et al. 2012). These conditions will possibly intensify the climate change stressors inhibiting recovery of ESA-listed species in the future.

2.2.1 Status of the Species

For Pacific salmon and steelhead, 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. We apply the same criteria for other species as well (but in those instance, they are not referred to as “salmonid” population criteria). When any animal population or species has sufficient spatial structure, diversity, abundance, and productivity, it will generally be able to maintain its capacity to adapt to various environmental conditions and sustain itself in the natural environment. These attributes are influenced by survival, behavior, and experiences throughout a species’ entire life cycle, and these characteristics, in turn, are influenced by habitat and other environmental conditions.

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

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

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

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

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

A species' status thus is a function of how well its biological requirements are being met: the greater the degree to which the requirements are fulfilled, the better the species' status. Information on the status and distribution of all the species considered here can be found in a number of documents, but the most pertinent are the status review updates and recovery plans listed in Table 2 and the specific species sections that follow. These documents and other relevant information may be found on the NOAA Fisheries West Coast Region website; the discussions they contain are summarized in the tables below. For the purposes of our later analysis, all the species considered here require functioning habitat and adequate spatial structure, abundance, productivity, and diversity to ensure their survival and recovery in the wild.

Table 2. Listing classification and date, recovery plan reference, most recent status review, status summary, and limiting factors for each species considered in this opinion.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Puget Sound Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	SSDC 2007 NMFS 2006	NWFSC 2015	This ESU comprises 22 populations distributed over five geographic areas. Most populations within the ESU have declined in abundance over the past 7 to 10 years, with widespread negative trends in natural-origin spawner abundance, and hatchery-origin spawners present in high fractions in most populations outside of the Skagit watershed. Escapement levels for all populations remain well below the Technical Recovery Team (TRT) planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the TRT as consistent with recovery.	• Degraded floodplain and in-river channel structure • Degraded estuarine conditions and loss of estuarine habitat • Degraded riparian areas and loss of in-river large woody debris • Excessive fine-grained sediment in spawning gravel • Degraded water quality and temperature • Degraded nearshore conditions • Impaired passage for migrating fish • Severely altered flow regime
Puget Sound steelhead	Threatened 05/11/2007 (72 FR 26722)	NMFS 2018a (draft)	NWFSC 2015	This DPS comprises 32 populations. The DPS is currently at very low viability, with most of the 32 populations and all three population groups at low viability. Information considered during the most recent status review indicates that the biological risks faced by the Puget Sound Steelhead DPS have not substantively changed since the listing in 2007, or since the 2011 status review. Furthermore, 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 populations. In the near term, the outlook for environmental conditions affecting Puget Sound steelhead is not optimistic. While harvest and hatchery production of steelhead in Puget Sound are currently at low levels and are not likely to increase substantially in the foreseeable future, some recent environmental trends not favorable to Puget Sound steelhead survival and production are expected to continue.	• Continued destruction and modification of habitat • Widespread declines in adult abundance despite significant reductions in harvest • Threats to diversity posed by use of two hatchery steelhead stocks • Declining diversity in the DPS, including the uncertain but weak status of summer-run fish • A reduction in spatial structure • Reduced habitat quality • Urbanization • Dikes, hardening of banks with riprap, and channelization
Puget Sound/ Georgia Basin DPS of	Endangered 04/28/2010 (75 FR 22276)	NMFS 2017d	NMFS 2016c	Though bocaccio were never a predominant segment of the multi-species rockfish population within the Puget Sound/Georgia	• Over harvest • Water pollution • Climate-induced changes to rockfish habitat

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Bocaccio				Basin, their present-day abundance is likely a fraction of their pre-contemporary fishery abundance. Most bocaccio within the DPS may have been historically spatially limited to several basins within the DPS. They were apparently historically most abundant in the Central and South Sound with no documented occurrences in the San Juan Basin until 2008. The apparent reduction of populations of bocaccio in the Main Basin and South Sound represents a further reduction in the historically spatially limited distribution of bocaccio, and adds significant risk to the viability of the DPS.	• Small population dynamics
Puget Sound/ Georgia Basin DPS of Yelloweye Rockfish	Threatened 04/28/2010 (75 FR 22276)	NMFS 2017d	NMFS 2016c	Yelloweye rockfish within the Puget Sound/Georgia Basin (in U.S. waters) are very likely the most abundant within the San Juan Basin of the DPS. Yelloweye rockfish spatial structure and connectivity is threatened by the apparent reduction of fish within each of the basins of the DPS. This reduction is probably most acute within the basins of Puget Sound proper. The severe reduction of fish in these basins may eventually result in a contraction of the DPS' range.	• Over harvest • Water pollution • Climate-induced changes to rockfish habitat • Small population dynamics
Hood Canal summer-run chum salmon	Threatened 06/28/2005 (70 FR 37160)	HCCC 2005 NMFS 2007	NWFSC 2015	This ESU is made up of two independent populations in one major population group. Natural-origin spawner abundance has increased since ESA-listing and spawning abundance targets in both populations have been met in some years. Productivity was quite low at the time of the last review, though rates have increased in the last five years, and have been greater than replacement rates in the past two years for both populations. However, productivity of individual spawning aggregates shows only two of eight aggregates have viable performance. Spatial structure and diversity viability parameters for each population have increased and nearly meet the viability criteria.	• Reduced floodplain connectivity and function • Poor riparian condition • Loss of channel complexity Sediment accumulation • Altered flows and water quality

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				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.	
Upper Columbia River spring-run Chinook salmon	Endangered 06/28/2005 (70 FR 37160)	UCSRB 2007	NWFSC 2015	This ESU comprises four independent populations. Three are at high risk and one is functionally extirpated. Current estimates of natural origin spawner abundance increased relative to the levels observed in the prior review for all three extant populations, and productivities were higher for the Wenatchee and Entiat populations and unchanged for the Methow population. However, abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Recovery Plan for all three populations.	• Effects related to hydropower system in the mainstem Columbia River • Degraded freshwater habitat • Degraded estuarine and nearshore marine habitat • Hatchery-related effects • Persistence of non-native (exotic) fish species • Harvest in Columbia River fisheries
Upper Columbia River steelhead	Threatened 01/05/2006 (71 FR 834)	UCSRB 2007	NWFSC 2015	This DPS comprises four independent populations. Three populations are at high risk of extinction while 1 population is at moderate risk. Upper Columbia River steelhead populations have increased relative to the low levels observed in the 1990s, but natural origin abundance and productivity remain well below viability thresholds for three out of the four populations. The status of the Wenatchee River steelhead population continued to improve based on the additional year's information available for the most recent review. The abundance and productivity viability rating for the Wenatchee River exceeds the minimum threshold for 5% extinction risk. However, the overall DPS status remains unchanged from the prior review, remaining at high risk driven by low abundance and productivity relative to viability objectives and diversity concerns.	• Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded floodplain connectivity and function, channel structure and complexity, riparian areas, large woody debris recruitment, stream flow, and water quality • Hatchery-related effects • Predation and competition • Harvest-related effects
Middle Columbia River steelhead	Threatened 01/05/2006 (71 FR 834)	NMFS 2009b	NWFSC 2015	This DPS comprises 17 extant populations. The DPS does not currently include steelhead that are designated as part of an experimental	• Degraded freshwater habitat • Mainstem Columbia River hydropower-related impacts

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				population above the Pelton Round Butte Hydroelectric Project. Returns to the Yakima River basin and to the Umatilla and Walla Walla Rivers have been higher over the most recent brood cycle, while natural origin returns to the John Day River have decreased. There have been improvements in the viability ratings for some of the component populations, but the DPS is not currently meeting the viability criteria in the MCR steelhead recovery plan. In general, the majority of population level viability ratings remained unchanged from prior reviews for each major population group within the DPS.	• Degraded estuarine and nearshore marine habitat • Hatchery-related effects • Harvest-related effects • Effects of predation, competition, and disease
Snake River spring/summer-run Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2017b	NWFSC 2015	This ESU comprises 28 extant and four extirpated populations. All expect one extant population (Chamberlin Creek) are at high risk. Natural origin abundance has increased over the levels reported in the prior review for most populations in this ESU, although the increases were not substantial enough to change viability ratings. Relatively high ocean survivals in recent years were a major factor in recent abundance patterns. While there have been improvements in abundance and productivity in several populations relative to prior reviews, those changes have not been sufficient to warrant a change in ESU status.	• Degraded freshwater habitat • Effects related to the hydropower system in the mainstem Columbia River, • Altered flows and degraded water quality • Harvest-related effects • Predation
Snake River fall-run Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2017a	NWFSC 2015	This ESU has one extant population. Historically, large populations of fall Chinook salmon spawned in the Snake River upstream of the Hells Canyon Dam complex. The extant population is at moderate risk for both diversity and spatial structure and abundance and productivity. The overall viability rating for this population is 'viable.' Overall, the status of Snake River fall Chinook salmon has clearly improved compared to the time of listing and compared to prior status reviews. The single extant population in the ESU is currently	• Degraded floodplain connectivity and function • Harvest-related effects • Loss of access to historical habitat above Hells Canyon and other Snake River dams • Impacts from mainstem Columbia River and Snake River hydropower systems • Hatchery-related effects • Degraded estuarine and nearshore habitat.

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				meeting the criteria for a rating of 'viable' developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Dam complex.	
Snake River basin steelhead	Threatened 01/05/2006 (71 FR 834)	NMFS 2017b	NWFSC 2015	This DPS comprises 24 populations. Two populations are at high risk, 15 populations are rated as maintained, 3 populations are rated between high risk and maintained, 2 populations are at moderate risk, 1 population is viable, and 1 population is highly viable. Four out of the five MPGs are not meeting the specific objectives in the draft recovery plan based on the updated status information available for this review, and the status of many individual populations remains uncertain A great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural spawning areas near major hatchery release sites within individual populations.	• Adverse effects related to the mainstem Columbia River hydropower system • Impaired tributary fish passage • Degraded freshwater habitat • Increased water temperature • Harvest-related effects, particularly for B-run steelhead • Predation • Genetic diversity effects from out-of-population hatchery releases
Snake River sockeye salmon	Endangered 06/28/2005 (70 FR 37160)	NMFS 2015a	NWFSC 2015	This single population ESU is at very high risk dues to small population size. There is high risk across all four basic risk measures. Although the captive brood program has been successful in providing substantial numbers of hatchery produced fish for use in supplementation efforts, substantial increases in survival rates across all life history stages must occur to re-establish sustainable natural production In terms of natural production, the Snake River Sockeye salmon ESU remains at extremely high risk although there has been substantial progress on the first phase of the proposed recovery approach – developing a hatchery based program to amplify and conserve the stock to facilitate reintroductions.	• Effects related to the hydropower system in the mainstem Columbia River • Reduced water quality and elevated temperatures in the Salmon River • Water quantity • Predation

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Lower Columbia River Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2013	NWFSC 2015	This ESU comprises 32 independent populations. Twenty-seven populations are at very high risk, 2 populations are at high risk, one population is at moderate risk, and 2 populations are at very low risk Overall, there was little change since the last status review in the biological status of this ESU, although there are some positive trends. Increases in abundance were noted in about 70% of the fall-run populations and decreases in hatchery contribution were noted for several populations. Relative to baseline VSP levels identified in the recovery plan, there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals.	• Reduced access to spawning and rearing habitat • Hatchery-related effects • Harvest-related effects on fall Chinook salmon • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Contaminant
Lower Columbia River coho salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2013	NWFSC 2015	Of the 24 populations that make up this ESU, 21 populations are at very high risk, 1 population is at high risk, and 2 populations are at moderate risk. Recent recovery efforts may have contributed to the observed natural production, but in the absence of longer term data sets it is not possible to parse out these effects. Populations with longer term data sets exhibit stable or slightly positive abundance trends. Some trap and haul programs appear to be operating at or near replacement, although other programs still are far from that threshold and require supplementation with additional hatchery-origin spawners .Initiation of or improvement in the downstream juvenile facilities at Cowlitz Falls, Merwin, and North Fork Dam are likely to further improve the status of the associated upstream populations. While these and other recovery efforts have likely improved the status of a number of coho salmon populations, abundances are still at low levels and the majority of the populations remain at moderate or high risk. For the Lower Columbia River region land development and increasing human population pressures will	• Degraded estuarine and near-shore marine habitat • Fish passage barriers • Degraded freshwater habitat: Hatchery-related effects • Harvest-related effects • An altered flow regime and Columbia River plume • Reduced access to off-channel rearing habitat in the lower Columbia River • Reduced productivity resulting from sediment and nutrient-related changes in the estuary • Juvenile fish wake strandings • Contaminants

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				likely continue to degrade habitat, especially in lowland areas. Although populations in this ESU have generally improved, especially in the 2013/14 and 2014/15 return years, recent poor ocean conditions suggest that population declines might occur in the upcoming return years	
Upper Willamette River Chinook salmon	Threatened 06/28/2005 (70 FR 37160)	ODFW and NMFS 2011	NWFSC 2015	This ESU comprises seven populations. Five populations are at very high risk, one population is at moderate risk (Clackamas River) and one population is at low risk (McKenzie River). Consideration of data collected since the last status review in 2010 indicates the fraction of hatchery origin fish in all populations remains high (even in Clackamas and McKenzie populations). The proportion of natural origin spawners improved in the North and South Santiam basins, but is still well below identified recovery goals. Abundance levels for five of the seven populations remain well below their recovery goals. Of these, the Calapooia River may be functionally extinct and the Molalla River remains critically low. Abundances in the North and South Santiam rivers have risen since the 2010 review, but still range only in the high hundreds of fish. The Clackamas and McKenzie populations have previously been viewed as natural population strongholds, but have both experienced declines in abundance despite having access to much of their historical spawning habitat. Overall, populations appear to be at either moderate or high risk, there has been likely little net change in the VSP score for the ESU since the last review, so the ESU remains at moderate risk.	• Degraded freshwater habitat • Degraded water quality • Increased disease incidence • Altered stream flows • Reduced access to spawning and rearing habitats • Altered food web due to reduced inputs of microdetritus • Predation by native and non-native species, including hatchery fish • Competition related to introduced salmon and steelhead • Altered population traits due to fisheries and bycatch
Oregon Coast coho salmon	Threatened 06/20/2011 (76 FR 35755)	NMFS 2016b	NWFSC 2015	This ESU comprises 56 populations including 21 independent and 35 dependent populations. The last status review indicated a moderate risk of extinction. Significant improvements in	• Reduced amount and complexity of habitat including connected floodplain habitat • Degraded water quality • Blocked/impaired fish passage

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				hatchery and harvest practices have been made for this ESU. Most recently, spatial structure conditions have improved in terms of spawner and juvenile distribution in watersheds; none of the geographic area or strata within the ESU appear to have considerably lower abundance or productivity. The ability of the ESU to survive another prolonged period of poor marine survival remains in question.	• Inadequate long-term habitat protection • Changes in ocean conditions
Southern Oregon/ Northern California Coast coho salmon	Threatened 06/28/2005 (70 FR 37160)	NMFS 2014b	Williams et al. 2015	This ESU comprises 31 independent, 9 independent, and 5 ephemeral populations all grouped into 7 diversity strata. Of the 31 independent populations, 24 are at high risk of extinction and 6 are at moderate risk of extinction. The extinction risk of an ESU depends upon the extinction risk of its constituent independent populations; because the population abundance of most independent populations are below their depensation threshold, the SONCC coho salmon ESU is at high risk of extinction and is not viable	• Lack of floodplain and channel structure • Impaired water quality • Altered hydrologic function • Impaired estuary/mainstem function • Degraded riparian forest conditions • Altered sediment supply • Increased disease/predation/competition • Barriers to migration • Fishery-related effects • Hatchery-related effects
California Central Valley steelhead	Threatened 3/19/1998 (63 FR 13347)	NMFS 2014a	Williams et al. 2016	Steelhead are present throughout most of the watersheds in the Central Valley, but often in low numbers, especially in the San Joaquin River tributaries. The status of this DPS appears to have changed little since the 2011 status review stating the DPS was in danger of extinction. There is still a paucity of data on the status of wild populations. There are some encouraging signs of increased returns over the last few years. However, the catch of unmarked (wild) steelhead at Chipps Island is still less than 5 percent of the total smolt catch, which indicates natural production of steelhead throughout the Central Valley remains at very low levels. Despite a positive trend on Clear Creek and encouraging signs from Mill Creek, all other concerns raised in the previous status review remain.	• Major dams • Water diversions • Barriers • Levees and bank protection • Dredging and sediment disposal • Mining • Contaminants • Alien species • Fishery-related effects • Hatchery-related effects

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
Central California Coast steelhead	Threatened 8/18/1997 (62 FR 43937)	NMFS 2016a	NMFS 2016c	Both adult and juvenile abundance data are limited for this DPS. It was historically comprised of 37 independent populations (11 functionally independent and 26 potentially independent) and perhaps 30 or more dependent populations of winter-run steelhead. Most of the coastal populations are assumed to be extant with other populations (Coastal San Francisco Bay and Interior San Francisco Bay) likely at high risk of extirpation. While data availability for this DPS remains poor, there is little new evidence to suggest that the extinction risk for this DPS has changed appreciably in either direction since the last status review.	• Dams and other barriers to migration • Stream habitat degradation • Estuarine habitat degradation • Hatchery-related effects
Southern DPS of eulachon	Threatened 03/18/2010 (75 FR 13012)	NMFS 2017c	Gustafson et al. 2016	The Southern DPS of eulachon includes all naturally-spawned populations that occur in rivers south of the Nass River in British Columbia to the Mad River in California. Sub populations for this species include the Fraser River, Columbia River, British Columbia and the Klamath River. In the early 1990s, there was an abrupt decline in the abundance of eulachon returning to the Columbia River. Despite a brief period of improved returns in 2001-2003, the returns and associated commercial landings eventually declined to the low levels observed in the mid-1990s. Although eulachon abundance in monitored rivers 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	• Changes in ocean conditions due to climate change, particularly in the southern portion of the species' range where ocean warming trends may be the most pronounced and may alter prey, spawning, and rearing success. • Climate-induced change to freshwater habitats • Bycatch of eulachon in commercial fisheries • Adverse effects related to dams and water diversions • Water quality • Shoreline construction • Over harvest • Predation
Southern resident killer whale	Endangered 11/18/2005 (70 FR 69903)	NMFS 2008	Ford 2013	The Southern Resident killer whale DPS is composed of a single population that ranges as far south as central California and as far north as southeast Alaska. The estimated effective size of the population (based on the number of breeding individuals under ideal genetic conditions) is very small — <30 whales, or about	• Quantity and quality of prey • Exposure to toxic chemicals • Disturbance from sound and vessels • Risk from oil spills

Species	Listing Classification and Date	Recovery Plan Reference	Most Recent Status Review	Status Summary	Limiting Factors
				1/3 of the current population size. The small effective population size, the absence of gene flow from other populations, and documented breeding within pods may elevate the risk from inbreeding and other issues associated with genetic deterioration. As of July 1, 2013, there were 26 whales in J pod, 19 whales in K pod and 37 whales in L pod, for a total of 82 whales. Estimates for the historical abundance of Southern Resident killer whales range from 140 whales (based on public display removals to 400 whales, as used in population viability analysis scenarios.	

2.2.1.1 Puget Sound Chinook Salmon

Listed Hatchery Juvenile Releases – Twenty-six artificial propagation programs are part of the species and are also listed (79 FR 20802; Table 3). Juvenile listed hatchery PS Chinook salmon abundance estimates come from the annual hatchery production goals. Hatchery production varies annually due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggest that production averages from previous years is not a reliable indication of future production. For these reasons, abundance is assumed to equal production goals. The combined hatchery production goal for listed PS Chinook salmon from Table 3 is 43,568,630 adipose-fin-clipped and non-clipped juvenile Chinook salmon.

Table 3. Expected 2019 Puget Sound Chinook salmon hatchery releases (WDFW 2018).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Deschutes	Tumwater Falls	2018	Fall	3,800,000	-
Dungeness-Elwha	Dungeness	2018	Spring	-	50,000
	Elwha	2017	Fall	-	200,000
		2018	Fall	250,000	2,250,000
	Gray Wolf River	2018	Spring	-	50,000
	Hurd Creek	2018	Spring	-	50,000
	Upper Dungeness Pond	2018	Spring	-	50,000
Duwamish	Icy Creek	2017	Fall	300,000	-
	Palmer	2018	Fall	-	1,000,000
	Soos Creek	2018	Fall	3,000,000	200,000
Hood Canal	Hood Canal Schools	2018	Fall	-	500
	Hoodsport	2017	Fall	120,000	-
		2018	Fall	3,000,000	-
Kitsap	Bernie Gobin	2017	Spring	40,000	-
		2018	Fall	-	200,000
			Summer	2,300,000	100,000
	Garrison	2018	Fall	850,000	-
	George Adams	2018	Fall	3,375,000	425,000
	Gorst Creek	2018	Fall	730,000	-
	Grovers Creek	2018	Fall	1,250,000	-
	Hupp Springs	2018	Spring	-	400,000
	Lummi Sea Ponds	2018	Fall	500,000	-
	Minter Creek	2018	Fall	1,250,000	-
Lake Washington	Salmon in the Schools	2018	Fall	-	540
	Issaquah	2018	Fall	2,000,000	-
Nisqually	Clear Creek	2018	Fall	3,300,000	200,000
	Kalama Creek	2018	Fall	600,000	-
	Nisqually MS	2018	Fall	-	90
Nooksack	Kendall Creek	2018	Spring	800,000	-
	Skookum Creek	2018	Spring	-	1,000,000
Puyallup	Clarks Creek	2018	Fall	400,000	-
	Voights Creek	2018	Fall	1,600,000	-
	White River	2017	Spring	-	55,000
		2018	Spring	-	340,000
San Juan Islands	Glenwood Springs	2018	Fall	725,000	-

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Skokomish	McKernan	2018	Fall	-	100,000
Skykomish	Wallace River	2017	Summer	500,000	-
		2018	Summer	800,000	200,000
Stillaguamish	Brenner	2018	Fall	-	200,000
	Whitehorse Pond	2018	Summer	220,000	-
Strait of Georgia	Samish	2018	Fall	3,800,000	200,000
Upper Skagit	Marblemount	2018	Spring	387,500	200,000
			Summer	200,000	-
Total Annual Release Number				**36,297,500**	**7,271,130**

Adult spawners and expected outmigration – The average abundance (2013-2017) for PS Chinook salmon populations is 37,941 adult spawners (22,398 natural-origin and 15,543 hatchery-origin spawners; Table 4). Natural-origin spawners range from 18 (in the South Fork Nooksack River population) to 9,505 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).

Table 4. Average abundance estimates for PS Chinook salmon natural- and hatchery-origin spawners 2012-2016 (unpublished data, Mindy Rowse, NWFSC, April 10, 2019).

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[d]	181	945	83.95%	16,000	90,009
SF Nooksack River[d]	18	15	45.04%	9,100	2,597
Strait of Juan de Fuca MPG					
Elwha River	130	2,156	94.30%	15,100	182,895
Dungeness River	189	213	52.91%	4,700	32,163
Hood Canal MPG					
Skokomish River	224	1,158	83.82%	12,800	110,505
Mid-Hood Canal	165	117	41.55%	11,000	22,589
Whidbey Basin MPG					
Skykomish River	2,001	1,466	42.29%	17,000	277,348
Snoqualmie River	881	219	19.93%	17,000	87,978
NF Stillaguamish River	385	291	43.04%	17,000	54,137
SF Stillaguamish River	42	29	40.57%	15,000	5,676
Upper Skagit River	9,505	120	1.25%	17,000	770,047
Lower Skagit River	2,207	13	0.60%	16,000	177,643
Upper Sauk River	1,106	5	0.46%	3,000	88,899
Lower Sauk River	559	3	0.59%	5,600	44,984
Suiattle River	590	5	0.77%	600	47,582
Cascade River	205	7	3.12%	1,200	16,937

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Minimum Viability Abundance[b]	Expected Number of Outmigrants[c]
Central / South Sound MPG					
Sammamish River	125	885	87.64%	10,500	80,823
Cedar River	883	440	33.26%	11,500	105,864
Duwamish/Green River	1,120	4,171	78.83%	17,000	423,326
Puyallup River	565	1,240	68.72%	17,000	144,384
White River	569	1,438	71.64%	14,200	160,622
Nisqually River	747	606	44.81%	13,000	108,281
ESU Average	**22,398**	**15,543**	**40.97%**		**3,035,288**

[a] Five-year geometric mean of post-fishery spawners (2013-2017).
[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

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 – 15,543 females), the ESU is estimated to produce approximately 30.4 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 3.04 million natural-origin outmigrants annually.

2.2.1.2 Puget Sound Steelhead

Listed Hatchery Juvenile Releases – Six artificial propagation programs were listed as part of the DPS (79 FR 20802; Table 5). For 2019, 222,500 hatchery steelhead are expected to be released throughout the range of the PS steelhead DPS (WDFW 2018).

Table 5. Expected 2019 Puget Sound steelhead listed hatchery releases (WDFW 2018).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Dungeness/Elwha	Dungeness	2018	Winter	10,000	-
	Hurd Creek	2018	Winter	-	34,500
Duwamish/Green	Flaming Geyser	2018	Winter	-	15,000
	Icy Creek	2018	Summer	50,000	-
			Winter	-	28,000
	Soos Creek	2018	Summer	50,000	-
Puyallup	White River	2018	Winter	-	35,000
Total Annual Release Number				**110,000**	**112,500**

Adult spawners and expected outmigration – The average abundance (2012-2016) for the PS steelhead DPS is 19,313 adult spawners (natural-origin and hatchery-production combined). Juvenile PS steelhead abundance estimates is calculated from the escapement data (Table 6). 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 (9,657 females), 33.80 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 2.20 million natural-origin outmigrants annually.

Table 6. Abundance of PS steelhead spawner escapements (natural-origin and hatchery-production combined) from 2012-2016 (pers. comm., A. Marshall, WDFW, July 13, 2017; WDFW Steelhead - General Information Page).

Demographically Independent Populations	Spawners[a]	Expected Number of Outmigrants[b]
Central and South Puget Sound MPG		
Cedar River	3	391
Green River	977	111,179
Nisqually River	759	86,323
N. Lake WA/Lake Sammamish	-	-
Puyallup/Carbon River	603	68,646
White River	629	71,638
Hood Canal and Strait of Juan de Fuca MPG		
Dungeness River[c]	26	2,984
East Hood Canal Tribs.	89	10,120
Elwha River	878	99,954
Sequim/Discovery Bay Tribs.	19	2,186
Skokomish River	862	98,066
South Hood Canal Tribs.	73	8,304
Strait of Juan de Fuca Tribs.	173	19,697
West Hood Canal Tribs.	122	13,858
North Cascades MPG		
Nooksack River	1,790	203,631
Pilchuck River	868	98,709
Samish River/ Bellingham Bay Tribs.	977	111,167
Skagit River	8,038	914,353
Snohomish/Skykomish Rivers	1,053	119,762
Snoqualmie River	824	93,772
Stillaguamish River	476	54,170
Tolt River	70	7,988
TOTAL	**19,313**	**2,196,901**

[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.

2.2.1.3 Puget Sound/Georgia Basin Bocaccio

Bocaccio in the Puget Sound/Georgia Basin were historically most common within the South Sound and Main Basin (Drake et al. 2010). Though bocaccio were never a predominant segment of the multi-species rockfish abundance within the Puget Sound/Georgia Basin (Drake et al. 2010), their present-day abundance is likely a fraction of their pre-contemporary fishery abundance. Bocaccio abundance may be very low in large segments of the Puget Sound/Georgia Basin. Productivity is driven by high fecundity and episodic recruitment events, largely correlated with environmental conditions. Thus, bocaccio populations do not follow consistent growth trajectories and sporadic recruitment drives population structure (Drake et al. 2010).

Natural annual mortality is approximately 8 percent (Palsson et. al 2009). Tolimieri and Levin (2005) found that the bocaccio population growth rate is around 1.01, indicating a very low intrinsic growth rate for this species. 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). Given their severely reduced abundance, Allee effects may be particularly acute for bocaccio, even considering the propensity of some individuals to move long distances and potentially find mates.

In Canada, the median estimate of bocaccio biomass is 3.5 percent of its unfished stock size (though this included Canadian waters outside of the DPS's area) (Stanley et al. 2012). There are no analogous biomass estimates in the U.S. portion of the bocaccio DPS. However, the Remotely Operated Vehicle (ROV) survey of the San Juan Islands in 2008 estimated a population of 4,606±4,606 (based on four fish observed along a single transect), but no estimate could be obtained in the 2010 ROV survey because this species was not encountered. A single bocaccio encountered in the 2015 ROV survey produced a statistically invalid population estimate for that portion of the DPS lying south of the entrance to Admiralty Inlet and east of Deception Pass. Several bocaccio have been caught in genetic surveys and by recreational anglers in Puget Sound proper in the past several years.

In summary, though abundance and productivity data for yelloweye rockfish and bocaccio is relatively imprecise, both abundance and productivity have been reduced largely by fishery removals within the range of each Puget Sound/Georgia Basin DPSs.

2.2.1.4 Puget Sound/Georgia Basin Yelloweye Rockfish

Yelloweye rockfish within the Puget Sound/Georgia Basin (in U.S. waters) are very likely the most abundant within the San Juan Basin. The San Juan Basin has the most suitable rocky benthic habitat (Palsson et al. 2009) and historically was the area of greatest numbers of angler catches (Moulton and Miller 1987; Olander 1991).

Productivity for yelloweye rockfish is influenced by long generation times that reflect intrinsically low annual reproductive success. Natural mortality rates have been estimated from 2 to 4.6 percent (Yamanaka and Kronlund 1997; Wallace 2007). Productivity may also be particularly impacted by Allee effects, which occur as adults are removed by fishing and the density and proximity of mature fish decreases. Adult yelloweye rockfish typically occupy relatively small ranges (Love et al. 2002) and it is unknown the extent they may move to find suitable mates.

In Canada, yelloweye rockfish biomass is estimated to be 12 percent of the unfished stock size on the inside waters of Vancouver Island (DFO 2011). There are no analogous biomass estimates in the U.S. portion of the yelloweye rockfish DPS. However, WDFW has generated several population estimates of yelloweye rockfish in recent years. ROV surveys in the San Juan Island region in 2008 (focused on rocky substrate) and 2010 (across all habitat types) estimated a population of 47,407±11,761 and 114,494±31,036 individuals, respectively. A 2015 ROV survey of that portion of the DPSs south of the entrance to Admiralty Inlet encountered 35 yelloweye rockfish, producing a preliminary population estimate of 66,998±7,370 individuals (final video review is still under way) (WDFW 2017).

2.2.1.5 Hood Canal Summer-run Chum Salmon

Listed Hatchery Juvenile Releases – Four artificial propagation programs were listed as part of the ESU (79 FR 20802); however, only one program is currently active. The combined hatchery production goal for listed HCS chum salmon from Table 7 is 150,000 unmarked juvenile chum salmon.

Table 7. Expected 2019 Hood Canal summer-run juvenile chum salmon hatchery releases (WDFW 2018).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Hood Canal	LLTK - Lilliwaup	2018	Summer	-	150,000
Total Annual Release Number				**-**	**150,000**

Adult spawners and expected outmigration – The current average run size of 26,598 adult spawners (25,146 natural-origin and 1,452 hatchery-origin spawners; Table 8) 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 2015 to 2019, Jimmycomelately Creek averaged 1,288 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 1,836 and 311, respectively, for the 2015-2019 period.

Table 8. Abundance of natural-origin and hatchery-origin HCS chum salmon spawners in escapements 2013-2017 (unpublished data, Mindy Rowse, NWFSC, Apr 12, 2019).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	% Hatchery Origin	Expected Number of Outmigrants[c]
Strait of Juan de Fuca Population				
Jimmycomelately Creek	1,288	0	0.00%	188,313
Salmon Creek	1,836	0	0.00%	268,531
Snow Creek	311	0	0.00%	45,541
Chimacum Creek	902	0	0.00%	131,971
Population Average[d]	4,337	0	0.00%	634,355

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	% Hatchery Origin	Expected Number of Outmigrants[c]
Hood Canal Population				
Big Quilcene River	6,437	0	0.00%	941,450
Little Quilcene River	122	0	0.00%	17,795
Big Beef Creek	10	0	0.00%	1,532
Dosewallips River	2,021	0	0.00%	295,524
Duckabush River	3,172	0	0.00%	463,856
Hamma Hamma River	2,944	10	0.34%	432,056
Anderson Creek	3	0	0.00%	376
Dewatto River	95	0	0.00%	13,947
Lilliwaup Creek	857	1,141	57.10%	292,159
Tahuya River	205	299	59.36%	73,777
Union River	2,789	2	0.07%	408,166
Skokomish River	2,154	0	0.00%	314,960
Population Average[d]	20,809	1,452	6.52%	3,255,599
ESU Average	**25,146**	**1,452**	**5.46%**	**3,889,955**

[a] Five-year geometric mean of post fishery natural-origin spawners (2015-2019).
[b] Five-year geometric mean of post fishery hatchery-origin spawners (2015-2019).
[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 (2015-2019).

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 – 11,969 females), the ESU is estimated to produce approximately 29.9 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 3.89 million natural-origin outmigrants annually.

2.2.1.6 Upper Columbia River Spring-run Chinook Salmon

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – This ESU includes Chinook salmon from six artificial propagation programs (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries were 621,759 LHAC and 368,642 LHIA UCR spring-run Chinook salmon smolts annually (Zabel 2014, 2015, 2017a, 2017b, 2018). To estimate abundance of natural juvenile UCR spring-run Chinook salmon, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For natural-origin juvenile UCR spring-run Chinook salmon, an estimated average of 468,820 juveniles outmigrated over the last five years.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2018). The most recent five-year geometric means (2014-2018) for UCR spring-run Chinook salmon are 2,872 natural-origin; 6,226 LHAC and 3,364 LHIA adults. The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

2.2.1.7 Upper Columbia River Steelhead

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – Six artificial propagation programs were listed as part of the DPS (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries are 687,567 LHAC and 138,601 LHIA UCR steelhead annually (Zabel 2015, 2017a, 2017b, 2018, 2020). To estimate abundance of natural juvenile UCR steelhead, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For natural-origin juvenile UCR steelhead, an estimated average of 199,380 juveniles outmigrated over the last five years.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2019). The five-year geometric means (2015-2019) for UCR steelhead are 1,931 natural-origin; 5,309 LHAC, and 1,163 LHIA adults. The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

2.2.1.8 Middle Columbia River Steelhead

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – Seven artificial propagation programs were listed as part of the DPS (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries are 444,973 LHAC and 110,469 LHIA MCR steelhead annually (Zabel 2015, 2017a, 2017b, 2018, 2020). To estimate abundance of natural juvenile MCR steelhead, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For natural-origin juvenile MCR steelhead, an estimated average of 407,697 juveniles outmigrated over the last five years.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2019). The five-year geometric means (2015-2019) for MCR steelhead are 5,052 natural-origin; 448 LHAC, and 112 LHIA adults. The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

2.2.1.9 Snake River Spring/Summer-run Chinook Salmon

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – 11 artificial propagation programs were listed as part of the DPS (79 FR 20802). From 2014-2018, the geometric means for the releases from these hatcheries are 4,760,250 LHAC and 868,679 LHIA spr/sum Chinook annually (Zabel 2014, 2015, 2017a, 2017b, 2018). To estimate abundance of natural juvenile spr/sum Chinook, we calculate the geometric means for outmigrating smolts over the past five years for which we have data (2014-2018) by using annual abundance estimates provided by the NWFSC (Zabel 2014, 2015, 2017a, 2017b, 2018). For natural-origin juvenile spr/sum Chinook, an estimated average of 1,296,641 juveniles outmigrated over the five most recent years for which we have data.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2018). The five-year geometric means (2014-2018) for SnkR spr/sum-run Chinook salmon are 12,798 natural-origin; 2,387 LHAC, and 421 LHIA adults. The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

2.2.1.10 Snake River fall-run Chinook Salmon

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – four artificial propagation programs were listed as part of the DPS (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries are 2,483,713 LHAC and 2,862,418 LHIA SnkR fall Chinook annually (Zabel 2015, 2017a, 2017b, 2018, 2020). To estimate abundance of natural juvenile SnkR fall Chinook, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For natural-origin juvenile SnkR fall Chinook, an estimated average of 692,819 juveniles outmigrated over the last five years.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2020). The five-year geometric means (2015-2019) for SnkR fall Chinook salmon are 10,337 natural-origin; 12,508 LHAC, and 13,551 LHIA adults. The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

2.2.1.11 Snake River Basin Steelhead

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – six artificial propagation programs were listed as part of the DPS (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries are 3,300,152 LHAC and 705,490 LHIA SnkR basin steelhead annually (Zabel 2015, 2017a, 2017b, 2018, 2020). To estimate abundance of natural juvenile SnkR basin steelhead, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For natural-origin juvenile SnkR basin steelhead, an estimated average of 798,341 juveniles outmigrated over the last five years.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2018). The five-year geometric means (2014-2018) for SnkR basin steelhead are 10, 547 natural-origin; 79,510 LHAC, and 16,137 LHIA adults. The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery constituents found in the NWFSC outmigration estimate memos (above).

2.2.1.12 Snake River Sockeye Salmon

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – One artificial propagation program was listed as part of this ESU – Redfish Lake Captive Broodstock Program (79 FR 20802). From 2015-2019, the geometric mean for the releases from this hatchery program was 242,610 LHAC fish (Zabel 2015, 2017a, 2017b, 2018, 2020). There were no LHIA SnkR sockeye because all the fish from the program are clipped. To estimate abundance of natural juvenile SnkR sockeye, we calculate the geometric means for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For natural-origin juvenile SnkR sockeye, an estimated average of 19,181 juveniles outmigrated over the last five years.

Adult Abundance – To calculate the abundance figures for adult spawners (natural and hatchery), we calculate the geometric means of the last five years of adult returns as measured by dam counts. This is part of the tracking done for the Federal Columbia River Power System's Adaptive Management and Implementation Plan (AMIP 2018). The five-year geometric means (2014-2018) for SnkR sockeye salmon are 546 natural-origin and 4,004 LHAC adults. The AMIP figures represent natural returns only. We calculate the hatchery returns by taking the wild return numbers and expanding them by the fractions of the wild vs. hatchery outmigrants found in the NWFSC outmigration estimate memos (above).

2.2.1.13 Lower Columbia River Chinook Salmon

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – This ESU includes fifteen ESA-listed artificial propagation programs (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries are 31,353,395 LHAC and 962,458 LHIA LCR Chinook salmon smolts (Zabel 2015, 2017a, 2017b, 2018, 2020). To estimate abundance of juvenile LCR Chinook salmon, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2014, 2015, 2017a, 2017b, 2018). For juvenile natural-origin LCR Chinook salmon, an estimated average of 11,745,027 juvenile salmon outmigrated over the last five years.

Adult Abundance – The average abundance for LCR Chinook salmon populations is 68,061 adult spawners (29,469 natural-origin and 38,594 hatchery-origin spawners; Table 9).

Table 9. Average abundance estimates for LCR Chinook salmon natural- and hatchery-origin spawners (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project; WDFW Chinook - General Information Page).

Population Name	Years	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin
Coastal Stratum – Fall run				
Youngs Bay	2012-2014	233	5,606	96.01%
Grays/Chinook	2010-2014	100	357	78.12%
Big Creek	2012-2014	32	1,510	97.92%
Elochoman/Skamokowa	2010-2014	116	580	83.33%
Clatskanie	2012-2014	98	3,193	97.02%
Mill/Abernathy/Germany	2010-2014	92	805	89.74%
Cascade Stratum – Fall run				
Lower Cowlitz	2010-2013	723	196	21.33%
Upper Cowlitz	2010-2013	2,873	961	25.07%
Toutle	2010-2014	3,305	5,400	62.03%
Coweeman	2010-2014	385	963	71.44%
Kalama	2010-2014	803	8,892	91.72%
Lewis	2010-2014	2,178	943	30.21%
Washougal	2010-2014	192	116	37.66%
Clackamas	2012-2014	1,272	2,955	69.91%
Sandy	2012-2014	1,207	320	20.96%
Columbia Gorge Stratum – Fall run				
Lower Gorge	2003-2007	146	-	-
Upper Gorge	2010-2012	200	327	62.05%
White Salmon	2010-2014	829	246	22.88%
Cascade Stratum – Late fall run				
North Fork Lewis	2010-2014	12,330	0	0.00%
Cascade Stratum – Spring run				
Upper Cowlitz/Cispus	2010-2014	279	3,614	92.83%
Kalama	2011-2014	115	-	-
North Fork Lewis	2010-2014	217	0	0.00%
Sandy	2010-2014	1,731	1,470	45.92%
Gorge Stratum – Spring run				
White Salmon	2013-2014	13	140	91.50%
ESU Average		**29,469**	**38,594**	**56.70%**

2.2.1.14 Lower Columbia River Coho Salmon

Listed Hatchery Juvenile Releases and Natural Juvenile Abundance – The LCR coho salmon ESU includes 21 artificial propagation programs (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries are 7,287,647 LHAC and 249,784 LHIA LCR coho salmon smolts annually (Zabel 2015, 2017a, 2017b, 2018, 2020). To estimate abundance of juvenile LCR coho salmon, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2015, 2017a, 2017b, 2018, 2020). For juvenile natural-origin LCR coho salmon, an estimated average of 661,468 juvenile salmon outmigrated over the last five years.

Adult Abundance – The average abundance for LCR coho salmon populations is 38,657 adult spawners (29,866 natural-origin and 8,791 hatchery-origin spawners; Table 10).

Table 10. Average abundance estimates for LCR coho salmon natural- and hatchery-origin spawners (Lewis et al. 2009, 2010, 2011, 2012, 2014; Sounhein et al. 2014, 2015, 2016, 2017, 2018; WDFW Conservation - Coho salmon webpage).

Population Name	Years	Natural-origin Spawners	Hatchery-origin Spawners	% Hatchery Origin
Coastal Stratum				
Grays/Chinook	2013-2017	284	429	60.14%
Elochoman/Skamokowa	2013-2017	587	306	34.22%
Mill/Abernathy/Germany	2013-2017	733	73	9.05%
Youngs Bay	2008-2012	79	121	60.61%
Big Creek	2008-2012	349	171	32.86%
Clatskanie	2013-2017	614	81	11.71%
Scappoose	2013-2017	811	3	0.39%
Cascade Stratum				
Lower Cowlitz	2013-2017	4,502	668	12.92%
Upper Cowlitz/Cispus	2013-2017	5,245	478	8.36%
Titlton	2013-2017	3,039	3,193	51.24%
SF Toutle	2013-2017	1,711	472	21.63%
NF Toutle	2013-2017	1,039	789	43.15%
Coweeman	2013-2017	2,032	309	13.21%
Kalama	2013-2017	33	172	83.96%
NF Lewis	2013-2017	520	151	22.55%
EF Lewis	2013-2017	835	283	25.29%
Salmon Creek	2013-2017	1,465	44	2.91%
Washougal	2013-2017	219	416	65.52%
Clackamas	2013-2017	3,762	319	7.82%
Sandy	2013-2017	1,315	25	1.87%
Gorge Stratum				
Lower Gorge	2012-2016	576	142	19.75%
Upper Gorge/White Salmon	2013-2017	47	13	21.12%
Hood	2012-2016	68	133	66.15%

Population Name	Years	Natural-origin Spawners	Hatchery-origin Spawners	% Hatchery Origin
ESU Average		**29,866**	**8,791**	**22.74%**

2.2.1.15 Upper Willamette River Chinook Salmon

Listed Hatchery Juvenile Releases – This ESU includes spring-run Chinook salmon from six artificial propagation programs (79 FR 20802). From 2015-2019, the geometric means for the releases from these hatcheries are 4,709,045 LHAC and 157 LHIA UWR Chinook salmon smolts annually (Zabel 2015, 2017a, 2017b, 2018, 2020). To estimate abundance of juvenile UWR Chinook salmon, we calculate the geometric mean for outmigrating smolts over the past five years (2015-2019) by using annual abundance estimates provided by the NWFSC (Zabel 2014, 2015, 2017a, 2017b, 2018). For juvenile natural-origin UWR Chinook salmon, and estimated average of 1,211,863 juvenile salmon outmigrated over the last five years.

Adult spawners and expected outmigration – The average (2013-2017) abundance of UWR Chinook salmon is 41,679 adult spawners (10,203 natural-origin and 31,476 hatchery-origin spawners; Table 11).

Table 11. Adult UWR spring-run Chinook salmon abundance (ODFW and WDFW 2014, 2015, 2016, 2017, 2018).

Year	Natural-origin Spawners	Hatchery-origin Spawners	Total Spawner Abundance[a]
2013	11,182	24,532	35,714
2014	7,758	29,523	37,281
2015	11,973	49,561	61,534
2016	10,588	27,679	38,267
2017	10,054	31,096	41,150
ESU Average[b]	**10,203**	**31,476**	**41,679**

[a] Sum of Natural + Hatchery escapement to Willamette Falls fish ladder and the Clackamas River
[b] Five-year geometric mean of post-fishery spawners (2013-2017)

2.2.1.16 Oregon Coast Coho Salmon

Listed Hatchery Juvenile Releases – The OC coho salmon ESU includes one artificial propagation programs – Cow Creek Hatchery Program (Oregon Department of Fish and Wildlife Stock #18) (79 FR 20802). The hatchery production goal is 60,000 adipose-fin-clipped yearling OC coho salmon (ODFW 2017).

Adult spawners and expected outmigration – The average abundance for OC coho salmon populations is 94,879 adult spawners (94,320 natural-origin and 559 hatchery-origin spawners; Table 12).

Table 12. Average abundance estimates for OC coho salmon natural- and hatchery-origin spawners (Sounhein et al. 2014, 2015, 2016, 2017, 2018).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[b]
North Coast Stratum				
Necanicum River	1,139	5	0.42%	80,063
Nehalem River	7,073	11	0.16%	495,889
Tillamook Bay	4,771	19	0.39%	335,290
Nestucca River	2,320	2	0.09%	162,547
North Coast Dependents	602	3	0.49%	42,350
Mid-Coast Stratum				
Salmon River	924	9	0.98%	65,352
Siletz River	5,534	2	0.04%	387,545
Yaquina River	4,585	2	0.05%	321,141
Beaver Creek	1,634	1	0.09%	114,493
Alsea River	8,627	0	0.00%	603,904
Siuslaw River	12,994	0	0.00%	909,584
Mid Coast Dependents	1,190	7	0.56%	83,747
Lakes Stratum				
Siltcoos Lake	2,362	0	0.00%	165,333
Tahkenitch Lake	1,356	2	0.13%	95,077
Tenmile Lake	2,909	0	0.00%	203,660
Umpqua Stratum				
Lower Umpqua River	8,755	2	0.02%	612,987
Middle Umpqua River	3,080	0	0.00%	215,578
North Umpqua River	2,320	191	7.59%	175,760
South Umpqua River	3,683	299	7.52%	278,743
Mid-South Coast Stratum				
Coos River	6,320	0	0.00%	442,407
Coquille River	10,781	3	0.03%	754,870
Floras Creek	1,154	0	0.00%	80,785
Sixes River	200	0	0.00%	14,029
Mid-South Coast Dependents	5	1	16.36%	428
ESU Average	**94,320**	**559**	**0.59%**	**6,641,564**

[a] Five-year geometric mean of post-fishery spawners (2013-2017).

[b] Expected number of outmigrants=Total spawners*50% proportion of females*2,000 eggs per female*7% survival rate from egg to outmigrant.

While we currently lack data on how many natural juvenile coho salmon this ESU produces, it is possible to make rough estimates of juvenile abundance from adult return data. The five-year geometric mean from 2013 through 2017 is estimated at 94,879 spawners (Table 12). Sandercock (1991) published fecundity estimates for several coho salmon stocks; average fecundity ranged from 1,983 to 5,000 eggs per female. By applying a very conservative value of 2,000 eggs per female to an estimated 47,440 females returning (roughly half of 94,879) to this ESU, one may expect approximately 94.88 million eggs to be produced annually. Nickelson (1998) found survival of coho salmon from egg to parr in Oregon coastal streams to be around 7%. Thus, we can estimate that roughly 6.64 million juvenile coho salmon are produced annually by the Oregon Coast ESU.

2.2.1.17 Southern Oregon/Northern California Coast Coho Salmon

Listed Hatchery Juvenile Releases – Three artificial propagation programs were listed as part of the ESU (79 FR 20802). Hatchery releases from these hatcheries average 200,000 LHAC and 575,000 LHIA SONCC coho salmon juveniles annually (ODFW 2011, CHSRG 2012).

Adult spawners and expected outmigration – The average abundance for SONCC coho salmon populations is 19,990 adult spawners (9,065 natural-origin and 10,934 hatchery-origin spawners; Table 13).

Table 13. Estimates of the natural-origin and hatchery-produced adult coho salmon returning to the Rogue, Trinity, and Klamath rivers (ODFW Corvallis Research Laboratory - Oregon Adult Salmonid Inventory & Sampling Project, Kier et al 2015, CDFW 2012).

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

[a] Hatchery proportion unknown, but assumed to be low.
[b] 3-year average of most recent years of data.
[c] Annual returns of adults are likely less than 50 per year (NMFS 2014b).

While we currently lack data on naturally-produced juvenile coho salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. Quinn (2005) published estimates for salmonids in which average fecundity for coho salmon is 2,878 eggs per female. By applying the average fecundity of 2,878 eggs per female to the estimated 9,995 females returning (half of the average total number of spawners), approximately 28.8 million eggs may be expected to be produced annually. Nickelson (1998) found survival of coho salmon from egg to parr in Oregon coastal streams to be around 7 percent. Thus, we approximate that this ESU produces about 2,013,593 juvenile SONCC coho salmon outmigrants annually.

2.2.1.18 California Central Valley Steelhead

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

Table 14. Abundance geometric means for adult CCV steelhead natural- and hatchery-origin spawners (CHSRG 2012, Hannon and Deason 2005, Teubert et al. 2011, additional unpublished data provided by the NMFS SWFSC)

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

[a] Expected number of outmigrants=Total spawners*50 percent proportion of females*3,500 eggs per female*6.5 percent survival rate from egg to outmigrant
[b] Based upon number of natural-origin spawners

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

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

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

Both adult and juvenile abundance data are limited for this DPS. While we currently lack data on naturally-produced juvenile CCV steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCV steelhead abundance estimates come from the escapement data (Table 14). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of hatchery- and natural-origin spawners – 2,771 females), 9.7 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 630,403 naturally produced outmigrants annually. In addition, hatchery managers could produce approximately 1.6 million listed hatchery juvenile CCV steelhead each year (Table 15).

Table 15. Expected Annual CCV Steelhead Hatchery Releases (CHSRG 2012).

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

2.2.1.19 Central California Coast Steelhead

The CCC steelhead DPS includes winter-run steelhead populations from the Russian River (Sonoma County) south to Aptos Creek (Santa Cruz County) inclusive and eastward to Chipps Island (confluence of the Sacramento and San Joaquin rivers) and including all drainages of San Francisco, San Pablo, and Suisun bays (Table 16).

Table 16. Historical CCC Steelhead Populations (NMFS 2011).

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

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

Data for both adult and juvenile abundance are limited for this DPS. While we currently lack data on naturally-produced juvenile CCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCC steelhead abundance estimates come from the escapement data (Table 18). All returnees to the hatcheries do not contribute to the natural population and are not used in this calculation. For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of natural-origin spawners – 1,094 females), 3.8 million eggs are expected to be produced annually. In addition, hatchery managers could produce 648,841 listed hatchery juvenile CCC steelhead each year (Table 17). With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 248,771 natural outmigrants annually (Table 18).

Table 17. Approximate annual releases of hatchery CCC steelhead (J. Jahn, pers. comm., July 2, 2013).

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

Table 18. Geometric Mean Abundances of CCC Steelhead Spawners Escapements by Population (Ettlinger et al. 2012, Jankovitz 2013, Source:

http://www.marinwater.org/DocumentCenter/View/200/Walker-Creek-Salmon-Monitoring-Program-Reports-and-References-March-2010?bidId=, Natural abundance: Manning and Martini-Lamb (ed.) 2012; Hatchery abundance source: http://www.scwa.ca.gov/files/docs/projects/rrifr/Final_BO_Report_2011_2012.pdf, Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoUpercent3D&tabid=1772, Atkinson 2010, Williams et al. 2011, Koehler and Blank 2012, additional unpublished data provided by the NMFS SWFSC).

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

[a]Expected number of outmigrants=Total spawners*50 percent proportion of females*3,500 eggs per female*6.5 percent survival rate from egg to outmigrant
[b]Based upon natural-origin spawner numbers

Good et al. (2005) concluded that due to past declines, threats to genetic integrity, and available abundance data the CCC steelhead DPS was not presently in danger of extinction but was likely to become so in the future. While data indicated that CCC steelhead remain present in the Santa Cruz mountains, reducing overall extinction risk of the DPS, subsequent reviews of DPS viability (Williams et al. 2011, NMFS 2016e) have concluded there was not sufficient information to indicate any change in DPS viability, although they acknowledge high levels of uncertainty surrounding most populations (NMFS 2016e). This indicates the DPS may not be viable in the long term. DPS populations that historically provided enough steelhead strays to support dependent populations may no longer be able to do so, placing dependent populations at increased risk of extirpation. However, because CCC steelhead have maintained a wide distribution throughout the DPS, roughly approximating the known historical distribution, CCC steelhead likely possess a resilience that is likely to slow their decline relative to other salmonid species in worse condition (*e.g.,* CCC coho salmon).

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

2.2.1.20 Southern Eulachon

For most S eulachon DPS spawning runs, abundance is unknown with the exception of the Columbia and Fraser River spawning runs. Beginning in 1995, the Canada's Department of Fisheries and Oceans (DFO) started annual surveys in the Fraser River. These surveys consisted of estimating larval density, measuring river discharge, and using estimates of relative fecundity to determine spawning biomass (Hay et al. 2002). Beginning in 2011, Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW) began instituting similar monitoring in the Columbia River. From 2014 through 2018, the eulachon spawner population estimate for the Fraser River is 2,608,909 adults and for the Columbia River 16,188,081 adults (Table 19). The combined spawner estimate from the Columbia and Fraser rivers is 18.80 million eulachon.

Table 19. Southern DPS eulachon spawning estimates for the lower Fraser River (British Columbia, Canada) and Columbia River (Oregon/Washington states, USA).

Year	Fraser River		Columbia River	
	Biomass estimate (metric tons)[a]	Estimated spawner population[ab]	Biomass estimate (metric tons)[c]	Estimated spawner population[bc]
2011	31	765,445	723	17,860,400
2012	120	2,963,013	810	20,008,600
2013	100	2,469,177	1,845	45,546,700
2014	66	1,629,657	3,412	84,243,100
2015	317	7,827,292	2,330	57,525,700
2016	44	1,086,438	877	21,654,800
2017	35	864,212	330	8,148,600
2018	408	10,074,243	53	1,300,000
2014-2018[d]	**106**	**2,608,009**	**656**	**16,188,081**

[a] Data from unpublished data, R. Gustafson, NWFSC, September 17, 2017 and Canada Department of Fisheries and Ocean - Fraser River Eulachon Egg/larval Abundance Surveys

[b] Estimated population numbers are calculated as 11.2 eulachon per pound.

[c] Langness 2018

[d] Five-year geometric mean of mean eulachon biomass estimates (2014-2018).

2.2.2 Status of the Species' Critical Habitat

This section describes the status of designated critical habitat affected by the proposed action by examining the condition and trends of the essential physical and biological features of that habitat throughout the designated areas. These features are essential to the conservation of the ESA-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 most salmon and steelhead, NMFS's critical habitat analytical review teams (CHARTs) 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 ESA-listed species that they support (NMFS 2005). The conservation rankings were high, medium, or low. To determine the conservation value of each watershed to species viability, the CHARTs evaluated the quantity and quality of habitat features, the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Even if a location had poor habitat quality, it could be ranked with a high conservation value if it were essential due to factors such as limited availability, a unique contribution of the population it served, or is serving another important role.

A summary of the status of critical habitats, considered in this opinion, is provided in Table 20, below.

Table 20. Critical habitat, designation date, federal register citation, and status summary for critical habitat considered in this opinion.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Puget Sound Chinook salmon	09/02/2005 70 FR 52630	Critical habitat for Puget Sound Chinook salmon includes 1,683 miles of streams, 41 square mile of lakes, and 2,182 miles of nearshore marine habitat in Puget Sounds. The Puget Sound Chinook salmon ESU has 61 freshwater and 19 marine areas within its range. Of the freshwater watersheds, 41 are rated high conservation value, 12 low conservation value, and eight received a medium rating. Of the marine areas, all 19 are ranked with high conservation value. Primary constitute elements relevant for this consultation include: 1) Estuarine areas free of obstruction with water quality and aquatic vegetation to support juvenile transition and rearing; 2) Nearshore marine areas free of obstruction with water quality conditions, forage, submerged and overhanging large wood, and aquatic vegetation to support growth and maturation; 3) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.
Puget Sound steelhead	02/24/2016 81 FR 9252	Critical habitat for Puget Sound steelhead includes 2,031 stream miles. Nearshore and offshore marine waters were not designated for this species. There are 66 watersheds within the range of this DPS. Nine watersheds received a low conservation value rating, 16 received a medium rating, and 41 received a high rating to the DPS.
Puget Sound/Georgia Basin DPS of bocaccio	11/13/2014 79 FR 68042	Critical habitat for bocaccio includes 590.4 square miles of nearshore habitat and 414.1 square miles of deepwater habitat. Critical habitat is not designated in areas outside of United States jurisdiction; therefore, although waters in Canada are part of the DPSs' ranges for all three species, critical habitat was not designated in that area. Based on the natural history of bocaccio and their habitat needs, NMFS identified two physical or biological features, essential for their conservation: 1) Deepwater sites (>30 meters) that support growth, survival, reproduction, and feeding opportunities; 2) Nearshore juvenile rearing sites with sand, rock and/or

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		cobbles to support forage and refuge. Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality as specific threats to rockfish habitat in the Georgia Basin.
Puget Sound/Georgia Basin DPS of yelloweye rockfish	11/13/2014 79 FR 68042	Critical habitat for yelloweye rockfish includes 414.1 square miles of deepwater marine habitat in Puget Sound, all of which overlaps with areas designated for canary rockfish and bocaccio. No nearshore component was included in the CH listing for juvenile yelloweye rockfish as they, different from bocaccio and canary rockfish, typically are not found in intertidal waters (Love et al. 1991). Yelloweye rockfish are most frequently observed in waters deeper than 30 meters (98 ft) near the upper depth range of adults (Yamanaka et al. 2006). Habitat threats include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality as specific threats to rockfish habitat in the Georgia Basin.
Hood Canal summer-run chum salmon	09/02/2005 70 FR 52630	Critical habitat for Hood Canal summer-run chum salmon includes 79 miles and 377 miles of nearshore marine habitat in HC. Primary constituent elements relevant for this consultation include: 1) Estuarine areas free of obstruction with water quality and aquatic vegetation to support juvenile transition and rearing; 2) Nearshore marine areas free of obstruction with water quality conditions, forage, submerged and overhanging large wood, and aquatic vegetation to support growth and maturation; 3) Offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.
Upper Columbia River spring-run Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses four subbasins in Washington containing 15 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. We rated conservation value of HUC5 watersheds as high for 10 watersheds, and medium for five watersheds. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Upper Columbia River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Washington containing 31 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 20 watersheds, medium for eight watersheds, and low for three watersheds.
Middle Columbia River steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses 15 subbasins in Oregon and Washington containing 111 occupied watersheds, as well as the Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of occupied HUC5 watersheds as high for 80 watersheds, medium for 24 watersheds, and low for 9 watersheds.
Snake River spring/summer-run Chinook salmon	10/25/1999 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers (except the Clearwater River) presently or historically accessible to this ESU (except reaches above impassable natural falls and Hells Canyon Dam). Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River fall-run Chinook salmon	10/25/1999 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers, and all tributaries of the Snake and Salmon rivers presently or historically

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		accessible to this ESU (except reaches above impassable natural falls, and Dworshak and Hells Canyon dams). Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River basin steelhead	09/02/2005 70 FR 52630	Critical habitat encompasses 25 subbasins in Oregon, Washington, and Idaho. Habitat quality in tributary streams varies from excellent in wilderness and roadless areas, to poor in areas subject to heavy agricultural and urban development (Wissmar et al. 1994). Reduced summer stream flows, impaired water quality, and reduced habitat complexity are common problems. Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Snake River sockeye salmon	10/25/1999 64 FR 57399	Critical habitat consists of river reaches of the Columbia, Snake, and Salmon rivers; Alturas Lake Creek; Valley Creek; and Stanley, Redfish, Yellow Belly, Pettit and Alturas lakes (including their inlet and outlet creeks). Water quality in all five lakes generally is adequate for juvenile sockeye salmon, although zooplankton numbers vary considerably. Some reaches of the Salmon River and tributaries exhibit temporary elevated water temperatures and sediment loads that could restrict sockeye salmon production and survival (NMFS 2015a). Migratory habitat quality in this area has been severely affected by the development and operation of the dams and reservoirs of the Federal Columbia River Power System.
Lower Columbia River Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 47 occupied watersheds, as well as the lower Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some, or high potential for improvement. We rated conservation value of HUC5 watersheds as high for 30 watersheds, medium for 13 watersheds, and low for four watersheds.
Lower Columbia River coho salmon	02/24/2016 81 FR 9252	Critical habitat encompasses 10 subbasins in Oregon and Washington containing 55 occupied watersheds, as well as the lower Columbia River and estuary rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition (NMFS 2005). However, most of these watersheds have some or a high potential for improvement. We rated conservation value of HUC5 watersheds as high for 34 watersheds, medium for 18 watersheds, and low for three watersheds.
Upper Willamette River Chinook salmon	09/02/2005 70 FR 52630	Critical habitat encompasses 10 subbasins in Oregon containing 56 occupied watersheds, as well as the lower Willamette/Columbia River rearing/migration corridor. Most HUC5 watersheds with PBFs for salmon are in fair-to-poor or fair-to-good condition. However, most of these watersheds have some, or high, potential for improvement. Watersheds are in good to excellent condition with no potential for improvement only in the upper McKenzie River and its tributaries (NMFS 2005). We rated conservation value of HUC5 watersheds as high for 22 watersheds, medium for 16 watersheds, and low for 18 watersheds.
Oregon Coast coho salmon	02/11/2008 73 FR 7816	Critical habitat encompasses 13 subbasins in Oregon. The long-term decline in Oregon Coast coho salmon productivity reflects deteriorating conditions in freshwater habitat as well as extensive loss of access to habitats in estuaries and tidal freshwater. Many of the habitat changes resulting from land use practices over the last 150 years that contributed to the ESA-listing of Oregon Coast coho salmon continue to hinder recovery of the populations; changes in the watersheds due to land use practices have weakened natural watershed processes and functions, including loss of connectivity to historical floodplains, wetlands and side channels; reduced riparian area functions (stream temperature regulation, wood

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
		recruitment, sediment and nutrient retention); and altered flow and sediment regimes (NMFS 2016b). Several historical and ongoing land uses have reduced stream capacity and complexity in Oregon coastal streams and lakes through disturbance, road building, splash damming, stream cleaning, and other activities. Beaver removal, combined with loss of large wood in streams, has also led to degraded stream habitat conditions for coho salmon (Stout et al. 2012)
Southern Oregon/Northern California Coast coho salmon	05/05/1999 64 FR 24049	Critical habitat includes all areas accessible to any life-stage up to long-standing, natural barriers and adjacent riparian zones. SONCC coho salmon critical habitat within this geographic area has been degraded from historical conditions by ongoing land management activities. Habitat impairments recognized as factors leading to decline of the species that were included in the original listing notice for SONCC coho salmon include: 1) Channel morphology changes; 2) substrate changes; 3) loss of in-stream roughness; 4) loss of estuarine habitat; 5) loss of wetlands; 6) loss/degradation of riparian areas; 7) declines in water quality; 8) altered stream flows; 9) fish passage impediments; and 10) elimination of habitat
California Central Valley steelhead	9/2/2005 70 FR 52488	There are approximately 2,308 miles of stream habitats and 254 square miles of estuary habitats designated as critical habitat for CCV steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS. CCV steelhead PBFs are those sites and habitat components which support one or more life stages. There are 67 watersheds within the range of this DPS. Twelve watersheds received a low rating, 18 received a medium rating, and 37 received a high rating of conservation value to the DPS. Since designation, critical habitat for this species has continued to be degraded somewhat by the factors listed above in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities resulting in slightly improved conditions in some areas and a slowing of the negative trend.
Central California Coast steelhead	9/2/2005 70 FR 52488	There are approximately 1,465 miles of stream habitats and 386 square miles of estuary habitats designated as critical habitat for CCC steelhead. NMFS determined that marine areas did not warrant consideration as critical habitat for this DPS. CCC steelhead PBFs are sites and habitat components which support one or more life stages including freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and nearshore marine areas. There are 46 watersheds within the range of this DPS. For conservation value to the DPS, fourteen watersheds received a low rating, 13 received a medium rating, and 19 received a high rating. Since designation, critical habitat for this species continues to be degraded by several factors listed in the status section. Nonetheless, a number of restoration efforts have been undertaken by local, state, and Federal entities to improve conditions in some areas and slow the negative trend.
Southern DPS of eulachon	10/20/2011 76 FR 65324	Critical habitat for eulachon includes portions of 16 rivers and streams in California, Oregon, and Washington. All of these areas are designated as migration and spawning habitat for this species. In Oregon, we designated 24.2 miles of the lower Umpqua River, 12.4 miles of the lower Sandy River, and 0.2 miles of Tenmile Creek. We also designated the mainstem Columbia River from the mouth to the base of Bonneville Dam, a distance of 143.2 miles. Dams and water diversions are moderate threats to eulachon in the Columbia and Klamath rivers where hydropower generation and flood control are major activities. Degraded water quality is common in some areas occupied by southern DPS eulachon. In the Columbia and Klamath river basins, large-scale impoundment of water has increased winter water temperatures, potentially altering the water temperature during eulachon spawning periods. Numerous chemical contaminants are also present in spawning rivers, but the exact effect these compounds have on spawning and egg development is unknown. Dredging is a low to moderate threat to eulachon in the Columbia River. Dredging during eulachon spawning would be particularly detrimental.

Species	Designation Date and Federal Register Citation	Critical Habitat Status Summary
Southern resident killer whale	11/29/2006 71 FR 69054	Critical habitat consists of three specific marine areas of inland waters of Washington: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. These areas comprise approximately 2,560 square miles of marine habitat. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified three PBFs, or physical or biological features, essential for the conservation of Southern Residents: 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 Water quality in Puget Sound, in general, is degraded. On September 19, 2019 NMFS proposed to revise the critical habitat designation for the SRKW DPS under the ESA by designating six new areas along the U.S. West Coast (84 FR 49214). Specific new areas proposed along the U.S. West Coast include 15,626.6 square miles (mi\2\) (40,472.7 square kilometers (km\2\)) of marine waters between the 6.1-meter (m) (20 feet (ft)) depth contour and the 200-m (656.2 ft) depth contour from the U.S. international border with Canada south to Point Sur, California. The proposed rule to revise critical habitat designation was based on new information about the SRKW's habitat use along the coast.

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For the purposes of this opinion, the action area includes all river reaches accessible to listed Chinook salmon, chum salmon, coho salmon, sockeye salmon, and steelhead in all sub-basins of the Pacific Northwest (Washington, Oregon, Idaho) and California. Additionally, the action area includes all marine waters off the West Coast of the continuous United States, including nearshore waters from California to the 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 (see permit summaries below for the instances in which this would be applicable). Still, the action area is generally spread out over much of Idaho, Oregon, Washington and California. It is also discontinuous. That is, there are large areas in between the various actions' locations where listed salmonids, eulachon, rockfish, etc., do exist, but where they would not be affected to any degree by any of the proposed activities. As noted earlier, the proposed actions could affect the killer whales' prey base (Chinook salmon) and those effects are described in the Not Likely to Adversely Affect section (2.11).

In most 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 the proposed research activities 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 (Table 20).

2.3.1. Action Areas for the Individual Permits

Permit 1339-5M – The activities entailed in the proposed modification would take place in several locations along tributaries to the mainstem of the lower Salmon River in Idaho below the town of Riggins, Idaho. Different tributaries may be targeted on a year-to-year basis, so it is difficult to be more precise about the exact locations in any given year, but in general, the activities would take place in Slate, Whitebird, or Skookumchuck Creeks.

Permit 14772-4R – The proposed activities would take place in the mainstems of the South Umpqua, the North Umpqua, and the Umpqua River itself. In Umpqua River, the activities would extend from River Forks Park to the mouth. In the South Umpqua River, the activities would extend from the mouth to Tiller, Oregon—including the Cow Creek tributary in its entirety. In the North Umpqua River, the activities would extend from the mouth up to Winchester Dam.

Permit 15205-4R – The proposed activities would take place in multiple nearshore locations throughout the San Juan Islands archipelago in Puget Sound (San Juan County, WA) – Decatur Island (Brigantine Bay), Lopez Island (Watmough Bight), and Waldron Island (Cowlitz Bay).

Permit 15230-3R – The proposed activities would take place in the South Fork of the Tolt River (Snoqualmie River sub-basin; King County, WA). Sampling locations within the river would occur from RM 3.5 to RM 7.5.

Permit 17062-6R – The proposed activities would take place in the marine environment throughout the Puget Sound and Hood Canal (Washington state). Therefore, it is impossible to characterize the action area more narrowly for this project. .

Permit 17761-2R – The proposed activities would take place in several locations through the Lower Mokelumne River in the San Joaquin Valley, CA. Rotary screw traps are located at rkm 62 below Woodbridge Dam, at rkm 76 upstream of Lodi Lake, and at rkm 87 upstream of Elliott Rd in Lockeford. Spawning areas are surveyed weekly below Camanche Dam from rkm 103 to rkm 90. Additional survey methods (hook and line, beach seine, dip net, fyke trap, trawling, and electrofishing (backpack and boat) may also be used to capture fish in the lower Mokelumne River.

Permit 18696-4R – The proposed activities would take place in various locations on the Snake River—though primarily in the reservoir behind Lower Granite Dam. In total, the research would extend from River Mile 108 (Lower Granite Dam) to River mile 247.

Permit 18852-2R – The proposed activities would take place in various mainstem and tributary locations in the Yakima, Entiat, Wenatchee, Methow, and Okanogan watersheds in Washington state. The locations would change from year to year, depending on varying monitoring and surveying needs, so it is difficult to be more precise about the exact locations in any given year.

Permit 18906-2R – The proposed activities would take place in multiple nearshore locations in eastern Puget Sound from Saratoga Passage (in the south) to Fidalgo Bay (to the north) (Island and Skagit counties, WA). Specific locations include Bowman Bay (five sites), Cornet Bay (ten sites), Fidalgo Bay (nine sites), and Saratoga Passage (six sites). The use of a beach seine to capture fish is minimally invasive and would not have any impacts beyond the immediate reach of the seine.

Permit 19013-2R – The proposed activities would take place in the Hamma Hamma River 300m upstream of the uppermost tidal intrusion from Hood Canal (Mason County, WA). An eight-foot rotary screw trap would be used to capture fish. The activities' nature are such that all effects are expected to be restricted to the immediate vicinity of the trap where the research takes place.

Permit 19386-2R – The proposed activities would take place in the Lower Duwamish River estuary (King County, WA). A fyke net would be deployed during high tide and fished during the falling ebb tide. The activities' nature are such that all effects are expected to be restricted to the immediate vicinity of the net where the research takes place.

Permit 23567 – The proposed activities would take in Rector Creek downstream of Rector Dam for 1.7 miles to the confluence with Conn Creek, Napa County, CA. The surveys would be presence/absence surveys (electrofishing, beach seine) that are expected to be minimally intrusive and not expected to have any measurable downstream effects.

Permit 23600 – The proposed activities would take place in the marine environment throughout the Puget Sound and the Strait of Juan de Fuca (Washington state). Therefore, it is impossible to characterize the action area more narrowly for this project. Longline gear set to a depth between 60m and 100m would be used. The activities' nature are such that all effects are expected to be restricted to the immediate vicinity of where the research takes place.

Permit 23629 – The proposed activities would take place in and near lakes and reservoirs in the following watersheds: Middle Fork and Coast Fork of the Willamette River, the McKenzie River, the North and South Santiam Rivers, and the upper Rogue River—all in Oregon. The sampling areas and regimes would change from year to year, so it is difficult to be more precise about the activities' locations in any given year.

Permit 23633 – The proposed activities would take place between River Mile 1 and River Mile 11 in Abernathy Creek, Washington. All activities would take place directly in the stream.

Permit 23637 – All the proposed activities that could affect listed fish would take place in the Adult Fish Facility at Bonneville Dam on the Columbia River.

2.4 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. 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 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (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. In many cases, the action area under consideration covers individual animals that could come from anywhere in the various listed species' entire ranges (see Sections 1.3 and 2.3). As a result, the effects of these past activities on the species themselves (that is, effects on abundance, productivity, etc.) cannot be tied to any particular population and are therefore displayed individually in the species status section summaries above (see Section 2.2).

Thus, for some of the work being contemplated here, the impacts that previous Federal, state, and private activities in the action area have had on the species are indistinguishable from those effects summarized below and in the previous section on the species' rangewide status. The same is true with respect to the species' habitat: for some of the work contemplated, the environmental baseline is the result of these activities' rangewide effects on the PBFs that are essential to the conservation of the species. However, as noted previously, some of the proposed work has a more limited geographic scope. If the work would not take place in marine or mainstem areas or would not be randomly distributed throughout the majority of a given species' range, then the action area can be narrowed for a more specific analysis—and in those instances, the relevant local status information will be taken into account for both species and critical habitat.

Analysis at the ESU/DPS level will be performed for all permits listed in Table 1. The permits for which population-level analysis will be performed are:

- 1339-5M
- 14772-4R
- 15230-3R
- 18852-2R
- 19013-2R
- 19386-2R
- 23629
- 23633

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 harvest and hatchery practices and habitat degradation and curtailment caused by human development and resource extraction. NMFS' decisions to list the species 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 tables 2 and 21 for summaries of the major factors limiting recovery of the listed species and how various factors have degraded PBFs and harmed listed species considered in this opinion. Also, please see section 2.2 for information regarding how climate change has affected and is affecting species and habitat in the action areas. Climate change was not generally considered a relevant factor when the species were listed and the critical habitat designated: it is now.

As a general matter, all the species considered in this opinion have at least some biological requirements that are not being met in the action areas. The listed species are still experiencing the impact of a variety of past and ongoing Federal, state, and private activities in the action areas and that impact is expressed in the limiting factors described above and in the species status sections—all of which, in combination, are currently keeping the species from recovering and actively preventing them from having all their biological requirement met in the action area.

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 2020, 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 21 displays the total take for the ongoing research authorized under ESA sections 4(d) and 10(a)(1)(A).

Table 21. Total expected take of the ESA listed species for scientific research and monitoring already approved for 2020.

Species	Life Stage	Origin	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	948	39	4.233	0.174
		Listed Hatchery Intact Adipose	900	12	15.351	0.566
		Listed Hatchery Adipose Clip	1,486	76		
	Juvenile	Natural	499,804	10,318	16.466	0.340
		Listed Hatchery Intact Adipose	90,542	3,018	1.245	0.042
		Listed Hatchery Adipose Clip	178,103	11,155	0.491	0.031
	Adult	Natural	1,452	31	7.777	0.192

Species	Life Stage	Origin	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Steelhead		Listed Hatchery Intact Adipose	22	0		
		Listed Hatchery Adipose Clip	28	6		
	Juvenile	Natural	67,508	1,223	3.073	0.056
		Listed Hatchery Intact Adipose	2,405	39	2.138	0.035
		Listed Hatchery Adipose Clip	4,974	99	4.522	0.090
Puget Sound/Georgia Basin DPS Rockfish, Bocaccio	Adult	Natural	20	13	0.434	0.282
	Subadult	Natural	2	1	-	-
	Juvenile	Natural	66	18		
Puget Sound/Georgia Basin DPS Rockfish, Yelloweye	Adult	Natural	17	12	0.025	0.018
	Subadult	Natural	2	1	-	-
	Juvenile	Natural	37	13		
Hood Canal summer-run chum salmon	Adult	Natural	2,006	31	7.977	0.123
	Juvenile	Natural	726,706	2,532	18.682	0.065
		Listed Hatchery Intact Adipose	135	3	0.090	0.002
Upper Columbia River spring-run Chinook salmon	Adult	Natural	102	4	3.552	0.139
		Listed Hatchery Adipose Clip	18	4	0.289	0.064
	Juvenile	Natural	1,091	40	0.233	0.009

Species	Life Stage	Origin	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		Listed Hatchery Intact Adipose	34	3	0.009	0.000
		Listed Hatchery Adipose Clip	484	37	0.078	0.006
Upper Columbia River Steelhead	Adult	Natural	99	2	5.127	0.104
		Listed Hatchery Intact Adipose	4	0	0.344	0.000
		Listed Hatchery Adipose Clip	19	2	0.358	0.038
	Juvenile	Natural	17,028	358	8.540	0.180
		Listed Hatchery Intact Adipose	2,418	69	1.745	0.050
		Listed Hatchery Adipose Clip	10,334	248	1.503	0.036
Middle Columbia River Steelhead	Adult	Natural	1,108	13	21.932	0.257
		Listed Hatchery Intact Adipose	39	1	34.821	0.893
		Listed Hatchery Adipose Clip	933	12	208.259	2.679
	Juvenile	Natural	116,807	2,386	28.650	0.585
		Listed Hatchery Intact Adipose	4,272	60	3.867	0.054

Species	Life Stage	Origin	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		Listed Hatchery Adipose Clip	3,650	70	0.820	0.016
Snake River spring/summer-run Chinook salmon	Adult	Natural	2,456	22	19.190	0.172
		Listed Hatchery Intact Adipose	586	6	139.192	1.425
		Listed Hatchery Adipose Clip	1,803	14	75.534	0.587
	Juvenile	Natural	763,061	7,121	75.736	0.707
		Listed Hatchery Intact Adipose	36,086	330	4.654	0.043
		Listed Hatchery Adipose Clip	74,425	1,064	1.671	0.024
Snake River fall-run Chinook salmon	Adult	Natural	43	7	0.416	0.068
		Listed Hatchery Intact Adipose	2	1	0.015	0.007
		Listed Hatchery Adipose Clip	44	10	0.284	0.064
	Juvenile	Natural	2,582	112	0.373	0.016
		Listed Hatchery Intact Adipose	634	43	0.022	0.002
		Listed Hatchery Adipose Clip	1,006	127	0.041	0.005

Species	Life Stage	Origin	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Snake River Basin Steelhead	Adult	Natural	3,362	51	31.876	0.484
		Listed Hatchery Intact Adipose	304	11	1.884	0.068
		Listed Hatchery Adipose Clip	816	21	1.026	0.026
	Juvenile	Natural	259,311	3,356	32.481	0.420
		Listed Hatchery Intact Adipose	14,089	178	1.997	0.025
		Listed Hatchery Adipose Clip	58,679	711	1.778	0.022
Snake River sockeye salmon	Adult	Natural	13	4	2.381	0.733
		Listed Hatchery Intact Adipose	6	0	-	-
		Listed Hatchery Adipose Clip	1	0	0.025	0.000
	Juvenile	Natural	10,570	459	55.107	2.393
		Listed Hatchery Intact Adipose	1	0	-	-
		Listed Hatchery Adipose Clip	391	260	0.161	0.107
	Adult	Natural	381	13	1.293	0.044

Species	Life Stage	Origin	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Lower Columbia River Chinook salmon		Listed Hatchery Intact Adipose	12	0	0.422	0.034
		Listed Hatchery Adipose Clip	151	13		
	Juvenile	Natural	819,220	11,375	6.975	0.097
		Listed Hatchery Intact Adipose	293	35	0.030	0.004
		Listed Hatchery Adipose Clip	62,013	1,727	0.198	0.006
Lower Columbia River coho salmon	Adult	Natural	1,242	18	4.159	0.060
		Listed Hatchery Intact Adipose	31	0	7.280	0.466
		Listed Hatchery Adipose Clip	609	41		
	Juvenile	Natural	174,722	2,508	26.414	0.379
		Listed Hatchery Intact Adipose	560	112	0.224	0.045
		Listed Hatchery Adipose Clip	53,543	1,845	0.735	0.025
	Adult	Natural	185	12	1.813	0.117

Species	Life Stage	Origin	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Willamette River Chinook salmon	Adult	Listed Hatchery, Clipped and Intact	156	19	0.495	0.060
		Natural	46,773	903	3.859	0.074
	Juvenile	Listed Hatchery Intact Adipose	46	6	1.092	0.142
		Listed Hatchery Adipose Clip	8,912	240	0.189	0.005
Oregon Coast coho salmon	Adult	Natural	9,248	110	9.805	0.117
		Listed Hatchery Adipose Clip	21	4	3.757	0.716
	Juvenile	Natural	556,044	12,305	8.372	0.185
		Listed Hatchery Adipose Clip	284	20	0.473	0.033
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	1,579	29	17.419	0.320
		Listed Hatchery Intact Adipose	1,577	17	19.874	0.284
		Listed Hatchery Adipose Clip	596	14		
	Juvenile	Natural	190,052	2,695	9.438	0.134
		Listed Hatchery Intact Adipose	11,991	681	2.085	0.118

Species	Life Stage	Origin	Total Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		Listed Hatchery Adipose Clip	1,456	42	0.728	0.021
California Central Valley Steelhead	Adult	Natural	2,438	76	144.603	4.508
		Listed Hatchery Adipose Clip	2,092	106	54.253	2.749
	Juvenile	Natural	57,670	1,840	9.148	0.292
		Listed Hatchery Adipose Clip	24,681	1,423	1.542	0.089
Central California Coast Steelhead	Adult	Natural	2,738	52	125.194	2.378
		Listed Hatchery Adipose Clip	494	19	12.778	0.491
	Spawned Adult/ Carcass	Natural	265	4	-	-
		Listed Hatchery Adipose Clip	100	2		
	Juvenile	Natural	239,225	5,365	96.163	2.157
		Listed Hatchery Intact Adipose	6,200	124	-	-
		Listed Hatchery Adipose Clip	12,881	355	1.985	0.055
Southern DPS Eulachon	Adult	Natural	34,349	31,086	0.183	0.165
	Subadult	Natural	1,030	1,030	-	-
	Juvenile	Natural	540	456		

Actual take levels associated with these activities are almost certain to be a substantially lower than the permitted levels. There are several reasons for this. First, most researchers do not handle the full number of juveniles or adults they are allowed. 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 (20.45% of requested take and 14.74% of requested mortalities were used in ID, OR, and WA Section 10a1A permits from 2008 to 2017). Over the past five years, (2014-2019) all section 10(a)(1)(A) permits active in California for ESA-listed steelhead and salmon resulted in only 8.8% of the requested handling take (489,389 of 5,575,092) and 3.6% of the requested mortalities (6,854 of 192,328). Second, we purposefully inflate our take and mortality estimates for each proposed study to account for the effects of potential accidental deaths. Therefore it is very likely that far fewer fish—especially juveniles—would be killed under any given research project than the researchers are permitted. Third, for salmonids, many of the fish that may be affected would be in the smolt stage. 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 estimates of percentages of ESUs/DPSs taken 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 seventh of the values given in the tables.

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

2.5 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b).

2.5.1 Effects on Critical Habitat

Full descriptions of effects of the proposed research activities are given in the following sections. In general, the permitted 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 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. Therefore none of the activities analyzed in this Opinion will measurably affect any habitat PBF function or value described earlier.

2.5.2 Effects on the Species

As discussed above, the proposed research activities would not measurable affect any of the listed species' habitat The actions are therefore not likely to measurably affect any of the listed species by reducing that 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 that are difficult to assess in terms of their impact on individuals, let alone entire species.

The following subsections describe the types of activities being proposed. Each is described in terms broad enough to apply to all the permits. The activities would be carried out by trained professionals using established protocols. The effects of the activities are well documented and discussed in detail below. 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

The primary effect of the proposed research on the listed species would be in the form of capturing and handling fish. We discuss effects from handling and anesthetizing fish, and the general effects of capture using seines and traps here. We discuss effects from other capture methods in more detail in the subsections below.

Harassment caused by capturing, handling, and releasing fish generally leads to stress and other sub-lethal effects that are difficult to assess in terms of their impact on individuals, populations, and species (Sharpe et al. 1998). Handling of fish may cause stress, injury, or death, which typically are due to overdoses of anesthetic, differences in water temperatures between the river and holding buckets, depleted dissolved oxygen in holding buckets, holding fish out of the water, and physical trauma. Stress on salmonids increases rapidly from handling if the water temperature exceeds 18ºC or dissolved oxygen is below saturation. Fish transferred to holding buckets can experience trauma if care is not taken in the transfer process, and fish can experience stress and injury from overcrowding in traps, nets, and buckets. 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). The permit conditions identified in Section 1.3 contain measures that mitigate 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, which makes them easy to capture. It can cause a suite of effects ranging from disturbing the fish to killing them. The percentage of fish that are unintentionally killed by electrofishing varies widely depending on the equipment used, the settings on the equipment, and the expertise of the technician (Sharber and Carothers 1988, McMichael 1993, Dalbey et al. 1996; Dwyer and White 1997). Research indicates that using continuous direct current (DC) or low-frequency (30 Hz) pulsed DC waveforms produce lower spinal injury rates, particularly for salmonids (Fredenberg 1992, McMichael 1993, Sharber et al. 1994, Snyder 1995).

Most studies on the effects of electrofishing on fish have been conducted on adult fish greater than 300 mm in length (Dalbey et al. 1996). Electrofishing can have severe effects on adult salmonids. Adult salmonids can be injured or killed due to spinal injuries that can result from forced muscle contractions. Sharber and Carothers (1988) reported that electrofishing killed 50 percent of the adult rainbow trout in their study.

Spinal injury rates are substantially lower for juvenile fish than for adults. 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) reported a 5.1% injury rate for juvenile Middle Columbia River steelhead captured by electrofishing in the Yakima River subbasin.

When using appropriate electrofishing protocols and equipment settings, shocked fish normally revive quickly. Studies on the long-term effects of electrofishing indicate that even with spinal injuries, salmonids can survive long-term, however, severely injured fish may have stunted growth (Dalbey et al. 1996, Ainslie et al. 1998).

Permit conditions would require that all researchers follow NMFS' electrofishing guidelines (NMFS 2000). The guidelines require that field crews:

- Use electrofishing only when other survey methods are not feasible.
- Be trained by qualified personnel in equipment handling, settings, maintenance to ensure proper operating condition, and safety.
- Conduct visual searches prior to electrofishing on each date and avoid electrofishing near adults or redds. If an adult or a redd is detected, researchers must stop electrofishing at the research site and conduct careful reconnaissance surveys prior to electrofishing at additional sites.
- Test water conductivity and keep voltage, pulse width, and rate at minimal effective levels. Use only DC waveforms.
- Work in teams of two or more technicians to increase both the number of fish seen at one time and the ability to identify larger fish without having to net them. Working in teams allows netter(s) to remove fish quickly from the electrical field and to net fish farther from the anode, where the risk of injury is lower.
- Observe fish for signs of stress and adjust electrofishing equipment to minimize stress.

- Provide immediate and adequate care to any fish that does not revive immediately upon removal from the electrical current.

The preceding discussion focused on the effects backpack electrofishing and the ways those effects would be mitigated. In larger streams and rivers, electrofishing units are sometimes mounted on boats or rafts. These units often use more current than backpack electrofishing equipment because they need to cover larger and deeper areas. The environmental conditions in larger, more turbid streams can limit researchers' ability to minimize impacts on fish. As a result, boat electrofishing can have a greater impact on fish. Researchers conducting boat electrofishing must follow NMFS' electrofishing guidelines.

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 percent 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 percent and 84 percent respectively.

Hook and Line/Angling

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

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

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

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

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

Only a few reports are available that provide empirical evidence showing what the catch and release mortality is for Chinook salmon in freshwater. The ODFW has conducted studies of hooking mortality incidental to the recreational fishery for Chinook salmon in the Willamette River. A study of the recreational fishery estimates a per-capture hook-and-release mortality for wild spring Chinook 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, gear type, and unhook time is important in determining the mortality of released fish. Fish hooked in the jaw or tongue suffered lower mortality (2.3 and 17.8% in Lindsay et al. (2004)) compared to fish hooked in the gills or esophagus (81.6 and 67.3%). Numerous studies have reported that deep hooking is more likely to result from using bait (e.g. eggs, prawns, or ghost shrimp) than lures (Lindsay et al. 2004). One theory is that bait tends to be passively fished and the fish is more likely to swallow bait than a lure. Passive angling techniques (e.g. drift fishing) are often associated with higher hooking mortality rates for salmon while active angling techniques (e.g. trolling) are often associated with lower hooking mortality rates (Cox-Rogers et al. 1999).

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

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

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

Observation

For some parts of the proposed studies, listed fish would be observed but not captured (e.g., by snorkel surveys or from the banks). Observation without handling is the least disruptive method for determining a species’ presence/absence and estimating their relative numbers. Its effects are also generally the shortest-lived and least harmful of the research activities discussed in this section because a cautious observer can effectively obtain data while only slightly disrupting the fishes’ behavior. Fry and juveniles frightened by the turbulence and sound created by observers are likely to seek temporary refuge in deeper water or behind or under rocks or vegetation. In extreme cases, some individuals may leave a particular pool or habitat type and then return when observers leave the area. At times, the research involves observing adult fish—which are more sensitive to disturbance. During some of the research activities discussed below, redds may be visually inspected, but per NMFS' pre-established mitigation measures (included in state fisheries agency submittals), would not be walked on. Harassment is the primary form of take associated with these observation activities, and few if any injuries (and no deaths) are expected to occur—particularly in cases where the researchers observe from the stream banks rather than in the water. Because these effects are so small, there is little a researcher can do to mitigate them except to avoid disturbing sediments, gravels, and, to the extent possible, the fish themselves, and allow any disturbed fish the time they need to reach cover.

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 2017d). 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.

Sacrifice (Intentionally Killing)

In some instances, it is necessary to kill a captured fish in order to gather whatever data a study is designed to produce. In such cases, determining effect is a very straightforward process: the sacrificed fish, if they are juveniles, are forever removed from the gene pool and the effect of their deaths is weighed in the context that the effect on their listed unit and, where possible, their local population. If the fish are adults, the effect depends upon whether they are killed before or after they have a chance to spawn. If they are killed after they spawn, there is very little overall effect. Essentially, it amounts to removing the nutrients their bodies would have provided to the spawning grounds. If they are killed before they spawn, not only are they removed from the population, but so are all their potential progeny. Thus, killing pre-spawned adults has the greatest potential to affect the listed species. Because of this, NMFS only very rarely allows pre-spawned adults to be sacrificed. And, in almost every instance where it is allowed, the adults are stripped of sperm and eggs so their progeny can be raised in a controlled environment such as a hatchery—thereby greatly decreasing the potential harm posed by sacrificing the adults. As a general rule, adults are not sacrificed for scientific purposes and no such activity is considered in this opinion.

Screw trapping

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

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

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

Spearfishing

Spearfishing is a fish harvest strategy which involves "fishing for, attempting to fish for, catching or attempting to catch fish by any person with a spear or a powerhead (see 50 CFR 600.10)". Spear means "a sharp, pointed, or barbed instrument on a shaft" (50 CFR 600.10). Spears can be operated by hand (manually) or shot from a gun or sling. In some coastal environments, underwater spearfishing can alter fish assemblages (Lloret et al. 2008) by selectively targeting large individuals, altering size structure of target species or decreasing fish densities (Basta and Kennedy 2006). Large fish are ecologically important due to food web impacts and reproductive contributions, among other reasons; therefore, selective fishing for large individuals through this gear type could have indirect impacts on fish community assemblages. However, we would not allow spearfishing that would intentionally target adults or juveniles for ESA-listed species, so there would be no such effects on these species.

One advantage of this gear type is its high selectivity and minimal impacts to nontarget species and surrounding habitat compared to other fishing methods. A major disadvantage of the spearfishing method is the inability to catch and release captured individuals. Spears are designed to penetrate fish flesh and therefore can be lethal. The main concern with this technique centers on whether spearfish operators are able to reliably determine species, as releasing the fish post-capture would likely result in mortality, depending on wound severity. As a result, we will only authorize this technique in cases where it can be reliably demonstrated that the persons carrying out the action are sufficiently trained and experienced in fish identification.

Tangle Netting

Tangle nets are similar to gillnets, having a top net with floats and a bottom net with weights, but tangle nets have smaller mesh sizes than gill nets. Tangle nets are designed to capture fish by the snout or jaw, rather than the gills. Researchers must select the mesh size carefully depending on their target species, since a tangle net may act as a gill net for fish that are smaller than the target size.

Tangle nets can efficiently capture salmonids in large rivers and estuaries, and have been used successfully for the lower Columbia River spring Chinook salmon commercial fishery (Ashbrook et al. 2005, Vander Haegen et al. 2004). However, fish may be injured or die if they become physiologically exhausted in the net or if they sustain injuries such as abrasion or fin damage. Entanglement in nets can damage the protective slime layer, making fish more susceptible to infections. These injuries can result in immediate or delayed mortality. Vander Haegen et al. (2005) reported that spring Chinook salmon had lower delayed mortality rates when captured in tangle nets (92% survival) versus gill nets (50% survival), relative to a control group. Vander Haegen et al. (2005) emphasized that, to minimize both immediate and delayed mortality, researchers must employ best practices including using short nets with short soak times, and removing fish from the net carefully and promptly after capture. As with other types of capture, fish stress increases rapidly if the water temperature exceeds 18 ºC or dissolved oxygen is below saturation.

Tagging/Marking

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

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

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

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

1968; Bordner et al. 1990). The conditions under which CWTs may be inserted are similar to those required for applying PIT-tags.

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

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

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

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

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

Tissue Sampling

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

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

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

Trawls

Trawls are cone-shaped, mesh nets that are towed, often, along benthic habitat (Hayes 1983, Hayes et al. 1996). Rectangular doors, attached to the towing cables, keep the mouth of the trawl open. Most trawls are towed behind a boat, but small trawls can be operated by hand. As fish enter the trawl, they tire and fall to the codend of the trawl. Mortality and injury rates associated with trawls can be high, particularly for small or fragile fish. Fish can be crushed by debris or other fish caught in the net. However, all of the trawling considered in this opinion is midwater trawling which may be less likely to capture heavy debris loads than benthic or demersal trawl sampling. Depending on mesh size, some small fish are able to escape the trawl through the netting. However, not all fish that escape the trawl are uninjured, as fish may be damaged while passing through the netting. Short duration trawl hauls (5 to 10 minutes maximum) may reduce injuries (Hayes 1983, Stickney 1983, Hayes et al. 1996).

Weirs

Capture of adult salmonids by weirs is common practice in order to collect information; (1) enumerate adult salmon and steelhead entering the watershed; (2) determine the run timing of adult salmon and steelhead entering the watershed; (3) estimate the age, sex and length composition of the salmon escapement into the watershed; and (4) used to determine the genetic composition of fish passing through the weir (i.e. hatchery versus natural). Information pertaining to the run size, timing, age, sex and genetic composition of salmon and steelhead returning to the respective watershed will provide managers valuable information to refine existing management strategies.

Some weirs have a trap to capture fish, while other weirs have a video or DIDSON sonar to record fish migrating through the weir. Weirs with or without a trap, have the potential to delay migration. All weir projects will adhere to the draft NMFS West Coast Region Weir Guidelines and have included detailed descriptions of the weirs. The Weir Guidelines require the following: (1) traps must be checked and emptied daily, (2) all weirs including video and DIDSON sonar weirs must be inspected and cleaned of any debris daily, (3) the development and implementation of monitoring plans to assess passage delay, and (4) a development and implementation of a weir operating plan. These guidelines are intended to help improve fish weir design and operation in ways which will limit fish passage delays and increase weir efficiency.

2.5.3 Species-specific Effects of Each Permit

In previous sections, we estimated the annual abundance of adult and juvenile listed salmonids, eulachon, bocaccio, and rockfish. Since there are no measurable habitat effects, the analysis will consist primarily of examining directly measurable impacts of proposed activities on abundance. Abundance effects are themselves relevant to extinction risk, are directly related to productivity effects, and are somewhat but 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 22 displays the estimated annual abundance of the listed species.

The analysis process relies on multiple sources of data. In Section 2.2.1 (Status of the Species), we estimated the average annual abundance for the species considered in this document. For most of the listed species, we estimated abundance for adult returning fish and outmigrating smolts. These data come from estimates compiled by our Science Centers for the species status reviews, which are updated every five years. Additional data sources include state agencies (i.e. CDFW, IDFW, ODFW, WDFW), county and local agencies, and educational and non-profit institutions. These sources are vetted for scientific accuracy before their use. For hatchery propagated juvenile salmonids, we use hatchery production goals. Table 22 displays the estimated annual abundance of hatchery-propagated and naturally produced listed fish.

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 those instances, the status of the local population will be discussed and taken into account. In other instances, the nature of the project (i.e., it is broadly distributed or situated in mainstem habitat) is such that the take cannot reliably be assigned to any population or group of populations. In those cases, the effects of the action are measured in terms of how they are expected to affect each listed unit at the species scale, rather than at the population scale.

Table 22. Estimated annual abundance of ESA listed fish.

Species	Life Stage	Origin	Abundance
Puget Sound Chinook salmon	Adult	Natural	22,398
		Listed Hatchery, Clipped and Intact	15,543
	Juvenile	Natural	3,035,288
		Listed Hatchery Intact Adipose	7,271,130
		Listed Hatchery Adipose Clip	36, 297,500
Puget Sound Steelhead	Adult	Listed Hatchery and Natural Origin	19,313
	Juvenile	Natural	2,196,901
		Listed Hatchery Intact Adipose	112,500
		Listed Hatchery Adipose Clip	110,000
Puget Sound/Georgia Basin DPS Rockfish, Bocaccio	Adult	Natural	4,606
Puget Sound/Georgia Basin DPS Rockfish, Yelloweye		Natural	66,998
Hood Canal summer-run chum salmon		Natural	25,146
		Listed Hatchery Intact Adipose	1,452
	Juvenile	Natural	3,889,955
		Listed Hatchery Intact Adipose	150,000
Upper Columbia River spring-run Chinook salmon	Adult	Natural	2,872
		Listed Hatchery Intact Adipose	3,364
		Listed Hatchery Adipose Clip	6,226
	Juvenile	Natural	468,820
		Listed Hatchery Intact Adipose	368,642

Species	Life Stage	Origin	Abundance
		Listed Hatchery Adipose Clip	621,759
Upper Columbia River Steelhead	Adult	Natural	1,931
		Listed Hatchery Intact Adipose	1,163
		Listed Hatchery Adipose Clip	5,309
	Juvenile	Natural	199,380
		Listed Hatchery Intact Adipose	138,601
		Listed Hatchery Adipose Clip	687,567
Middle Columbia River Steelhead	Adult	Natural	5,052
		Listed Hatchery Intact Adipose	112
		Listed Hatchery Adipose Clip	448
	Juvenile	Natural	407,697
		Listed Hatchery Intact Adipose	110,469
		Listed Hatchery Adipose Clip	444,973
Snake River spring/summer-run Chinook salmon	Adult	Natural	12,798
		Listed Hatchery Intact Adipose	421
		Listed Hatchery Adipose Clip	2,387
	Juvenile	Natural	1,007,526
		Listed Hatchery Intact Adipose	775,305
		Listed Hatchery Adipose Clip	4,453,663
Snake River fall-run Chinook salmon	Adult	Natural	10,337
		Listed Hatchery Intact Adipose	13,551
		Listed Hatchery Adipose Clip	15,508
	Juvenile	Natural	692,819

Species	Life Stage	Origin	Abundance
		Listed Hatchery Intact Adipose	2,862,418
		Listed Hatchery Adipose Clip	2,483,713
Snake River Basin Steelhead	Adult	Natural	10,547
		Listed Hatchery Intact Adipose	16,137
		Listed Hatchery Adipose Clip	79,510
	Juvenile	Natural	798,341
		Listed Hatchery Intact Adipose	705,490
		Listed Hatchery Adipose Clip	3,300,152
Snake River sockeye salmon	Adult	Natural	546
		Listed Hatchery Adipose Clip	4,004
	Juvenile	Natural	19,181
		Listed Hatchery Adipose Clip	242,610
Lower Columbia River Chinook salmon	Adult	Natural	29,469
		Listed Hatchery, Clipped and Intact	38,594
	Juvenile	Natural	11,745,027
		Listed Hatchery Intact Adipose	962,458
		Listed Hatchery Adipose Clip	31,353,395
Lower Columbia River coho salmon	Adult	Natural	29,866
		Listed Hatchery, Clipped and Intact	8,791
	Juvenile	Natural	661,468
		Listed Hatchery Intact Adipose	249,784
		Listed Hatchery Adipose Clip	7,287,647
	Adult	Natural	10,203

Species	Life Stage	Origin	Abundance
Upper Willamette River Chinook salmon		Listed Hatchery, Clipped and Intact	31,476
	Juvenile	Natural	1,211,863
		Listed Hatchery Intact Adipose	4,214
		Listed Hatchery Adipose Clip	4,709,045
Oregon Coast coho salmon	Adult	Natural	94,320
		Listed Hatchery Adipose Clip	559
	Juvenile	Natural	6,641,564
		Listed Hatchery Adipose Clip	60,000
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	9,065
		Listed Hatchery, Clipped and Intact	10,934
	Juvenile	Natural	2,013,593
		Listed Hatchery Intact Adipose	575,000
		Listed Hatchery Adipose Clip	200,000
California Central Valley Steelhead	Adult	Natural	1,686
		Listed Hatchery Adipose Clip	3,856
	Juvenile	Natural	630,403
		Listed Hatchery Adipose Clip	1,600,653
Central California Coast Steelhead	Adult	Natural	2,187
		Listed Hatchery Adipose Clip	3,866
	Juvenile	Natural	248,771
		Listed Hatchery Adipose Clip	648,891
Southern DPS Eulachon	Adult	Natural	18,796,090

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 1339-5M

Under Permit 1339-5M the Nez Perce Tribe would modify and expand on work they have been conducting for over 20 years in the Snake River basin in Idaho and Eastern Oregon. The researchers would expand their operation to include small tributaries to the lower Salmon River in Idaho. Using temporary picket weirs, they would capture (primarily) SnkR steelhead, tag them, tissue sample them, enumerate them, and track them for the purposes of increasing managers' knowledge of the animals' demographics, life histories, and genetics.

The researchers are requesting to add the following amounts of take to their previously authorized permit:

Table 23. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 1339-5M.

Species	Life Stage	Origin	Take Action	Prior Total Take	Prior Lethal Take	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Snake River spring/ summer-run Chinook salmon	Adult	Natural	C/H/R	200	2	5	0	0.039	0.000
Snake River Basin Steelhead	Adult	Natural	C/H/R	2,700	28	100	1	0.948	0.009
		Natural	C/M, T, ST/R	2,750	34	500	5	4.741	0.047
		Listed Hatchery Intact Adipose	C/H/R	950	11	100	1	0.620	0.006
		Listed Hatchery Intact Adipose	C/M, T, ST/R	950	15	100	1	0.620	0.006

Species	Life Stage	Origin	Take Action	Prior Total Take	Prior Lethal Take	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		Listed Hatchery Adipose Clip	C/H/R	950	11	100	1	0.126	0.001
		Listed Hatchery Adipose Clip	C/M, T, ST/R	1,200	17	100	1	0.126	0.001

C/H/R – Capture/Handle/Release; C/M,T,ST/R – Capture/Mark, Tag, Sample Tissue/Release Live Animal

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that the action is likely to kill. To determine the effect of these losses, it is necessary to compare them to the total average returns over the last five years for which we have data (see species status section) This signifies that the research may kill 0.056% of the natural SnkR steelhead returns, 0.012% of the LHIA returns, and 0.002% of the LHAC returns.

Thus, the research would kill no more than a few fractions of a percent of the returning steelhead adults (and no Chinook). However, because the steelhead would only be taken from tributaries in the lower Salmon River, the effect would be somewhat magnified at the local level. Unfortunately, there are currently data gaps on steelhead abundance in the areas where the actions are proposed. (This research is designed to fill that data gap.) This lack of data is complicated by the fact that steelhead often "nose-in" to tributaries in an exploratory manner and this means—because the temporary weirs would generally be near the confluence of each tributary and the Salmon River—that the researchers could very well encounter steelhead from Salmon River populations. Given that the Salmon River supports twelve independent populations and, in general, produces the majority of the SnkR steelhead, it becomes very difficult to estimate the effect at a local level. But even if the local effect were magnified by a very conservative 10 times, that would still mean that the maximum impact the research could have would be the loss of approximately 0.5% of any independent population—a level of effect that is unlikely to have any lasting impact on abundance, productivity, or any other VSP criterion.

Moreover, it is very likely that even that small effect is actually even smaller. That is, if the past may be used as an indicator, in the 20 years the NPT has been performing this research, they have never taken the number of steelhead allotted in their permit. Over recent five-year period, their total steelhead take has averaged approximately 15% of the amount allotted, and the actual mortalities have been as low or lower. But even if all the fish were to be taken, this would still amount to only a very small impact on the species' abundance, a similarly small impact on their productivity, and no measureable effect on their spatial structure or diversity.

Therefore, while these are negative effects, they are unlikely to compromise the viability of any individual populations—let alone the species as a whole. In addition, the information derived from the research is used to help fisheries managers determine if recovery actions are benefiting wild Snake River salmonid populations as expected and therefore would be used to guide future management actions in the three subbasins in which the work would take place. The research they are asking to perform is designed to fill critical data gaps in our knowledge of the species' status and has been deemed a priority in every relevant salmonid recovery forum in the region.

Permit 14772-4R

The ODFW is requesting to renew permit 14772 for a period of five years. ODFW is requesting authorization to annually take adult and juvenile OC coho using boat electrofishing equipment in the Umpqua River basin. ODFW will avoid adult coho, but a few may be shocked. In the event that an adult coho is encountered, ODFW will shut off the electrical current and allow the fish to swim away. No more electrofishing would occur in that location. The researchers do not propose to kill any of the juvenile OC coho being captured, but a small number may die as an unintended result of the activities. The following table (Table 24) displays the requested take.

Table 24. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 14772-4R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Oregon Coast coho salmon	Adult	Natural	C/H/R	3	0	0.003	0.000
	Juvenile	Natural	C/H/R	1,300	39	0.020	0.001

C/H/R – Capture/Handle/Release

Because no adults would be killed and the majority (at least 97%) of the juvenile OC coho salmon that would be captured, handled and released and expected to survive with no long-term effects, the true effects of the proposed action are best seen in the context of the juvenile fish that the research is likely to kill. The research would kill (at most) 0.001% of the juvenile fish in this ESU. However, because the research would be restricted to the Umpqua River watershed, that effect would be magnified somewhat at the local level. It is therefore necessary to compare the total mortalities to the total expected juvenile abundance in the Umpqua River subbasin.

As noted in the status of the species section, the recent average total spawners of naturally produced coho salmon in the Umpqua River basin is approximately 17,838 (Table 12). Sandercock (1991) published fecundity estimates for several coho salmon stocks; average fecundity ranged from 1,983 to 5,000 eggs per female. By applying a very conservative value of 2,000 eggs per female to an estimated 8,919 females returning (half of 17,838) to this ESU, one may expect approximately 18 million eggs to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around 7%. Thus, we can estimate that roughly 1.5 million juvenile coho salmon are produced annually in the Umpqua River basin. The permitted activities may therefore unintentionally cause the death of 0.003% of the naturally produced juvenile OC coho in the Umpqua River basin.

As a result, the action is not likely to have more than a negligible effect—at either the population or ESU levels—on the species' abundance or productivity, and essentially no effect at all on spatial structure or diversity. That is, if the past may be used as an indicator, in the 10 years that the ODFW has been performing this research, no adult coho have been captured or killed and 14 coho juvenile have been killed which represents a very low percent of the take authorized. And even that very small effect would be offset to some degree by the benefit of the research—one objective of which is to determine fish abundance and distribution, as well as habitat preference in the Umpqua River. The ODFW would also study the distribution of non-native invasive species, interspecific competition, and predator-prey interactions—and all that information would benefit OC coho by helping to improve management plans.

Permit 15205-4R

Under permit 15205-4R, the KWIATH would be renewing a permit for five years to annually take juvenile PS Chinook salmon offshore of Decatur, Lopez, and Waldron island beaches in the San Juan Island archipelago in Puget Sound (San Juan County, WA). The researchers would use beach seines to capture fish. Once captured, the fish would be anesthetized and measured, and a tissue sample would be taken (sample scale and fin clip). Next, the fishes' stomach contents would be sampled with gastric lavage. The fish would be returned to an aerated holding bucket until they are ready for release. The researchers do not propose to kill any of the listed salmonids being captured, but a small number may die as an unintended result of the activities. The requested take is laid out in Table 25.

Table 25. Proposed take and comparison of possible lethal take to annual abundance at the ESU scale under permit 15205-4R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Juvenile	Natural	C/M, T, ST/R	725	8	0.024	0.000
		Listed Hatchery Adipose Clip	C/H/R	175	3	0.000	0.000

C/H/R – Capture/Handle/Release; C/M,T,ST/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 that may be killed to the total abundance numbers expected for the population and species—these figures are represented in that last column of the table above.

Due to the marine location of the research activities, impacts cannot be examined at the population level since any outmigrating population may be present. At the ESU level, the permitted activities may kill at most less than 0.0001% of juvenile PS Chinook salmon. This research, therefore, would have a very small impact on the species' abundance, a likely similar impact on their productivity, and no measurable effect on their spatial structure or diversity. And it is possible that the impacts could be even smaller than those laid out above. For this project over the past ten years (2010-2019), the researchers have taken only 48.62% of their total request (4,273 of 8,789 fish) and 39.64% of their requested mortalities (44 of 111 fish).

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. Since 2010, this study has been analyzing trends in juvenile Chinook salmon, their prey species (sand lance and Pacific herring), and their changing environment (i.e., water temperatures). This research would benefit PS Chinook salmon by continuing to keep managers informed of the changes in the salmonids' environment and the impact those changes are having on juvenile wild Chinook salmon during their neritic life history stage.

Permit 15230-3R

Under permit 15230-3R, the WFE would be renewing a permit for five years to annually take juvenile PS Chinook salmon and PS steelhead the South Fork of the Tolt River (Snoqualmie River sub-basin; King County, WA). The researchers would use backpack electrofishing equipment and hook and line angling to capture fish. PS steelhead would be anesthetized, measured, weighed, have tissue samples taken (sample scale and fin clip), PIT tagged, and returned to an aerated holding bucket until they are ready for release. All other fish (including Chinook salmon) would be identified to species and released. The researchers do not propose to kill any of the listed salmonids being captured, but a small number may die as an unintended result of the activities. The requested take is laid out in Table 26.

Table 26. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 15230-3R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Juvenile	Natural	C/H/R	100	2	0.003	0.000
Puget Sound Steelhead	Juvenile	Natural	C/M, T, ST/R	1,450	29	0.066	0.001

C/H/R – Capture/Handle/Release; 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 that may be killed to the total abundance numbers expected for the population and species. This research may kill the percentages of listed fish abundances (Tables 26 and 27).

Table 27. Proposed take and comparison of possible lethal take to annual abundance at the population scale (Snoqualmie River population) under permit 15230-3R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of Population taken	Percent of Population killed
Puget Sound Chinook salmon	Juvenile	Natural	C/H/R	100	2	0.113	0.002
Puget Sound Steelhead	Juvenile	Natural	C/M, T, ST/R	1,450	29	1.546	0.031

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

At the population level, the permitted activities may kill at most 0.031% of natural-origin juvenile PS steelhead and 0.002% of natural-origin PS Chinook salmon. At the ESU/DPS levels, the permitted activities may kill at most 0.001% of natural-origin juvenile PS steelhead and less than 0.001% of natural-origin PS Chinook salmon. Therefore, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measurable effect on their spatial structure or diversity. And it is possible that the impacts could be even smaller than those laid out above. For this project over the past ten years (2010-2019), the researchers have taken only 25.93% of their total request (6,158 of 23,750 fish) and 16.99% of their requested mortalities (62 of 365 fish).

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of the study is to better understand the seasonal use of the Tolt River and its tributaries by juvenile PS steelhead prior to their outmigration. Since 2010, this study has increased our knowledge of size- and age-based movements in the upper reaches of the South Fork Tolt River. Further research would benefit PS steelhead by including an additional PIT-tag array to provide a better understanding of population-specific age structure, genetic structure, and movement patterns for both juveniles and returning adults.

Permit 17062-6R

Under permit 17062-6R, the NWFSC would be renewing a permit for five years to annually take juvenile and adult PS Chinook salmon, PS steelhead, HCS chum salmon, and PS/GB bocaccio. The NWFSC research may also cause them to take adult S eulachon and juvenile and adult PS/GB yelloweye rockfish, for which there are currently no ESA take prohibitions. Fish would be captured by using (1) hook and line equipment at depths of 20–200 meters; (2) hand nets and spear guns while conducting SCUBA diving transects; and (3) anchored minnow traps and Standard Monitoring Units for the recruitment of Reef Fishes (SMURFs). For the hook and line fishing, captured fish would be reeled slowly to the surface to reduce the impacts of barotrauma. All captured ESA-listed rockfish would be measured, weighed, sexed, tissue sampled (caudal fin clip and dorsal musculature), floy tagged, and released to the water via rapid submersion techniques to reduce barotrauma. If a rockfish individual is captured dead or deemed nonviable, it would be retained for genetic analysis. All other ESA-listed fish would be released after capture. For the SCUBA diving transects, juvenile rockfish would be collected in a plastic bag and brought to the surface and sacrificed for full body analysis. For minnow traps and SMURFs, the traps would be brought to the surface, emptied into a tub of water, and the fish would be identified to species, enumerated, and sacrificed for full body analysis. The researchers do not propose to kill any adult listed fish being captured, but a small number may die as an unintended result of the activities. The requested take is laid out in Table 28.

Table 28. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 17062-6R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	C/H/R	2	1	0.009	0.004
		Listed Hatchery Adipose Clip	C/H/R	2	1	0.013	0.006
	Juvenile	Natural	C/H/R	302	14	0.010	0.000
		Listed Hatchery Adipose Clip	C/H/R	302	14	0.001	0.000
Puget Sound Steelhead	Adult	Natural	C/H/R	2	1	0.021	0.010
		Listed Hatchery Adipose Clip	C/H/R	2	1		
	Juvenile	Natural	C/H/R	302	14	0.014	0.001
		Listed Hatchery Adipose Clip	C/H/R	302	14	0.275	0.013
Puget Sound/Georgia Basin DPS Rockfish, Bocaccio	Adult	Natural	C/M, T, ST/R	10	4	0.434	0.304
	Juvenile	Natural	IM	10	10		
Puget Sound/Georgia Basin DPS Rockfish, Yelloweye	Adult	Natural	C/M, T, ST/R	15	6	0.045	0.031
	Juvenile	Natural	IM	15	15		
Hood Canal summer-run chum salmon	Juvenile	Natural	C/H/R	100	4	0.003	0.000

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Southern DPS Eulachon	Adult	Natural	C/H/R	30	6	0.000	0.000

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

Because the majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action 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 that may be killed to the total abundance numbers expected for the population and species. To determine the 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—these figures are represented in that last column of the table above.

Since take activities would occur throughout multiple Puget Sound sub-basins, the effect of that take cannot be examined at the population level. At the ESU/DPS levels, the permitted activities may kill at most 0.010% of any natural-origin listed salmonids and eulachon (adult PS steelhead). For listed rockfish at the DPS level, the permitted activities may kill at most 0.304% of PS/GB bocaccio and 0.031% of PS/GB yelloweye rockfish. Since abundance estimates for listed juvenile rockfish do not exist, the impact to the DPS is inflated since only the adult abundances are being used as the denominator to calculate the mortality rate while both juveniles and adults are combined as the numerator. Further, the unknown juvenile abundances are expected to be at least a magnitude greater than the adult abundances since fecundity for both listed rockfish species range from tens of thousands to millions of eggs. 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. And it is possible that the impacts could be even smaller than those laid out above. For this project over the past eight years (2012-2019), the researchers have taken only 1.34% of their total request (84 of 6,255 fish) and none of their requested mortalities (0 of 600 fish).

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purposes of the study are to (1) determine how much genetic variation exists between coastal and PS/GB DPS bocaccio populations; (2) investigate how characteristics (patch size and level of nearby urbanization) of rocky reef habitats, kelp forests, and eelgrass beds affect the relative quality of these habitats as nursery habitat for rockfishes in Puget Sound; and (3) examine the trophic relationships of rockfish in Puget Sound and their reliance on productivity from rocky reef habitats, kelp forests, and eelgrass beds. Since 2012, this study has been collecting genetic samples from ESA-listed rockfish to determine whether or not the PS/GB DPS rockfish designations are supported. For yelloweye and canary rockfish, enough genetic information was collected to support the PS/GB DPS designation for yelloweye rockfish but suggested that canary rockfish in Puget Sound were not a unique DPS. For bocaccio, not enough individuals were captured to support a determination. Further research would benefit these ESA-listed rockfish by collecting more biological samples to better understand DPS/species uniqueness and their habitat (i.e., rocky reef, kelp forests, and eelgrass beds) interactions.

Permit 17761-2R

Under permit 17761-2R the EBMUD would be renewing a permit that for five years has authorized them to take juvenile and adult listed CCV steelhead in the lower Mokelumne River. The researchers would observe (video monitoring in the fish ladder, escapement surveys, snorkel surveys, and redd surveys), capture (boat and backpack electrofishing, rotary screw traps, fish ladder trap, fyke traps, beach seines, smolt bypass trap, hook and line, trawling), handle (anesthetize, weigh, measure, and check for marks or tags), and release live fish. A subsample may be marked, tagged, and/or sampled for stomach content or biological tissue. The requested take is described in Table 29.

Table 29. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 17761-2R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
California Central Valley Steelhead	Adult	Natural	C/H/R	575	13	34.104	0.771
		Natural	C/M, T, ST/R	200	6	11.862	0.356
		Natural	O/H	650	0	38.553	0.000
	Spawned Adult/ Carcass	Natural	O/ST	200	0	-	-
	Juvenile	Natural	C/H/R	3,670	139	0.582	0.022
		Natural	C/M, T, ST/R	1,200	29	0.190	0.005
		Natural	O/H	200	0	0.032	0.000

C/H/R – Capture/Handle/Release; C/M,T,S/R – Capture/Mark, Tag, ST – Sample Tissue, Sample Tissue/Release Live Animal, O/H – observe/harass

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 that may be killed to the total abundance numbers expected for the population and species—these figures are represented in that last column of the table above.

Population data is not available for Lower Mokelumne CCV steelhead. At the ESU/DPS level, the permitted activities at most may kill 0.027% of juvenile and 1.127% of adult CCV steelhead. In the past five years, the EBMUD has not killed one adult steelhead and has captured less than 5% of the adult steelhead permitted (230 captured, 4750 authorized). During the permit renewal process, the EBMUD decreased the amount of adult steelhead take requested. 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.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. Since 1998, this study has been assessing the flow requirements and non-flow measures set forth in the 1998 Joint Settlement Agreement (JSA) between East Bay EBMUD, USFWS, and California Department of Fish and Wildlife (CDFW). Data generated by this study is also be used to develop Hatchery and Genetics Management Plans for operation of the Mokelumne River Fish Hatchery's fall run Chinook salmon program and Central Valley steelhead program.

Permit 18696-4R

Under Permit 18696-4R the IPC would continue work they have been conducting for nearly 10 years in the mainstem Snake River. They currently use two capture methods. The first is a sinking style, small (5.1 cm stretch) multifilament mesh nets anchored to the bottom of Lower Granite Reservoir to fish for white sturgeon—these nets are deployed during the day and the sampling is conducted during the months of October and November in Lower Granite Reservoir between RM 138.5 (0.7 miles downstream from the confluence of the Clearwater River) downstream to RM 129.6 (1.3 miles downstream of Silcott Island); (2) they also use D-ring net sampling between the Salmon River confluence (RM 188) and the town of Lewiston, ID (RM 140) and that work takes place in the summer months. At each sample location, the researchers would record the river km, date and time of effort, depth fished, bottom water temperatures and dissolved oxygen levels. By-catch would be identified by species, counted, and measured for total length before being returned to the river. The exception to this is that all listed salmonids would be released with as little handling as possible, although the IPC would record the approximate size of all listed fish as well as noting any marks on the fish. The D-ring nets being employed only have a small chance of intercepting any salmonids, however, because any captured fish would spend some time in the net before they can be raised from the bottom of the river, there is a chance that they will not survive the encounter. As a result, the researchers will do everything in their power to both avoid listed salmonids and, when that is impossible, handle them only to the extent needed to get them back in the water.

The researchers are requesting the flowing levels of take:

Table 30. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 18696-4R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Snake River spring/summer-run Chinook salmon	Adult	Natural	C/H/R	3	3	0.023	0.023
		Listed Hatchery Adipose Clip	C/H/R	3	3	0.126	0.126
	Juvenile	Natural	C/H/R	170	25	0.017	0.002
		Listed Hatchery Adipose Clip	C/H/R	170	25	0.004	0.001

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Snake River fall-run Chinook salmon	Adult	Natural	C/H/R	8	4	0.077	0.039
	Adult	Listed Hatchery Adipose Clip	C/H/R	8	4	0.052	0.026
	Juvenile	Natural	C/H/R	101	18	0.015	0.003
		Listed Hatchery Adipose Clip	C/H/R	101	18	0.004	0.001
Snake River Basin Steelhead	Adult	Natural	C/H/R	8	4	0.076	0.038
	Juvenile	Natural	C/H/R	76	17	0.010	0.002
Snake River sockeye salmon	Adult	Natural	C/H/R	3	0	0.549	0.000
	Juvenile	Natural	C/H/R	10	3	0.052	0.016

C/H/R – Capture/Handle/Release

Due to the nature of the proposed capture method, a good number of the fish that may be caught will be killed as a result. That is why the mortality rates in the table are higher than nearly any others in this opinion. Nonetheless, even with those high mortality rates, the effect of the research on listed species would in only no case mean that more than about a tenth of a percent of any component would be killed—and that case (adult, ad-clipped spr/sum Chinook) is somewhat anomalous given that the rate is essentially at least 10 times higher than the rate for any other component or life stage. In addition, because the research would take place in the mainstem Snake River, the losses cannot be ascribed to any population for any species—they must be viewed in the context of the listed units as individual wholes. As a result, though the research may in some instances have a very small impact on species abundance and productivity, it would in no measurable way impact structure or diversity for any species.

Moreover, the researchers would take a number of additional precautions with the aim of reducing impacts even further.

- First, half the work would take place in October and November, and thus it is timed so that it is very unlikely that any salmonids at all would be present in the action area.
- Second, the nets would be deployed on the reservoir and river bottom and extend no more than two meters up from it. Also, they would be perpendicular to, and within the thalweg. These deep main channel habitats are used only very infrequently by salmonids (if they are present at all), so this would further reduce the chance of catching any listed fish

- Third, the nets would be set only for short durations and monitored closely. This is also expected to reduce encounters with listed fish, but if any *are* encountered, the fish would not be handled if at all possible and the net would be cut if necessary to minimize harm.
- Finally, the researchers would primarily use a scheme of adaptive sampling. This would have the effect of focusing on areas shown to produce juvenile white sturgeon in the catch and exclude areas where ESA salmonids may be encountered. In addition, adaptive sampling would rely on sampling habitats of high juvenile sturgeon use which would be determined by tracking individuals with implanted sonic transmitters. In the event that telemetered juvenile white sturgeon habits overlap with those where listed salmonids are captured, sampling effort will be relocated to new locations with the hope of preventing further encounters with listed salmonids.

The result of all this is that the researchers are very unlikely to encounter any listed salmonids at all, and are extremely unlikely to reach the numbers displayed above. In the last five years, they have in almost all cases taken none of the fish they were allotted and in those cases where they did, there has only been one mortality. Nonetheless, it is possible that they could have a maximum effect of the magnitude described above. But even in that instance, the effect would be very small, spread out across the entirely of each listing unit and, in any case, would be offset to some degree by the information on reservoir and fish community health the research is designed to generate.

Permit 18852-2R

Permit 18852 is to a great degree a continuation of work that the FWS has been conducting in the mid- and upper Columbia River on and off since before the year 2000, five years ago, they combined that work under one permit and they are now seeking to renew that permit. As noted above, under that renewed permit, the FWS would conduct two studies with different (but related) purposes and effects. They are combined here for ease of analysis. During these projects, MCR and UCR steelhead and UCR Chinook Salmon would generally be released with minimal handling but in some instances, they may be anesthetized using buffered tricaine methane sulfonate to identify to species, measured, and scanned for PIT tags. These fish would be held and allowed to recover in cool (ice packs used if needed), aerated water and released at or near the site of their capture. The researchers would use hook-and-line angling and electrofishing equipment to capture the fish. The following table displays the number of listed fish the researchers are requesting to take.

Table 31. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 18852-2R.

Species	Life Stage	Origin	Take Action	Requeste d Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Columbia River spring-run Chinook salmon	Adult	Natural	C/H/R	15	0	0.000	0.000
	Juvenile	Natural	C/H/R	200	4	0.043	0.001

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Columbia River Steelhead	Adult	Natural	C/H/R	30	0	1.554	0.000
	Juvenile	Natural	C/H/R	200	4	0.100	0.002
Middle Columbia River Steelhead		Natural	C/H/R	50	1	0.012	0.000

C/H/R – Capture/Handle/Release

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that action is likely to kill. Because the researcher would kill no adult fish, it is only necessary to examine the juvenile losses—and that is done by comparing them compare them to the total outmigrant numbers expected for these species (and their components) found in the status sections. This signifies that the research may kill at most two thousandths of a percent of any component (natural UCR steelhead, see table above). The other losses are 0.0001% of the UCR Chinook, and even less than that for the MCR steelhead.

These mortality rates are very small when compared with the listed units as individual wholes. And for the UCR Chinook and steelhead—that is as far as the comparison can go: the research would take place over the great majority of these species' range in the upper Columbia River, and so it is impossible to determine what effect those mortalities may have at the population level. At the level of the listing unit, the losses are so small that they unlikely to have any but the most minimal effect on any VSP.

However, because the work that could affect MCR steelhead would take place only in the Yakima River watershed, there could be a more magnified local effect. But given that the total loss is a maximum only one juvenile fish, even at a local level that effect is as close to zero as possible and would not have any but the most minimal effect on abundance—and effectively no impact on productivity, diversity, or structure.

Moreover, given past performance by the FWS in the areas where this research would take place, it is unlikely that the researchers would take even the small numbers of listed species displayed above. Nonetheless, it is possible that they could have a maximum effect of the magnitude described—but even in that instance, the effect would be very small and would be offset to some degree by the information on restoration actions and fish community health the research is designed to generate.

Permit 18906-2R

Under permit 18906-2R, the NWS would be renewing a permit for five years to annually take juvenile PS Chinook salmon and PS steelhead. The researchers may also take adult S eulachon, for which there are currently no ESA take prohibitions. Sampling would take place at up to 30 sites in the eastern Puget Sound from Saratoga Passage (in the south) to Fidalgo Bay (to the north) (Island and Skagit counties, WA). The researchers would use beach seines to capture fish. Fish would be identified to species, measured, and released. The researchers do not propose to kill any of the listed fish being captured, but a small number may die as an unintended result of the activities. The requested take is laid out in Table 32.

Table 32. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 18906-2R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Juvenile	Natural	C/H/R	575	7	0.019	0.000
		Listed Hatchery Adipose Clip	C/H/R	190	3	0.001	0.000
Puget Sound Steelhead	Juvenile	Natural	C/H/R	42	2	0.002	0.000
Southern DPS Eulachon	Adult	Natural	C/H/R	8	1	0.000	0.000

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 that may be killed to the total abundance numbers expected for the population and species—these figures are represented in that last column of the table above.

Due to the marine location of the research activities, impacts cannot be examined at the population level since any outmigrating population may be present. At the ESU/DPS level, the permitted activities may kill at most less than 0.001% for any listed species component. This research, therefore, would have a very small impact on the species' abundance, a likely similar impact on their productivity, and no measurable effect on their spatial structure or diversity. And it is possible that the impacts could be even smaller than those laid out above. For this project over the past five years (2015-2019), the researchers have taken only 0.59% of their total request (87 of 14,685 fish) and none of their requested mortalities (0 of 170 fish).

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of the study is to monitor ecosystem response to restoration efforts (pre- and post-) and determine their effectiveness at reestablishing habitat as a natural functioning ecosystem. The research would benefit the listed species by determining the effectiveness of these restoration efforts and applying them to future efforts which directly benefits listed salmon by increasing habitat.

Permit 19013-2R

Under permit 19013-2R, the LLTK would be renewing a permit for five years to annually take juvenile HCS chum salmon, PS Chinook salmon, and PS steelhead in the Hamma Hamma River (Mason County, WA). The researchers would use a rotary screw trap to capture fish. PS steelhead would be anesthetized, weighed, measured, have a tissue sample taken (sample scale and fin clip), and returned to an aerated holding bucket until they are ready for release. All other fish will be captured, identified to species, and released downstream of the trap. The researchers do not propose to kill any of the listed salmonids being captured, but a small number may die as an unintended result of the activities. The requested take is laid out in Table 33.

Table 33. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 19013-2R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Juvenile	Natural	C/H/R	3,000	30	0.099	0.001
		Listed Hatchery Intact Adipose	C/H/R	1,000	10	0.014	0.000
Puget Sound Steelhead	Juvenile	Natural	C/M, T, ST/R	300	3	0.014	0.000
Hood Canal summer-run chum salmon	Juvenile	Natural	C/H/R	1,500	15	0.039	0.000

C/H/R – Capture/Handle/Release; 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 that may be killed to the total abundance numbers expected for the population and species. This research may kill the percentages of listed fish abundances (Tables 33 and 34).

Table 34. Proposed take and comparison of possible lethal take to annual abundance at the population scale for PS Chinook salmon (natural origin – Mid-Hood Canal population; hatchery – George Adams hatchery), PS steelhead (South Hood Canal Tributaries population), and HCS chum salmon (Hamma Hamma River watershed) under permit 19013-2R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of population taken	Percent of population killed
Puget Sound Chinook salmon	Juvenile	Natural	C/H/R	3,000	30	13.281	0.133
		Listed Hatchery Intact Adipose	C/H/R	1,000	10	0.235	0.002
Puget Sound Steelhead	Juvenile	Natural	C/M, T, ST/R	300	3	3.613	0.036
Hood Canal summer-run chum salmon	Juvenile	Natural	C/H/R	1,500	15	0.347	0.003

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

For natural-origin fish at the population level, the permitted activities may kill at most 0.133% of juvenile PS Chinook salmon, 0.036% juvenile PS steelhead, and 0.003% of juvenile HCS chum salmon. At the ESU/DPS levels, the permitted activities may kill at most 0.001% of natural-origin juvenile PS Chinook salmon and less than 0.001% for all other listed salmonid components. Therefore, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measurable effect on their spatial structure or diversity. And it is possible that the impacts could be even smaller than those laid out above. For this project over the past five years (2015-2019), the researchers have taken only 0.16% of their total request (47 of 29,000 fish) and none of their requested mortalities (0 of 290 fish). For four of those five years, research activities did not occur due to other research priorities.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. The purpose of the study is to assess the long-term effects and effectiveness of PS steelhead supplementation when utilizing low-impact, innovative wild steelhead supplementation techniques in streams throughout the Hood Canal region. Further research would benefit the listed species by determining what legacy effects the PS steelhead hatchery program have had on natural steelhead populations (abundance, genetic diversity, life history diversity).

Permit 19386-2R

Under permit 19386-2R, the WEIS would be renewing a permit for five years to annually take juvenile PS Chinook salmon and PS steelhead in the Lower Duwamish River waterway (King County, WA). The researchers would use fyke nets during the spring salmonid outmigration (March through June) to capture fish. Fish would be anaesthetized, identified to species, measured for length, allowed to recover, and released. The researchers do not propose to kill any of the listed fish being captured, but a small number may die as an unintended result of the activities. The requested take is laid out in Table 35.

Table 35. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 19386-2R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Juvenile	Natural	C/H/R	250	3	0.008	0.000
		Listed Hatchery Adipose Clip	C/H/R	250	3	0.001	0.000
Puget Sound Steelhead	Juvenile	Natural	C/H/R	50	1	0.002	0.000
		Listed Hatchery Adipose Clip	C/H/R	50	1	0.045	0.001

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 that may be killed to the total abundance numbers expected for the population and species. This research may kill the percentages of listed fish abundances (Tables 35 and 36).

Table 36. Proposed take and comparison of possible lethal take to annual abundance at the population scale (Duwamish/Green River populations) under permit 19386-2R.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Juvenile	Natural	C/H/R	250	3	0.059	0.001
		Listed Hatchery Adipose Clip	C/H/R	250	3	0.008	0.000
Puget Sound Steelhead	Juvenile	Natural	C/H/R	50	1	0.045	0.001
		Listed Hatchery Adipose Clip	C/H/R	50	1	0.050	0.001

C/H/R – Capture/Handle/Release

At the population level, the permitted activities may kill at most 0.001% of both natural-origin listed salmonid components. At the ESU/DPS level, the permitted activities may kill at most less than 0.0001% of both natural-origin listed salmonid components. Therefore, the research would be a very small impact on the species' abundance, a likely similar impact on their productivity, and no measurable effect on their spatial structure or diversity. And it is possible that the impacts could be even smaller than those laid out above. For this project over the past five years (2015-2019), the researchers have taken only 24.40% of their total request (732 of 3,000 fish) and 2.50% of their requested mortalities (1 of 40 fish).

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. Under a Consent Decree settled through U.S. District Court (Western District of Washington), The Boeing Company agreed to construct two habitat restoration projects near Boeing Plant 2 in the Lower Duwamish Waterway to restore and create offchannel and riparian habitats in an area where they have been largely eliminated due to channelization and industrialization. The purpose of this study is to determine if fish, including ESA listed juvenile salmonids, are using the newly created/restored habitat. This is a planned ten-year study, and this renewal would cover the last five years of the study. This research would benefit the affected species by informing future restoration designs as well as providing data to support future enhancement projects.

Permit 23567

As noted previously, issuing permit 23567 would authorize Stillwater Sciences to take juvenile CCC steelhead in Rector Creek, CA. The researchers would use backpack electrofishing, beach seines and dip nets to capture fish. Captured fish will be contained in buckets with aerated fresh stream water, maintained within 2 degrees of the ambient river temperature, or in live cars placed in flowing water. Captured fish may be lightly anesthetized, measured, and released. Sampling will occur outside the adult steelhead migration and spawning season; however, if any adult steelhead (> 450 mm FL) are captured, they will be immediately released without processing. The researchers do not propose to kill any of the listed fish being captured, but a small number may die as an unintended result of the activities. The requested take is described in Table 37.

Table 37. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 23567.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Central California Coast Steelhead	Juvenile	Natural	C/H/R	800	16	0.322	0.006

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 that may be killed to the total abundance numbers expected for the population and species—these figures are represented in that last column of the table above. Population data is not available for Rector Creek CCC steelhead. At the ESU/DPS level, the permitted activities may kill at most 0.006% of the CCC steelhead ESU/DPS.

An effect of the research that cannot be quantified is the conservation benefit to the species resulting from the research. Very little is known about CCC steelhead in Rector Creek. Under this study, data will be collected to assess species composition, distribution, abundance, age-class distribution, and individual fish condition (size, growth rate, and presence of disease, parasites, or lesions) to evaluate the condition of fish in Rector Creek downstream of Rector Dam. Results of this study will be used to refine the conditions of the Rector Dam flow release schedule (e.g., timing, magnitude, duration, etc.) to improve habitat conditions for fish species downstream.

Permit 23600

As noted previously, issuing permit 23600 would authorize the UW to take adult PS Chinook salmon, PS steelhead, HCS chum salmon, and PS/GB bocaccio throughout the Puget Sound and the Strait of Juan de Fuca, WA. The UW research may also cause them to take adult PS/GB yelloweye rockfish, for which there are currently no ESA take prohibitions. The researchers would use long line fishing gear to capture fish. Targeted shark species would be tagged (satellite and acoustic), sampled (blood, fin clip, and muscle tissue biopsy), measured, and released. ESA-listed rockfish would be tissue sampled (fin clip), floy tagged, and released to the water via rapid submersion techniques to reduce barotrauma. If a rockfish individual is captured dead or deemed nonviable, it would be retained for genetic analysis. ESA-listed salmonids would either be immediately released or held an aerated livewell until they are ready for release. The researchers do not propose to kill any of the listed fish being captured, but a small number may die as an unintended result of the activities. The requested take is laid out in Table 38.

Table 38. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 23600.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	C/H/R	4	0	0.018	0.000
		Listed Hatchery Adipose Clip	C/H/R	4	0	0.026	0.000
		Natural	C/H/R	4	0	0.041	0.000

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Steelhead	Adult	Listed Hatchery Adipose Clip	C/H/R	4	0	0.041	0.000
Puget Sound/Georgia Basin DPS Rockfish, Bocaccio	Adult	Natural	C/H/R	8	4	0.174	0.087
Puget Sound/Georgia Basin DPS Rockfish, Yelloweye	Adult	Natural	C/H/R	8	4	0.012	0.006
Hood Canal summer-run chum salmon	Adult	Natural	C/H/R	1	0	0.000	0.000

C/H/R – Capture/Handle/Release

Because the majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action 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 that may be killed to the total abundance numbers expected for the population and species. To determine the 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—these figures are represented in that last column of the table above.

Since take activities would occur throughout multiple Puget Sound subbasins, the effect of that take cannot be examined at the population level. At the ESU/DPS levels, no lethal take was requested for any listed salmonid. For listed rockfish at the DPS level, the permitted activities may kill at most 0.087% of PS/GB bocaccio and 0.006% of PS/GB yelloweye rockfish. Further, the requested listed rockfish take is only precautionary for they are extremely rare in Puget Sound, but the capture methods proposed and requested locations may result in their incidental take. 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. And 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 study is to investigate the ecology and movement of broadnose sevengill shark (*Notorhynchus cepedianus*) and bluntnose sixgill shark (*Hexanchus griseus*) and to assess their potential to serve as sentinels for deep ocean ecosystems. This research would benefit the affected species by providing a better understanding of the marine ecosystem of Puget Sound and the Pacific Ocean.

Permit 23629

Permit 23629 would allow the USGS to continue and expand on work they have been performing in Western Oregon for a number of years under a different authority. As noted above they would be extensively sampling mainstem and reservoir habitat in the areas inhabited by UWR Chinook and SONCC coho salmon. They would use a wide variety of methods to capture the fish: traps; nets; seines; hook-an-line angling (barbless hooks); boat- and backpack electrofishing. In all cases, the researchers would seek to swiftly release all listed fish unharmed and they would coordinate with ODFW district biologists to avoid capturing salmonids wherever possible—especially adults.

The researchers are seeking the following amounts of take:

Table 39. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 23629

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Willamette River Chinook salmon	Adult	Natural	C/H/R	25	0	0.245	0.000
		Listed Hatchery Adipose Clip	C/H/R	25	0	0.079	0.000
	Juvenile	Natural	C/H/R	540	30	0.045	0.002
		Listed Hatchery Adipose Clip	C/H/R	540	30	0.011	0.001
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	C/H/R	5	0	0.055	0.000
		Listed Hatchery Intact Adipose	C/H/R	5	0	0.091	0.000
		Listed Hatchery Adipose Clip	C/H/R	5	0	0.091	0.000
	Juvenile	Natural	C/H/R	60	6	0.003	0.000
		Listed Hatchery Intact Adipose	C/H/R	60	6	0.010	0.001

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		Listed Hatchery Adipose Clip	C/H/R	60	6	0.030	0.003

Because the vast majority of the fish that would be captured are expected to recover with no ill effects, the true effects of the proposed action are best seen in the context of the fish that action is likely to kill. Because the researcher would kill no adult fish, it is only necessary to examine the juvenile losses—and that is done by comparing them compare them to the total outmigrant numbers expected for these species (and their components) found in the status sections. This signifies that the research may kill at most three thousandths of a percent of any component (LHAC juvenile SONCC coho, see table above). The other losses are, at most, 33% less than even that small figure.

All the mortality rates displayed in the table above are vanishingly small when compared with the listed units as individual wholes. And for the UWR Chinook, that is as far as the comparison can go: the research would take place over the great majority of these species' mainstem range in the upper Willamette River, so it is impossible to determine what effect those mortalities may have at the population level. At the level of the listing unit, the losses are so small that they unlikely to have any but the most minimal effect on any VSP.

However, because the work that could affect SONCC coho would take place only in the Rogue River watershed, there could be a more magnified local effect. We do not have recent data on how many juvenile coho (hatchery and natural) the Rogue River produces, but using the most recent information we have (see status section) and applying the same logic as found in the analysis for Permits 14772-2R and 23633, above (with the understanding that there are about three times as many LHIA as LHAC hatchery fish), we can estimate that the Rogue River produces approximately 99,190 natural juveniles, 333,480 LHIA juveniles, and 111,160LHAC juveniles. (Number of spawners X .5 (for females) X 2000 (for a conservative egg estimate) X 0.07 (for survival to juvenile life stage.))

This signifies that the research could kill, at most 0.006%, 0.002%, and 0.005% of the local (Rogue River) juvenile natural, LHIA and LHAC fish, respectively, in any given year. These are very small effects on abundance and productivity and essentially no measurable effect on structure or diversity—particularly for the LHAC fish, which, as noted above, are considered surplus to recovery needs.

Moreover, given past performance by the USGS in the areas where this research would take place, it is unlikely that the researchers would take even the small numbers of listed species displayed above. In the last four years, while conducting essentially the same research, the USGS has taken almost none of the fish they were allotted and killed none. Still, it is possible that they could have a maximum effect of the magnitude described—but even in that instance, the effect would be very small and would be offset to some degree by the information on fish community health the research is designed to generate.

Permit 23633

Under Permit 23633, the USFWS would use electrofishing gear at very low settings to capture Pacific lamprey in Abernathy Creek, Washington. During the course of this work, they could encounter both LCR Chinook and coho. However, highly agile fish like salmonids, can often detect the electrical field emanating from such gear at a sufficient distance to avoid being stunned and, typically, simply move farther away from the electrical field and suffer no more exposure. Still, to further minimize stress from handling, juvenile coho salmon that are dip netted at the time of electrofishing will be quickly enumerated and released into the creek downstream of the electrofishing team without any further handling. Adult Chinook salmon in Abernathy Creek are highly visible because Abernathy Creek is a small 3rd-order stream with very few deep pools where adult fish could be concealed from visual observation. Therefore, the researchers would be able to see adult fish before electrofishing and avoid them (and their redds). The researchers are asking for the following levels of take:

Table 40. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 23633.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Lower Columbia River Chinook salmon	Adult	Natural	O/H	10	0	0.034	0.000
Lower Columbia River coho salmon	Juvenile	Natural	C/H/R	1,000	10	0.151	0.002

O/H – observe/harass, C/H/R – Capture/Handle/Release

Because 99% of the fish that may be encountered are expected to recover with no ill effect, the true impact of the research is seen in the fish that the activities may kill. In this case, only juvenile LCR coho are expected to be so affected and the maximum impact would be the death of 2 thousandths of a percent of the listed unit. This is a vanishingly small effect that would be magnified by the fact that all the fish would be coming from Abernathy Creek.

We do not know how many fish Abernathy Creek produces, but it does produce roughly half fish found in the Mills/Abernathy/Germany Creek population (see status section). Therefore, applying the same logic as found in the analysis for Permit 14772-2R, above, we can estimate that Abernathy Creek produces about 25,655 juvenile coho. (That is, 733 adult natural spawners in the population X .5 (for Abernathy Cr. Alone) X .5 (for females) X 2000 (for a conservative egg estimate) X 0.07 (for survival to juvenile life stage) = 25,655).

This signifies that the research could kill, at most 0.04% of the local juvenile fish in any given year. This is a very small effect on abundance and productivity and essentially no effect on structure or diversity. But we have every reason to believe that this small effect is even smaller yet: NMFS has consulted on several larval lamprey sampling projects that use electrofishing equipment like that proposed for Permit 23633—and we have most often found it to have no measurable effect at all. However, even if the maximum effect displayed above were to occur, the impact would be offset by the ecosystem health information the study is designed to produce.

Permit 23637

Under Permit 23637, the ODFW would capture and tag (with acoustic tags) adult steelhead from three different DPSs. They would target MCR steelhead, but might also capture SnkR steelhead and UCR steelhead. The fish would be captured at Bonneville Dam, on the Columbia River, at the Adult Fish Facility (AFF). The researchers would simply remove the fish from the adult bypass (fish ladder) complex at the dam, anesthetize them, tag them, take a small tissue sample, and release them back to the fish ladder. They would then monitor the routes the fish take as they make their upriver migrations—particularly with an array of acoustic receivers in the John Day pool of the Columbia River. The researchers are requesting the following amounts of take:

Table 41. Proposed take and comparison of possible lethal take to annual abundance at the ESU/DPS scale under permit 23637.

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Upper Columbia River Steelhead	Adult	Natural	C/M, T, ST/R	30	0	1.554	0.000
Middle Columbia River Steelhead	Adult	Natural	C/M, T, ST/R	170	2	3.365	0.040

Species	Life Stage	Origin	Take Action	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Snake River Basin Steelhead		Natural	C/M, T, ST/R	100	1	0.948	0.009

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

Because nearly all the fish are expected to recover with no ill effects, the impacts of the research are best seen in the fish that the activities would be permitted to kill. As the table above illustrates, in this instance, the research could kill, at most 0.040% of the returning MCR steelhead, and 0.009% of the returning SnkR steelhead (and no UCR steelhead). These effects are very small and, because the fish could come from anywhere in the listed units' geographies, there is no way to assign the impacts to any individual population or population group. Therefore, at the DPS level, the mortality rates are likely to have some small impact on abundance, and therefore productivity, but no discernable effect on structure or diversity. Given that this is the first year this work has been done, we cannot know whether the effects displayed would actually be smaller than the numbers given. However, because the ODFW researchers are expert fish handlers with a long track record of staying below their allotted mortality levels for these species in other permits, it is likely that the effects will be less than those analyzed. And, in any case, the adverse effects would be offset to some degree by gaining information regarding MCR migration patterns and discerning some possible reasons why they have such a high straying rate.

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 and 402.17(a)). 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.

Because the action area falls entirely within designated critical habitat and navigable marine 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, habitat management, 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 salmonids, rockfish, eulachon, or their habitat, and therefore the effects such a project may have on listed species will be analyzed when the need arises.

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 status of the species section (Section 2.2).

In developing this biological opinion, we considered several efforts being made at the local, tribal, state, and national levels to conserve listed species—primarily final recovery plans and efforts laid out in the Status review updates for Pacific salmon and steelhead listed under the Endangered Species Act.[2] The recovery plans, status summaries, and limiting factors that are part of the analysis of this Opinion are discussed in detail in Table 2 (Section 2.2.1).

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.

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 listed species, 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.

Thus, non-Federal activities are likely to continue affecting listed species and habitat within the action area. These cumulative effects in the action area are difficult to analyze because of this opinion's large geographic scope, the different resource authorities in the action area, the uncertainties associated with government and private actions, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation; however, it seems likely that they will continue to increase as a general pattern over time. The primary cumulative effects will arise from those water quality and quantity impacts that occur as human population growth and development shift patterns of water and land use, thereby creating more intense pressure on streams and rivers within this geography in terms of volume, velocities, pollutants, baseflows, and peak flows. But the specifics of these effects, too, are impossible to predict at this time. In addition, there are the aforementioned effects of climate change—many of those will arise from or be exacerbated by actions taking place in the Pacific Northwest and elsewhere that will not undergo ESA consultation. Although many 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.

We can, however, make some generalizations based on population trends.

Puget Sound/Western Washington

[2] NOAA Fisheries – West Coast Region - 2016 Status Reviews of Listed Salmon & Steelhead

Non-Federal actions are likely to continue affecting listed species. The cumulative effects in this portion of the action area are difficult to analyze because of this opinion's geographic scope, 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: WA state Office of Financial Management homepage). 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.

Idaho and Eastern Oregon and Washington

According to the U.S. Census bureau, the State of Idaho's population has been increasing at about 1% per year over the last several years, but that increase has largely been confined to the State's urban areas. The rural population—the areas where the proposed actions would take place--saw a 14% decrease in population between 1990 and 2012.[3] This signifies that in the action areas, if this trend continues, there is likely to be a reduction in competing demands for resources such as water. Also, it is likely that streamside development will decrease. However, given the overall increase in population, recreation demand for resources such as the fish themselves may go up—albeit slowly.

The situation is similar for Eastern Oregon and Washington. Both states have seen population increases between 0.5% and 1.5% per year for Oregon between 2000 and 2010,[4] an overall 12% for Washington between 2000 and 2010, and a 2.7% increase for rural, eastern Oregon for the past five years (2013-2018).[5] And, though Eastern Washington has also seen some population increase, it has largely been restricted to the population centers rather than the rural areas.[6] This signifies that, as with Idaho, there is little likelihood that there will be increasing competing demands for primary resources like water, but recreational demand for the species themselves will probably increase along with the human population.

Western Oregon

[3] Idaho State Journal June 2, 2013 "Idaho's rural population continues to shrink"
[4] Portland State University "Annual Oregon Population Report"
[5] State of Oregon Employment Department Dec 20, 2018 "A Quick Look at Population Trends in Eastern Oregon"
[6] Cashmere Valley Record March 9, 2011 "Population growth slowed during last decade, but state is more diversified"

The situation in Western Oregon is likely to be similar to that of the Puget Sound region: cumulative effects are likely to continue increasing both in the Willamette valley and along the coast, with nearly all counties showing year-by-year population increases of about 0.5% to 1.5% over the last several years.[6] The result of this growth is that there will be more development and therefore more habitat impacts such as simplification, hydrologic effects, greater levels of pollution (in the Willamette Valley), other water quality impacts, soil disturbance, etc. These effects would be somewhat lessened in the coastal communities, but resource extraction (particularly timber harvest) would probably continue to increase slightly. Though once again, most such activities, whether associated with development or extraction, would undergo formal consultation if they were shown to take place in (or affect) critical habitat or affect listed species. So, it is difficult to characterize the effects that would not be consulted upon beyond saying they are likely to increase both in severity and geographic scope.

California

According to the U.S. Census Bureau, the State of California's population increased 6.1% from 2010 to 2019 (source: Census Bureau California Quick Facts). If this trend in population growth continues, there will be an increase in competing demands for water resources. Water withdrawals, diversions, and other hydrological modifications to regulate water bodies are likely to continue. Urbanization and rural development are limiting factors for many of the listed salmonids within the State of California and these factors are likely to increase with continued population growth. Therefore, 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.

One final thing to take into account when considering cumulative effects is the time period over which the activity would operate. The permits considered here would be good for a maximum of five years and the effects on listed species abundance they generate could continue for up to four years after that, though they would decrease in each succeeding year. We are unaware of any major non-Federal activity that could affect listed salmonids and is certain to occur in the action area during that timeframe.

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 diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

Aside from the considerations listed above, these assessments are also made in consideration of the other research that has been authorized and that may affect the various listed species. The reasons we integrate the proposed take in the 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, and 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 42), (b) add the take proposed by the researchers in this opinion to the take that has already been authorized in the region (Table 43), and then (c) compare those totals to the estimated annual abundance of each species under consideration (Table 22).

Table 42. Total requested take for the permits and percentages of the ESA listed species for permits covered in this Biological Opinion.

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	6	1	0.027	0.004
		Listed Hatchery Adipose Clip	6	1	0.039	0.006
	Juvenile	Natural	4,952	64	0.163	0.002
		Listed Hatchery Intact Adipose	1,000	10	0.014	0.000
		Listed Hatchery Adipose Clip	917	23	0.003	
Puget Sound Steelhead	Adult	Natural	6	1	0.062	0.010
		Listed Hatchery Adipose Clip	6	1		
	Juvenile	Natural	2,144	49	0.098	0.002
		Listed Hatchery Adipose Clip	352	15	0.320	0.014
Puget Sound/Georgia Basin DPS Rockfish, Bocaccio	Adult	Natural	18	8	0.608	0.391
	Juvenile	Natural	10	10		
	Adult	Natural	23	10	0.057	0.037

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound/Georgia Basin DPS Rockfish, Yelloweye	Juvenile	Natural	15	15		
Hood Canal summer-run chum salmon	Adult	Natural	1	0	0.004	0.000
	Juvenile	Natural	1,600	19	0.041	
Upper Columbia River spring-run Chinook salmon	Adult	Natural	15	0	0.000	0.043
	Juvenile	Natural	200	4	0.000	0.001
Upper Columbia River Steelhead	Adult	Natural	60	0	3.107	0.000
			30	0	-	-
	Juvenile	Natural	200	4	0.100	0.002
Middle Columbia River Steelhead	Adult	Natural	170	2	3.365	0.040
	Juvenile	Natural	50	1	0.012	0.000
Snake River spring/summer-run Chinook salmon	Adult	Natural	8	3	0.063	0.023
		Listed Hatchery Adipose Clip	3	3	0.126	0.126
	Juvenile	Natural	170	25	0.017	0.002
		Listed Hatchery Adipose Clip	170	25	0.004	0.001
Snake River fall-run Chinook salmon	Adult	Natural	8	4	0.077	0.039
		Listed Hatchery Adipose Clip	8	4	0.052	0.026
	Juvenile	Natural	101	18	0.015	0.003
		Listed Hatchery Adipose Clip	101	18	0.004	0.001
	Adult	Natural	708	15	6.713	0.142

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Snake River Basin Steelhead	Adult	Listed Hatchery Intact Adipose	200	2	1.239	0.012
		Listed Hatchery Adipose Clip	200	2	0.252	0.003
	Juvenile	Natural	76	17	0.010	0.002
Snake River sockeye salmon	Adult	Natural	3	0	0.549	0.000
	Juvenile	Natural	10	3	0.052	0.016
Lower Columbia River Chinook salmon	Adult	Natural	10	0	0.034	0.000
Lower Columbia River coho salmon	Juvenile	Natural	1,000	10	0.151	0.002
Upper Willamette River Chinook salmon	Adult	Natural	25	0	0.245	0.000
		Listed Hatchery Adipose Clip	25	0	0.079	
	Juvenile	Natural	540	30	0.045	0.002
		Listed Hatchery Adipose Clip	540	30	0.011	0.001
Oregon Coast coho salmon	Adult	Natural	3	0	0.003	0.000
	Juvenile	Natural	1,300	39	0.020	0.001
Southern Oregon/Northern California Coast coho salmon	Adult	Natural	5	0	0.055	0.000
		Listed Hatchery Intact Adipose	5	0	0.091	
		Listed Hatchery Adipose Clip	5	0		
	Juvenile	Natural	60	6	0.003	

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		Listed Hatchery Intact Adipose	60	6	0.010	0.001
		Listed Hatchery Adipose Clip	60	6	0.030	0.003
California Central Valley Steelhead	Adult	Natural	775	19	45.967	1.127
	Juvenile	Natural	4,870	122	0.773	0.019
Central California Coast Steelhead		Natural	170	5	0.068	0.002
Southern DPS Eulachon	Adult	Natural	38	7	0.000	0.000

Thus the activities contemplated in this opinion may kill—in combination and at most—as much as 1.127% of the fish from any component of any listed species; that component is for permit 17661-2R (19 adult steelhead) and this research project has not killed an adult steelhead.

In all other instances found in the table above, the effect is (at most) about one tenth of that figure and, in many cases, the effect is even more orders of magnitude smaller. And these figures are probably much lower in actuality, but before engaging in that discussion, it is necessary to add all the take considered in this opinion to the rest of the research take that has been authorized in the Pacific Northwest.

Table 43. Total expected take of the ESA listed species for scientific research and monitoring already approved for 2020 plus the permits covered in this Biological Opinion.

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Puget Sound Chinook salmon	Adult	Natural	954	40	4.259	0.179
		Listed Hatchery Intact Adipose	900	12	15.390	0.573
		Listed Hatchery Adipose Clip	1,492	77		

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
	Juvenile	Natural	504,756	10,382	16.630	0.342
		Listed Hatchery Intact Adipose	91,542	3,028	1.259	0.042
		Listed Hatchery Adipose Clip	179,020	11,178	0.493	0.031
Puget Sound Steelhead	Adult	Natural	1,458	32	7.839	0.202
		Listed Hatchery Intact Adipose	22	0		
		Listed Hatchery Adipose Clip	34	7		
	Juvenile	Natural	69,652	1,272	3.170	0.058
		Listed Hatchery Intact Adipose	2,405	39	2.138	0.035
		Listed Hatchery Adipose Clip	5,326	114	4.842	0.104
Puget Sound/Georgia Basin DPS Rockfish, Bocaccio	Adult	Natural	38	21	2.518	1.086
	Subadult	Natural	2	1		
	Juvenile	Natural	76	28		
Puget Sound/Georgia Basin DPS Rockfish, Yelloweye	Adult	Natural	40	22	0.140	0.076
	Subadult	Natural	2	1		
	Juvenile	Natural	52	28		
	Adult	Natural	2,007	31	7.981	0.123
	Juvenile	Natural	728,306	2,551	18.723	0.066

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Hood Canal summer-run chum salmon		Listed Hatchery Intact Adipose	135	3	0.090	0.002
Upper Columbia River spring-run Chinook salmon	Adult	Natural	117	4	4.074	0.139
		Listed Hatchery Adipose Clip	18	4	0.289	0.064
	Juvenile	Natural	1,291	44	0.275	0.009
		Listed Hatchery Intact Adipose	34	3	0.009	0.000
		Listed Hatchery Adipose Clip	484	37	0.078	0.006
Upper Columbia River Steelhead	Adult	Natural	159	2	8.234	0.104
		Listed Hatchery Intact Adipose	4	0	0.344	0.000
		Listed Hatchery Adipose Clip	19	2	0.358	0.038
			30	0	-	-
	Juvenile	Natural	17,228	362	8.641	0.182
		Listed Hatchery Intact Adipose	2,418	69	1.745	0.050
		Listed Hatchery Adipose Clip	10,334	248	1.503	0.036
	Adult	Natural	1,278	15	25.297	0.297

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Middle Columbia River Steelhead		Listed Hatchery Intact Adipose	39	1	34.821	0.893
		Listed Hatchery Adipose Clip	933	12	208.259	2.679
			170	2	-	-
	Juvenile	Natural	116,857	2,387	28.663	0.585
		Listed Hatchery Intact Adipose	4,272	60	3.867	0.054
		Listed Hatchery Adipose Clip	3,650	70	0.820	0.016
Snake River spring/summer-run Chinook salmon	Adult	Natural	2,464	25	19.253	0.195
		Listed Hatchery Intact Adipose	586	6	139.192	1.425
		Listed Hatchery Adipose Clip	1,806	17	75.660	0.712
	Juvenile	Natural	763,231	7,146	75.753	0.709
		Listed Hatchery Intact Adipose	36,086	330	4.654	0.043
		Listed Hatchery Adipose Clip	74,595	1,089	1.675	0.024
	Adult	Natural	51	11	0.493	0.106

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Snake River fall-run Chinook salmon		Listed Hatchery Intact Adipose	2	1	0.015	0.007
		Listed Hatchery Adipose Clip	52	14	0.335	0.090
	Juvenile	Natural	2,683	130	0.387	0.019
		Listed Hatchery Intact Adipose	634	43	0.022	0.002
		Listed Hatchery Adipose Clip	1,107	145	0.045	0.006
Snake River Basin Steelhead	Adult	Natural	4,070	66	38.589	0.626
		Listed Hatchery Intact Adipose	504	13	3.123	0.081
		Listed Hatchery Adipose Clip	1,016	23	1.278	0.029
			100	1	-	-
	Juvenile	Natural	259,387	3,373	32.491	0.423
		Listed Hatchery Intact Adipose	14,089	178	1.997	0.025
		Listed Hatchery Adipose Clip	58,679	711	1.778	0.022
	Adult	Natural	16	4	2.930	0.733

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Snake River sockeye salmon		Listed Hatchery Intact Adipose	6	0	-	-
		Listed Hatchery Adipose Clip	1	0	0.025	0.000
	Juvenile	Natural	10,580	462	55.159	2.409
		Listed Hatchery Intact Adipose	1	0	-	-
		Listed Hatchery Adipose Clip	391	260	0.161	0.107
Lower Columbia River Chinook salmon	Adult	Natural	381	13	1.293	0.044
		Listed Hatchery Intact Adipose	12	0	0.422	0.034
		Listed Hatchery Adipose Clip	151	13		
	Juvenile	Natural	819,220	11,375	6.975	0.097
		Listed Hatchery Intact Adipose	293	35	0.030	0.004
		Listed Hatchery Adipose Clip	62,013	1,727	0.198	0.006
Lower Columbia River coho salmon	Adult	Natural	1,242	18	4.159	0.060
		Listed Hatchery Intact Adipose	31	0	7.280	0.466

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		Listed Hatchery Adipose Clip	609	41		
	Juvenile	Natural	175,722	2,518	26.565	0.381
		Listed Hatchery Intact Adipose	560	112	0.224	0.045
		Listed Hatchery Adipose Clip	53,543	1,845	0.735	0.025
Upper Willamette River Chinook salmon	Adult	Natural	210	12	2.058	0.118
		Listed Hatchery Adipose Clip	181	19	0.575	0.060
	Juvenile	Natural	47,313	933	3.904	0.077
		Listed Hatchery Intact Adipose	46	6	1.092	0.142
		Listed Hatchery Adipose Clip	9,452	276	0.201	0.006
Oregon Coast coho salmon	Adult	Natural	9,251	110	9.808	0.117
		Listed Hatchery Adipose Clip	21	4	3.757	0.716
	Juvenile	Natural	557,344	12,344	8.392	0.186
		Listed Hatchery Adipose Clip	284	20	0.473	0.033
	Adult	Natural	1,584	29	17.474	0.320

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
Southern Oregon/Northern California Coast coho salmon		Listed Hatchery Intact Adipose	1,582	17	19.965	0.284
		Listed Hatchery Adipose Clip	601	14		
	Juvenile	Natural	190,112	2,701	9.441	0.134
		Listed Hatchery Intact Adipose	12,051	687	2.096	0.119
		Listed Hatchery Adipose Clip	1,516	48	0.758	0.024
California Central Valley Steelhead	Adult	Natural	3,213	95	190.569	5.635
		Listed Hatchery Adipose Clip	2,092	106	54.253	2.749
	Juvenile	Natural	62,540	1,962	9.921	0.311
		Listed Hatchery Adipose Clip	24,681	1,423	1.542	0.089
Central California Coast Steelhead	Adult	Natural	2,738	52	125.194	2.378
		Listed Hatchery Adipose Clip	494	19	12.778	0.491
	Spawned Adult/ Carcass	Natural	265	4	-	-
		Listed Hatchery Adipose Clip	100	2		
	Juvenile	Natural	239,395	5,370	96.231	2.159

Species	Life Stage	Origin	Requested Take	Lethal Take	Percent of ESU/DPS taken	Percent of ESU/DPS killed
		Listed Hatchery Intact Adipose	6,200	124	-	-
		Listed Hatchery Adipose Clip	12,881	355	1.985	0.055
Southern DPS Eulachon	Adult	Natural	34,387	31,093	0.191	0.173
	Subadult	Natural	1,030	1,030		
	Juvenile	Natural	540	456		

As the table above illustrates, in many cases the dead fish from all of the permits in this opinion and all the previously authorized research would amount to a less than a percent of each species' total abundance. However, in fourteen cases involving 7 species the potential mortality included in this opinion and all previously authorized research could amount to a more substantial percentage of an ESU component (i.e., life stage and origin) (Table 38). Therefore, we will review the potential mortality for each species by origin and life stage.

Salmonid Species

As the Tables 42 and 43 illustrate, in most instances, the research—even in total—would have only very small effects on any species' juvenile abundance (and therefore productivity) and no discernible effect on structure or diversity because the effects would be spread out across each entire species. For the adults, the research effects are similar to those described for the juveniles. The newly proposed research would kill, at most, about a tenth of one percent of the adult escapement for any component of listed species. In addition, because so few adults from any species will be killed by any of the new proposed research, nearly all of the stated take has already been analyzed in previous opinions and been determined not to jeopardize any of the species considered here. However, killing an adult fish has a potentially much greater effect than killing a juvenile, so it is necessary to examine more closely some of those impacts as well. Nonetheless, there are some instances where closer scrutiny of the effects on a particular component is warranted. These follow in the paragraphs below.

Juvenile Fish

MCR steelhead: Another figure requiring a closer view is the 0.585% of the natural-origin MCR steelhead juveniles killed by research activities in the basin. The actions considered in this opinion would add only one fish to the total being allotted, so the 0.585% represents a slight increase in the amount of take that has previously been found to not jeopardize the species. However, it should also be noted that the two largest authorizations for taking this species (held by the ODFW and WDFW – ongoing, various authorization numbers) have over the last four years generally not taken more than a third of the allotted number of natural-origin, juvenile MCR steelhead—and, in most cases, the take amounts have actually been even smaller fractions of the permitted amounts. As a result, the effects of the program as a whole are very likely to be much smaller than those displayed above.

And here again, the research being conducted in the region adds critical knowledge about the species' status—knowledge that we are required to have every five years to perform status reviews for this (or any) listed species. Moreover, when the total take is placed in the context of the species as a whole, the effect is 0.25%. So once again, even the impact of the program as a whole is a very small effect on abundance and productivity and the activities analyzed here, while adding only the smallest possible increment to that impact, would fill critical data gaps regarding the factors limiting the species' recovery.

SnkR spr/sum Chinook salmon: Under the research program as a whole, 0.709% of the natural-origin juvenile SnkR spr/sum Chinook salmon may be killed in a given year. While it should be noted that this figure actually represents very little increase in the baseline take, it is still means that about seven juvenile natural-origin fish out of every thousand may be killed every year by the research efforts in the basin. However, this minor effect has repeatedly been determined to not jeopardize the species, the information being generated is used in critical status monitoring and recovery. Also, in the approximately 20 years that the primary permits taking these fish has been in effect (Permits 1127, Permit 1134, and Permit 1339—the first held by the Shoshone-Bannock, the other two held by the Nez Perce Tribes) the researchers have never killed more than 70% of fish they were allotted; and in most years, the total mortalities were far less than 50% of the permitted amounts. This is also true for the research that the IDFG conducts under other authorizations—they generally take less than 70% of what they are allotted and kill even less than that.

In any case, when the losses of this component generated by the program as a whole are considered in the context of the entire listed unit instead of simply the natural-origin component, the mortality rate is actually 0.10% in even the most pessimistic scenario—which, though not negligible, is still a very small impact. And finally, majority of the research considered here in this opinion (as well as the permits and the IDFG research mentioned above) is critical for determining the status of this species every year.

SnkR sockeye salmon: Another effect on juvenile fish requiring further scrutiny is the 2.409% mortality rate for natural-origin SnkR sockeye salmon. While this figure should be viewed with caution, there are two important caveats associated with the mortality numbers: many of the fish that are listed as "natural" would in actuality probably be hatchery fish (of which there are 10 times as many), but they are considered "natural" for the purposes of this analysis in order to lay out the worst-case scenario associated with the research. Second, these truly are worst-case numbers. Over the last 10 years, the IDFG researchers under Permit 1124 (the main permit under which sockeye salmon are taken) have killed less than 20% of the permitted mortalities. That is also true for the other main permit under which this species is taken: Permit 1341 is held by the Shoshone-Bannock tribes and over the last five years they have killed, in total, less than 10% of the natural-origin juvenile sockeye salmon they have been permitted. As a result, the total mortality rate for the program is probably on the order of 0.2% to 0.4% rather than the 2.4% displayed. And while it is true that when the juvenile mortality rates are considered in the context of the species as a whole, the rate drops to 0.27%, the potential loss of roughly 2.4% of any component of a listed species is a number to be wary of—even though in this case (and as noted above), some fraction of that 2.4% would actually be hatchery fish rather than natural-origin fish. Still, the research program as a whole could have a small effect on the species abundance and productivity—but not on structure ore diversity given that there is only one population and it is largely upheld by hatchery actions.

So the 2.4% figure is one that bears careful consideration. However, in this instance, it is necessary to emphasize two things: First, the take contemplated in this opinion actually adds zero fish to the baseline, so all of that 2.4% figure has been analyzed multiple times in the past and been found not to jeopardize the species each time. Second, the entire purpose of the permit with the most juvenile SnkR sockeye salmon take (Permit 1124—held by the IDFG) is to help the sockeye salmon survive and recover. As noted previously, under that permit, the researchers support the use of captive broodstock and other methods and technology to capture, preserve, and study the few remaining sockeye salmon. It is even possible that without the research conducted under Permit 1124, the sockeye salmon might have gone extinct; and even if that is not the case, it is inarguable that the research has been critical to the recovery the sockeye salmon are starting to experience.

UWR Chinook salmon: Another component to examine is the LHIA portion of the UWR Chinook salmon juveniles. The possible program-wide yearly mortality rate for this component is 1.9108%. First, note that none of the research contemplated in this opinion would add even one fish of this component to the overall mortality rate. Therefore, impacts of exactly this magnitude have been analyzed before and determined not to jeopardize the species. Second, the percentage seems high because there are only a possible 157 of these hatchery fish to begin with and the total take is only three fish–almost none of which are actually ever taken. The reason researchers even ask for this component is for the sake of completeness—they do it out of an abundance of caution to be sure that should they encounter one (a very unlikely outcome) they will be able to continue their work without having to stop and modify their permits.

So, while it is very unlikely that even one of these fish would be killed in a given year, even if they were all killed, it would represent a small reduction in a component that probably adds no more than one returning adult every season. Therefore, the mortality rate is unlikely to have much of an effect on abundance or productivity and none on structure or diversity.

One further thing to note for the species above: the vast majority of the discussed impacts — particularly for juvenile fish—are ascribed to the natural-origin component of each listed unit, which means that in actuality the effects are in most cases very likely to be smaller than the displayed percentages. The reason for this is that when in doubt—in those instances where a non-clipped hatchery fish cannot be differentiated from a natural-origin fish—we ask that researchers err to the side of caution and treat all fish with intact adipose fins as if they were natural-origin fish. So for instance, given that for the UCR steelhead, unclipped hatchery fish make up approximately 37% of the animals with intact adipose fins, it is undoubtedly the case that some unclipped fish would be taken and counted as natural-origin fish. As another example, that figure is 39% for MCR steelhead. Therefore, in most cases, the natural-origin component would in actuality be affected to a lesser degree than the percentages displayed above. It is not possible to know *how much* smaller the take figures would be, but that they are smaller is not in doubt. The overall percentages for the listed unit would, however, remain at the same low levels shown.

Moving from the specific to the general, it is necessary to note that for *all* the species and *all* components the actual take amounts would almost certainly be a great deal smaller than what has been (or may be) authorized—particularly for juvenile fish. There are three reasons for this. First, we develop conservative estimates of juvenile abundance (described in subsection 2.2 above). Second, to account for potential accidental deaths, the researchers request more take and more mortalities than they estimate would actually occur in a given year. To illustrate this, our research tracking system reveals that for the past 12 years, on average, researchers end up taking about 21% of the fish they request and killing about 12% of the numbers they request. In the current context, this would mean that for the juvenile take in Table 32, above, that *actual* mortality levels would probably be nearly an order of magnitude smaller than those displayed. Third, some 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 subyearlings, parr, or even fry. (As an example, many of the MCR steelhead juveniles in the baseline would be fry taken in various efforts.) Thus, fish grouped into the juvenile life stage represent the progeny of multiple spawning years—a much greater number of individuals (perhaps as much as an order of magnitude greater) than is represented by the smolt stage.

Therefore, we derived the already small percentages for juvenile mortalities by (a) conservatively (under)estimating the actual number of outmigrating smolts (Table 17), (b) conservatively (over)estimating the number of fish likely to be killed, and (c) treating each dead juvenile fish as part of the same year class when it is certain that at least some of them won't be. Thus, it is highly likely that the actual numbers of juvenile salmonids the research would kill are a great deal smaller than the stated figures. But even if the worst-case scenario were to occur and all the fish that may be killed are killed in fact, the effects of even the entire program would still be very small, restricted to abundance and productivity reductions, and the new effects contemplated in this opinion (even in total) would add very little increment to the effects already considered and analyzed multiple times.

Adult Fish

MCR steelhead: For the MCR steelhead, the figures that stand out are the 2.679% of the adult LHAC and the 0.893% of the LHIA fish. While it should be noted that these figures actually represent no increase in baseline take, it still means that as many as 2.7% adipose-clipped adult hatchery fish out of every hundred will be killed every year by the research efforts in the basin (as well as six out of a thousand LHIA fish). However, these minor effects have repeatedly been determined to not jeopardize the species and the information being generated is used in critical status monitoring and recovery efforts. It should also be noted that approximately 80% of the hatchery fish in this DPS have had their adipose fins clipped, and there are no take prohibitions on this component of the species. As noted above, adipose-clipped hatchery fish are considered surplus to all species' recovery needs and, for example, are allowed to be retained in fisheries throughout the basin. They are listed under the ESA, so we must analyze any impacts on them, but the status of this adipose-fin-clipped component is such that losses greater than the approximately 2.7% contemplated here have been repeatedly determined not to jeopardize *any* listed species—including MCR steelhead. In any case, the potential loss drops to 0.50% when all mortalities from every component are taken into account, so the effect is a small one and is offset to some degree by the critical status information the research program generates. This is even more true for the minor, previously analyzed loss of up to one LHIA adult MCR steelhead.

SnkR spr/sum Chinook salmon: Under the research program as a whole, 0.712% of the adult LHAC fish and 1.4% of the LHIA fish may be killed in any given year. This actually represents no increase over what has previously been authorized and has therefore repeatedly been found not to jeopardize the species. The effect is, therefore, a very small reduction in abundance and productivity that is, in many cases, concentrated on a listed component that is considered surplus to recovery needs (the LHAC fish). In addition, when the total adult losses are considered in the context of the entire ESU, the mortality rate drops to 0.31%--a rate that would have no appreciable effect on diversity or structure and only a very minor and effect on abundance and productivity. Further, it should be noted that the vast majority of the take contemplated in the program as a whole comes from research being conducted by the IDFG under another authorization and research conducted under Permits 1127, 1134, and 1339 (the first held by the Shoshone-Bannock Tribe, the latter two held by the Nez Perce Tribe), the researchers have never killed more than 20% of fish they were allotted, and in most years, the total adult mortality rate was zero. And here, too, the research being carried out under these larger permits and authorizations goes directly into critical status assessments of the species in question.

SnkR basin steelhead: Another take level to note is the 0.626% of the natural-origin adult SnkR basin steelhead that the research program, in its entirety, may kill. Though this figure represents an increase of only one adult fish over that which has previously been permitted, it is still means that as many as six natural-origin fish out of a thousand may be killed every year by the research efforts. However, and as noted earlier, the effects of approximately this scale have repeatedly been determined to not jeopardize the species; and the information being generated is used in critical status monitoring and recovery efforts. Thus, while the species' abundance and productivity would be affected to a slight degree, structure and diversity would almost certainly not see any measurable impact, and critical data on the species' status would continue to be generated. And, too, researchers under the permits with the largest numbers of permitted adult SnkR basin steelhead mortalities (Permit 1339, held by CRITFC; Permit 1134, held by the Shoshone-Bannock Tribe; and Idaho's Adult Weir program under various authorizations) have killed about 25 adult natural SnkR steelhead, in total, over the years spanning 2016 through 2018. Nevertheless, even if all the permitted adults from all components were actually to be killed, that would still represent only 0.096% reduction in the abundance of the species as a whole, and even that small effect would be offset to some degree by the critical status information the research program generates.

SnkR sockeye salmon: Even though the research considered in this opinion would add no adult sockeye salmon mortalities to the baseline take, the overall program could still kill up to 0.733% of the listed unit's adult natural-origin component. This amount has previously been shown not to jeopardize the sockeye salmon, but given the sockeye salmon's precarious status, it should still be examined. A 0.733% loss of natural adult sockeye salmon would have a small impact on abundance and therefore productivity, but no discernable impact on structure or diversity (the sockeye salmon have only one population, and it is largely upheld by a number of projects associated with a long-running artificial propagation program). Also, the mortality rate is not likely to be that high. Over the last five years, the holders of the permits with the largest amount of adult sockeye salmon take (Permit 1124 - IDFG) have killed only one adult in total, so the likely impact in a given year is probably closer to 0.036% or less. Nonetheless, even if the entire 0.733% were to be killed, the loss in abundance would be offset to some degree by the knowledge the research program provides—and in this instance the majority of the allotted take is specifically intended to support programs whose sole purpose is to help the sockeye salmon survive and recover.

Oregon Coast Coho Salmon: For OC coho salmon, the figure that stands out as needing further explanation is the 0.716% of the LHAC adults that may be killed under the program as a whole in any given year. First, none of the permits considered in this opinion would add even one fish to that total, so the magnitude of this effect has previously and repeatedly been found to not jeopardize the species' continued existence. This is because (a) the loss would have only a minor effect on abundance and productivity and no discernable impact on structure or diversity and, more importantly, (b) the impact is entirely on a component of the species that is considered surplus to recovery needs. In fact, fish from this component are the target of numerous fisheries along the Oregon coast and the four fish that all the research in total may kill in a given year represents only a fraction of the fish that are regularly harvested in Oregon every year without jeopardizing the species.

CCV steelhead: For CCV steelhead, the figure that stands out as needing further explanation is the 5.635% of adults that may be killed under the program in a given year. The activities contemplated in this opinion represents 20% (19/95) potential mortality analyzed. Therefore, the majority of the displayed potential mortality has been previously analyzed and found not to jeopardize the species.

For the 19 potential adult moralities, in the past five years, the EBMUD has not killed one adult steelhead and has captured less than 5% of the adult steelhead permitted (230 captured, 4750 authorized). During the permit renewal process, the EBMUD decreased the amount of adult steelhead take requested.

Thus, the overall situation for adult fish is effectively the same as it is for juvenile fish: the losses are very small, the effects are only seen in reductions in abundance and productivity, and the estimates of adult mortalities are almost certainly much greater than the actual numbers are likely to be. As noted above, for the past 12 years, on average, researchers have generally killed about 12% of the adult fish they were allotted, or less than three of the 19 fish requested in this opinion. Still, even in the worst case scenarios the effects are tiny, restricted to abundance and productivity reductions, and to some degree the negative effects would be offset by the information to be gained—information that in all cases would be used to protect listed fish or promote their recovery.

Thus, we expect the research activities' detrimental effects on the species' abundance and productivity to be very small—even in combination with the entirety of the research authorized in the basin. And because that slight impact would be distributed throughout the entire listing units' ranges, it would be so attenuated as to have no appreciable effect on spatial structure or diversity. Moreover, we expect all the research actions to generate lasting benefits for the listed fish.

One further thing to note for the species above: most of the discussed impacts are ascribed to the natural-origin component of each listed unit, which means that in actuality the effects are in most cases very likely to be smaller than the displayed percentages. The reason for this is that when in doubt—in those instances where a non-clipped hatchery fish cannot be differentiated from a natural-origin fish—we ask that researchers err to the side of caution and treat all fish with intact adipose fins as if they were natural-origin fish. So for instance, given that for the UCR steelhead, unclipped hatchery fish make up approximately 37% of the animals with intact adipose fins, it is undoubtedly the case that some unclipped fish would be taken and counted as natural-origin fish. As another example, that figure is 39% for MCR steelhead. Therefore, in most cases, the natural-origin component would in actuality be affected to a lesser degree than the percentages displayed above. It is not possible to know *how much* smaller the take figures would be, but that they are smaller is not in doubt. The overall percentages for the listed unit would, however, remain at the same low levels shown.

Finally, as with the juveniles, the actual take levels are likely to be lower because our tracking system demonstrates that for the program as a whole, researchers general kill about 12% of the fish they are allotted. This means that the take levels for every component may actually be something on the order of one-eighth of the numbers displayed.

Other species

Beyond the salmonid ESUs and DPSs discussed above, one species merits additional discussion.

PS/GB bocaccio: For all life-stages combined for PS/GB bocaccio, there is a 1.086% lethal take level authorized; however, there are reasons to believe that the impact is much lower. First, there are no lethal take requests for PS/GB bocaccio, so all of the lethal take is precautionary. Second, there are only a couple of permits that primarily research ESA-listed rockfish, while the majority of the permits have lethal take requests as a precaution due to their capture methods and locations (within the marine waters of Puget Sound). Third, every permit that has listed rockfish take in Puget Sound and requires depth during surveying (i.e. hook and line, trawl nets) is required to have a descending device (e.g. Seaquilizer) that can return the rockfish to their capture depth. Fourth, PS/GB bocaccio abundance is underestimated in two ways: (1) lack of a juvenile estimate and (2) adult abundance is based on an ROV estimate of a small part of their range (i.e., the marine waters around the San Juan Islands). Since we do not have a juvenile estimate for the DPS (which should be greater than the adult estimate), we treat the juveniles as adults as an overabundance of caution. This combined with using a partial estimate of adult abundance (the only estimate available) means that we overestimate the impact to the DPS. Further, bocaccio are hard to find and are rarely captured. Since 2012, PS/GB bocaccio take has been very low with only five captures (all adults) with no mortalities.

Critical Habitat

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

Summary

As noted earlier, no listed species currently has all its biological requirements being met. Their status is such that there must be a substantial improvement in the environmental conditions of their habitat and other factors affecting their survival if they are to begin to approach recovery. In addition, while the future impacts of cumulative effects are uncertain at this time, they are likely to continue to be negative. 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, many of the proposed actions would actually help monitor the effects of climate change by noting stream temperatures, flows, etc. So while we can expect both cumulative effects and climate change to continue their negative trends, it is unlikely that the proposed actions would have any additive impact to the pathways by which those effects are realized (e.g., a slight reduction in 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, but those reductions are so small as to have no more than a very minor effect on the species' survival and recovery. In all cases, even the worst possible effect on abundance is expected to be minor compared to overall population abundance, the activity has never been identified as a threat, and the research is designed to benefit the species' survival in the long term.

For over two decades, 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 managers to produce population inventories; PIT-tagging efforts have increased our knowledge of anadromous fish abundance, migration timing, and survival; and fish passage studies have enhanced our understanding of how fish behave and survive when moving past dams and through reservoirs. By issuing research authorizations—including many of those being contemplated again in this opinion—NMFS has allowed information to be acquired that has enhanced resource managers' abilities to make more effective and responsible decisions with respect to sustaining anadromous salmonid populations, mitigating adverse impacts on endangered and threatened salmon and steelhead, and implementing 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.

Additionally, the information being generated is, to some extent, legally mandated. Though no law calls for the work being done in any particular permit or authorization, the ESA (section 4(c)(2)) requires that we examine the status of each listed species every five years and report on our findings. At that point, we must determine whether each listed species should (a) be removed from the list (b) have its status changed from threatened to endangered, or (c) have its status changed from endangered to threatened. As a result, it is legally incumbent upon us to monitor the status of every species considered here, and the research program, as a whole, is one of the primary means we have of doing that.

Thus, we expect the detrimental effects on the species to be minimal and those impacts would only be seen in terms of slight reductions in juvenile and adult 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 structure. Moreover, we expect the actions to provide lasting benefits for the listed fish and that all habitat effects would be negligible. And finally, we expect the program as a whole and the permit actions considered here to generate information we need to fulfill our mandate under the ESA.

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 existences of PS, UCR, SnkR spring/sumer-run, SnkR fall-run LCR and UWR Chinook salmon; HCS chum salmon; LCR, OC, and SONCC coho salmon; SnkR sockeye salmon; PS, UCR, MCR, SnkR basin, UCR, CCV, and CCC steelhead; S eulachon; PS/GB bocaccio; and PS/GB yelloweye rockfish; or destroy or adversely modify their designated critical habitats.

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 Sixteen 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 consultation is required and shall be requested by the Federal agency or by the Service 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 identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological 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's determination that an action "is not likely to adversely affect" listed species or critical habitat is based on our finding that the effects are expected to be discountable, insignificant, or completely beneficial (USFWS and NMFS 1998). Insignificant effects relate to the size of the impact and should never reach the scale where take occurs; discountable effects are those that are extremely unlikely to occur; and beneficial effects are contemporaneous positive effects without any adverse effects on the species or their critical habitat.

Southern Resident Killer Whales Determination

The Southern Resident killer whale DPS was listed as endangered on February 16, 2006 (70 FR 69903) and a recovery plan was completed in 2008 (NMFS 2008). A 5-year review under the ESA completed in 2016 concluded that Southern Residents should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016b). Because NMFS determined the action is not likely to adversely affect SKRWs, this document does not provide detailed discussion of environmental baseline or cumulative effects for the SRKW portion of the action area.

Several factors identified in the final recovery plan for Southern Resident killer whales may be limiting recovery including quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. It is likely that multiple threats are acting together to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008).

Southern Resident killer whales consist of three pods (J, K, and L) and inhabit coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008; Hanson et al. 2013; Carretta et al. 2017). During the spring, summer, and fall months, the whales spend a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford et al. 2000; Krahn et al. 2002; Hauser et al. 2007; Hanson and Emmons 2010c). By late fall, all three pods are seen less frequently in inland waters. In recent years, several sightings and acoustic detections of Southern Residents have been obtained off the Washington and Oregon coasts in the winter and spring (Hanson et al. 2010; Hanson et al. 2013, NWFSC unpubl. data). Satellite-linked tag deployments have also provided more data on the Southern Resident killer whale movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months.

Southern Resident killer whales consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford et al. 2000; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016), but salmon are identified as their primary prey. Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. Scale and tissue sampling from May to September indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90%) (Hanson et al. 2010; Ford et al. 2016). Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to the Southern Residents in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in spring and fall months when Chinook salmon are less abundant (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016). Prey remains and fecal samples collected in inland waters during October through December indicate Chinook salmon and chum salmon are primarily contributors of the whale's diet (NWFSC unpubl. data).

Observations of whales overlapping with salmon runs (Wiles 2004; Zamon et al. 2007; Krahn et al. 2007) and collection of prey and fecal samples have also occurred in the winter months. Preliminary analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated the majority of prey samples were Chinook salmon (80% of prey remains and 67% of fecal samples were Chinook salmon), with a smaller number of steelhead, chum salmon, and halibut (NWFSC unpubl. data). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook salmon genetic stock identification from samples collected in winter and spring in coastal waters included 12 U.S. west coast stocks, and over half the Chinook salmon consumed originated in the Columbia River (NWFSC unpubl. data).

At the time of the last status review in 2016 there were 83 Southern Resident killer whales left in the population (NMFS 2016f). Recent estimates based on a July 2019 survey indicate Southern Residents now total approximately 73 individuals (22 in J pod, 17 in K pod, and 34 in L pod, CWR 2019). The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the work on population viability analyses for Southern Resident killer whales and a science panel review of the effects of salmon fisheries (Krahn et al. 2004; Hilborn et al. 2012; Ward et al. 2013). Following from that work, the data now suggests a downward trend in population growth projected over the next 50 years. As the model projects out over a longer time frame (50 years) there is increased uncertainty around the estimates, however, if all of the parameters in the model remain the same the overall trend shows a decline in later years. To explore potential demographic projections, Lacy et al. (2017) constructed a population viability assessment that considered sublethal effects and the cumulative impacts of threats (contaminants, acoustic disturbance, and prey abundance). They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate (Lacy et al. 2017).

The proposed actions may affect Southern Residents indirectly by reducing availability of their preferred prey, Chinook salmon. This analysis focuses on effects to Chinook salmon availability in the ocean because the best available information indicates that salmon are the preferred prey of Southern Resident killer whales year round, including in coastal waters, and that Chinook salmon are the preferred salmon prey species. To assess the indirect effects of the proposed action on the Southern Resident killer whale DPS, we considered the geographic area of overlap in the marine distribution of Chinook salmon affected by the action, and the range of Southern Resident killer whales. We also considered the importance of the affected Chinook salmon ESUs compared to other Chinook salmon runs in Southern Resident diet composition, and the influence of hatchery mitigation programs. As described in the effects analysis for salmonids, approximately 282 juvenile and 22 adult Chinook salmon may be killed during the course of the research. As the previous effects analysis illustrated, these losses—even in total—are expected to have only very small effects on salmonid abundance and productivity and no appreciable effect on diversity or distribution for Chinook salmon ESUs. The affected Chinook salmon species are:

- Puget Sound (PS)
- Upper Columbia River (UCR)
- Middle Columbia River (MCR)
- Snake River spring-summer run
- Snake River fall-run
- Lower Columbia River (LCR)

The fact that the research would kill PS, SnkR spring/summer and SnkR fall-run Chinook salmon could affect prey availability to the whales in future years throughout their range. For the adult take, the 16 fish that may be killed from these ESUs would only be taken by research after they return to shallower bays and estuaries, and are unlikely to be available as prey to the whales that typically feed in offshore areas of the California coast. This impact would therefore likely have a minimal, if any, affect on prey availability for Southern Resident killer whales.

For the juveniles, the most recent ten-year average smolt-to-adult ratio (SAR) from PIT-tagged Chinook salmon returns is from the Snake River, and indicates that SARs are less than 1% (BPA 2018). If one percent of the 247 juvenile CVSR Chinook salmon that may be killed by the proposed research activities were otherwise to survive to adulthood, this would translate to the effective loss of 2-3 adult Chinook salmon. It is unlikely that SRKW would intercept and feed on these 2-3 salmon so we conclude that the effective loss of 2-3 salmon caused by the the proposed research activities would have an insignificant effect on the whales' prey base.

In addition, as described in Section 2.5 the estimated Chinook salmon mortality is likely to be much smaller than stated. First, the mortality rate estimates for most of the proposed studies are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer salmonids will be killed by the research than stated. In fact, as described in Section 2.5 according to our take tracking in the past researchers have only killed about 4% of the naturally-produced juvenile CVSR Chinook salmon they were permitted to kill (and even fewer adults). Thus, the actual reduction in prey available to the whales is probably closer to zero fish rather than 2-3 fish.

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

3. MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT CONSULTATION

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on the EFH assessment provided by the NMFS and descriptions of EFH for Pacific Coast salmon (PFMC 2014) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

3.1 Essential Fish Habitat Affected by the Project

In the estuarine and marine areas, salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km) offshore of Washington, Oregon, and California north of Point Conception. The EFH identified within the action areas are identified in the Pacific coast salmon fishery management plan (PFMC 2014). Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers (as identified by the PFMC), and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years).

3.2 Adverse Effects on Essential Fish Habitat

As the Biological Opinion above describes, the proposed research actions are not likely, singly or in combination, to adversely affect the habitat upon which Pacific salmon depend; the research is therefore not likely to affect EFH. 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 NOAA Fisheries - Environmental Consultation Organizer (ECO). 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 opinion 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

June 16, 1993 (58 FR 33212). Designated Critical Habitat; Sacramento River Winter-Run Chinook Salmon.

January 4, 1994 (59 FR 440). Endangered and Threatened Species; Status of Sacramento River Winter-run Chinook Salmon; Final Rule

October 31, 1996 (61 FR 56138). Endangered and Threatened Species; Threatened Status for Central California Coast Coho Salmon Evolutionarily Significant Unit (ESU).

March 23, 1999 (64 FR 14067). Endangered and Threatened Species; Regulations Consolidation.

May 5, 1999 (64 FR 24049). Final Rule: Designated Critical Habitat: Critical Habitat for 19 Evolutionarily Significant Units of Salmon and Steelhead in Washington, Oregon, Idaho, and California.

October 25, 1999 (64 FR 57399). Final Rule: Designated Critical Habitat: Revision of Critical Habitat for Snake River Spring/Summer Chinook Salmon.

September 16, 1999 (64 FR 50394). Endangered and Threatened Species; Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California.

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.

November 18, 2005 (70 FR 69903). Final Rule: Endangered and Threatened Wildlife and Plants: Endangered Status for Southern Resident Killer Whales.

September 2, 2005 (70 FR 52488). Final Rule: Endangered and Threatened Species: Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California.

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.

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.

February 11, 2008 (73 FR 7816). Final Rule: Endangered and Threatened Species: Final Threatened Determination, Final Protective Regulations, and Final Designation of Critical Habitat for Oregon Coast Evolutionarily Significant Unit of Coho Salmon.

April 28, 2010 (75 FR 22276). Endangered and Threatened Wildlife and Plants: Threatened Status for the Puget Sound/Georgia Basin Distinct Population Segments of Yelloweye and Canary Rockfish and Endangered Status for the Puget Sound/Georgia Basin Distinct Population Segment of Bocaccio Rockfish.

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

June 20, 2011 (76 FR 35755). Listing Endangered and Threatened Species: Threatened Status for the Oregon Coast Coho Salmon Evolutionarily Significant Unit.

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

April 2, 2012 (77 FR 19552). Endangered and Threatened Species; Range Extension for Endangered Central California Coast Coho Salmon.

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

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.

August 2, 2019 (84 FR 37838). Endangered and Threatened Species; Take of Anadromous Fish.

August 27, 2019 (84 FR 44976). Final Rule: Endangered and Threatened Wildlife and Plants; Regulations for Interagency Cooperation

February 19, 2019 (84 FR 4791). Endangered and Threatened Species; Take of Anadromous Fish.

March 8, 2019 (84 FR 8507). Endangered and Threatened Species; Take of Anadromous Fish.

5.2 Literature Cited

Abatzoglou, J. T., D. E. Rupp, and P. W. Mote. 2014. Seasonal climate variability and change in the Pacific Northwest of the United States. Journal of Climate. 27(5):2125-2142.

Ainslie, B. J., J. R. Post, and A. J. Paul. 1998. Effects of pulsed and continuous DC electrofishing on juvenile rainbow trout. North American Journal of Fisheries Management: 18(4):905-918.

Alexander, R. M. 1966. Physical aspects of swimbladder function. Biological Reviews 41:141–176.

AMIP (Adaptive Management and Implementation Plan). 2018. The FCRPS Adaptive Management and Implementation Plan (AMIP) ESU-Level Abundance and Trend Tracking Spreadsheet—updated February 2018, R. Graves pers comm.

Ashbrook, C. E., Yi, K. W., Arterburn, J., and Colville Tribes. 2005. Tangle nets and gill nets as a live capture selective method to collect fall Chinook salmon broodstock in the Okanogan River: 2004. Division of Fish and Wildlife, Colville Tribes and the Washington Department of Fish and Wildlife.

Bartholomew, A. and J. Bohnsack. 2005. A Review of Catch-and-Release Angling Mortality with Implications for No-take Reserves. Reviews in Fish Biology and Fisheries. 15:129-154.

Basta, D.J. and Kennedy, D.M., 2006. Gray's Reef National Marine Sanctuary environmental assessment on the regulation of spearfishing gear. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Sanctuary Program, Silver Spring, MD. 30 pp.

Beamer, E. M., R. E. McClure, and B. A. Hayman. 2000. Fiscal Year 1999 Skagit River Chinook Restoration Research. Skagit System Cooperative.

Bendock, T. and M. Alexandersdottir. 1993. Hooking mortality of Chinook salmon released in the Kenai River, Alaska. North American Journal of Fisheries Management. 13:540-549.

Bergman, P. K., K. B. Jefferts, H. F. Fiscus, and R. C. Hager. 1968. A preliminary evaluation of an implanted, coded wire fish tag. Washington Department of Fisheries, Fisheries Research Papers. 3(1):63-84.

Bigg, M. 1982. An assessment of killer whale (*Orcinus orca*) stocks off Vancouver Island, British Columbia. Report of the International Whaling Commission. 32(65): 655-666.

Booth, D. B., D. Hartley, and R. Jackson. 2002. Forest cover, impervious-surface area, and the mitigation of stormwater impacts. J Amer Water Res Assoc. 38(3):835-845.

Bordner, C. E., S. I. Doroshov, D. E. Hinton, R. E. Pipkin, R. B. Fridley, and F. Haw. 1990. Evaluation of marking techniques for juvenile and adult white sturgeons reared in captivity *In* Parker, N.C., Giorgi, A.E., Heindinger, R.C., Jester, D.B., Prince, E.D., and Winans, G.A., eds. Fish Marking Techniques, Symposium 7: American Fisheries Society, Bethesda, MD, p. 293-303.

BPA (Bonneville Power Administration). 2018. Comparative Survival Study of PIT-tagged Spring/Summer/Fall Chinook, Summer Steelhead, and Sockeye. 2018 Annual Report (12-1-2017 to 11-30-2018). BPA contract 70765, BPA Project 1996-020-00

Brewer, P.G. and J. Barry. 2008. Rising Acidity in the Ocean: The Other CO^2 Problem. Scientific American. October 7, 2008.

Bruesewitz, S. L. 1995. Hook placement in steelhead. Technical Report No. AF95-01. Washington Department of Fish and Wildlife, Olympia.

Brynildson, O. M. and C. L. Brynildson. 1967. The effect of pectoral and ventral fin removal on survival and growth of wild brown trout in a Wisconsin stream. Transactions of the American Fisheries Society 96:353-355.

California HSRG (Hatchery Scientific Review Group). 2012. California hatchery review report Appendix VIII – Feather River Hatchery Spring Chinook Program Report. Prepared for the U.S. Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. Available at: Feather Spring Chinook Program Report June 2012.pdf

Carretta, James V., Karin. A. Forney, Erin M. Oleson, David W. Weller, Aimee R. Lang, Jason Baker, Marcia M. Muto, Brad Hanson, Anthony J. Orr, Harriet Huber, Mark S. Lowry, Jay Barlow, Jeffrey E. Moore, Deanna Lynch, Lilian Carswell, and Robert L. Brownell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA Technical Memorandum NMFSSWFSC-617.

CDFG (California Department of Fish and Game). 1965. California Fish and Wildlife Plan, Volume I: Summary. 110 pages.; Volume II: Fish and Wildlife Plans, 216 pages.; Volume III: Supporting Data, 1802 pages. Sacramento, CA.

CDFG (California Department of Fish and Game). 1998. A Status Review of the Spring-Run Chinook Salmon [*Oncorhynchus tshawytscha*] in the Sacramento River Drainage. Candidate Species Status Report 98-01. California Department of Fish and Game.

CDFW (California Department of Fish and Wildlife). 2012. Recovery Strategy of California Coho Salmon Progress Report 2004-2012.

CDFW (California Department of Fish and Wildlife). 2018. California Central Valley Chinook Population Database Report - GrandTab 2018.04.09. Available at: GrandTab 2018.04.09

Center for Whale Research. 2018. Chinook Orca Survival – FACTS about Chinook Salmon. Center for Whale Research - Chinook Orca Survival webpage

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

CHSRG (California Hatchery Scientific Review Group). 2012. California Hatchery Review Report – Appendix VIII: Coleman National Fish Hatchery Steelhead Program Report. Prepared for the US Fish and Wildlife Service and Pacific States Marine Fisheries Commission. June 2012. Available at: California Hatchery Review Project Appendix VIII - Coleman NFH steelhead program report

Coble, D. W. 1967. Effects of fin-clipping on mortality and growth of yellow perch with a review of similar investigations. Journal of Wildlife Management 31:173-180.

Conner, W. P., H. L. Burge, and R. Waitt. 2001. Snake River fall Chinook salmon early life history, condition, and growth as affected by dams. Unpublished report prepared by the U.S. Fish and Wildlife Service and University of Idaho, Moscow, ID. 4 p.

Cowen, L. 2007. Effects of angling on chinook salmon for the Nicola River, British Columbia, 1996-2002. North Americana Journal of Fisheries Management 27:256-267.

Cox, P., and D. Stephenson. 2007. A changing climate for prediction. Science 113:207-208.

Cox-Rogers, S., T. Gjernes, and E. Fast. 1999. Canadian Stock Assessment Secretariat Research Document 99/127. Fisheries and Oceans Canada. 16 p.

Crozier, L. G., A. P. Hendry, P. W. Lawson, T. P. Quinn, N. J. Mantua, J. Battin, R. G. Shaw, and R. B. Huey. 2008. Potential responses to climate change in organisms with complex life histories: evolution and plasticity in Pacific salmon. Evolutionary Applications. 1(2):252-270.

Crozier, L. G., M. D. Scheuerell, and E. W. Zabel. 2011. Using Time Series Analysis to Characterize Evolutionary and Plastic Responses to Environmental Change: A Case Study of a Shift Toward Earlier Migration Date in Sockeye Salmon. The American Naturalist. 178(6):755-773.

Cuo, L., D. P. Lettenmaier, M. Alberti, and J. E. Richey. 2009. Effects of a century of land cover and climate change on the hydrology of the Puget Sound basin. Hydrol. Process. 23:907-933.

Dalbey, S. R., T. E. McMahon, and W. Fredenberg. 1996. Effect of electrofishing pulse shape and electrofishing-induced spinal injury to long-term growth and survival of wild rainbow trout. North American Journal of Fisheries Management. 16:560-569.

Denton, K. 2018. Estimating the 2017 Sockeye Salmon Escapement into Lake Ozette Using an ARIS multi-beam SONAR. K. Denton and Associates, LLC. Sequim, WA. 28 pp.

DFO (Department of Fisheries and Oceans Canada). 2011. Regional Science Advisory Process on the Pacific Review of Yelloweye Rockfish (*Sebastes ruberrimus*), September 22, 2010. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2011/011. iv + 16 pages.

Diffenbaugh, N. S., D. L. Swain, and D. Touma. 2015. Anthropogenic warming has increased drought risk in California. Proceedings of the National Academy of Sciences, 112(13): 3931-3936.

Dominguez, F., E. Rivera, D. P. Lettenmaier, and C. L. Castro. 2012. Changes in Winter Precipitation Extremes for the Western United States under a Warmer Climate as Simulated by Regional Climate Models. Geophysical Research Letters. 39(5). DOI:10.1029/2011GL050762.

Doney, S. C., M. Ruckelshaus, J. E. Duffy, J. P. Barry, F. Chan, C. A. English, H. M. Galindo, J. M. Grebmeier, A. B. Hollowed, N. Knowlton, J. Polovina, N. N. Rabalais, W. J. Sydeman, and L. D. Talley. 2012. Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science. 4:11-37.

Drake J. S., E. A. Berntson, J. M. Cope, R. G. Gustafson, E. E. Holmes, P. S. Levin, N. Tolimieri, R. S. Waples, S. M. Sogard, and G. D. Williams. 2010. Status review of five rockfish species in Puget Sound, Washington: bocaccio (*Sebastes paucispinis*), canary rockfish (*S. pinniger*), yelloweye rockfish (*S. ruberrimus*), greenstriped rockfish (*S. elongatus*), and redstripe rockfish (*S. proriger*). U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-108, 234 pp.

Dwyer, W. P. and R. G. White. 1997. Effect of electroshock on juvenile Arctic grayling and Yellowstone cutthroat trout growth 100 days after treatment. North American Journal of Fisheries Management. 17:174-177.

Endangered Species Act: Southwest. NOAA Technical Memorandum NOAA-TM-NMFW-SWFSC-564. Southwest Fisheries Science Center, National Marine Fisheries Service National Oceanic and Atmospheric Administration, U.S. Department of Commerce. July 2016.

Ettlinger, E., M. Horowitz, B. Schleifer, G.M. Andrew. 2012. Lagunitas Creek Salmon Spawner Survey Report 2011-2012. Marin Municipal Water District, Corte Madera, CA. 21 pp.

Feely, R.A., C.L. Sabine, K. Lee, W. Berelson, J. Kleypas, V.J. Fabry, and F.J. Millero. 2004. Impact of anthropogenic CO^2 on the $CaCO^3$ system in the oceans. Science 305: 362-366.

Feely, R. A., T. Klinger, J. A. Newton, and M. Chadsey (editors). 2012. Scientific summary of ocean acidification in Washington state marine waters. NOAA Office of Oceanic and Atmospheric Research Special Report.

Fletcher, D. H., F. Haw, and P. K. Bergman. 1987. Retention of coded-wire tags implanted into cheek musculature of largemouth bass. North American Journal of Fisheries Management 7:436-439.

Ford, J. K. B., G. M. Ellis, L. G. Barrett-Lennard, A. B. Morton, R. S. Palm, and K. C. B. III. 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Canadian Journal of Zoology. 76(8): 1456-1471.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 2000. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. Vancouver, British Columbia, UBC Press, 2nd Edition.

Ford, J. K. B., and G. M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. Marine Ecology Progress Series 316: 185–199.

Ford, M. J. (ed.). 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Depart. of Commer., NOAA Tech. Memo. NOAA-TM-NWFSC-113, 281 pp.

Ford, M. J. 2013. Status review update of Southern Resident killer whales. U.S. Dept. of Commerce, Northwest Fisheries Science Center.41p. Available at (Accessed July 2015): Status review update of Southern Resident killer whales weblink

Ford, M. J., J. Hempelmann, B. Hanson, K. L. Ayres, R. W. Baird, C. K. Emmons, J. I. Lundin, G. S. Schorr, S. K. Wasser, and L. K. Park. 2016. Estimation of a killer whale (*Orcinus orca*) population's diet using sequencing analysis of DNA from feces. PLoS ONE. 11(1): 1-14.

Fredenberg, W. A. 1992. Evaluation of electrofishing-induced spinal injuries resulting from field electrofishing surveys in Montana. Montana Department of Fish, Wildlife and Parks, Helena.

Glick, P., J. Clough, and B. Nunley. 2007. Sea-Level Rise and Coastal Habitats in the Pacific Northwest: An analysis for Puget Sound, southwestern Washington, and northwestern Oregon. National Wildlife Federation, Seattle, WA.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Tech. Memo. NMFS-NWFSC-66. 598 pp.

Goode, J. R., J. M. Buffington, D. Tonina D. J. Isaak, R. F. Thurow, S. Wenger, D. Nagel, C. Luce, D. Tetzlaff, and C. Soulsby. 2013. Potential effects of climate change on streambed scour and risks to salmonid survival in snow-dominated mountain basins. Hydrological Processes 27(5):750-765.

Griffith, J., M. Alexandersdottir, R. Rogers, J. Drotts, and P. Stevenson. 2004. 2003 annual Stillaguamish smolt report. Stillaguamish Tribe of Indians.

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

Haggerty, M. J., A. C. Ritchie, J. G. Shellberg, M. J. Crewson, and J. Jalonen. 2009. Lake Ozette Sockeye Limiting Factors Analysis. Prepared for the Makah Indian Tribe and NOAA Fisheries in Cooperation with the Lake Ozette Sockeye Steering Committee, Port Angeles, WA.

Hallacher, L. E. 1974. The comparative morphology of extrinsic gas bladder musculature in the scorpionfish genus, *Sebastes* (Pisces: *Scorpaenidae*). Proceedings of the California Academy of Sciences. 40(3):59–86.

Hallock RJ, Van Woert WF, Shapovalov L. 1961. An evaluation of stocking hatchery reared steelhead rainbow trout (Salmo gairdnerii gairdnerii) in the Sacramento River system. California Department of Fish and Game. Fish Bulletin 114. 74 p.

Hannah, R. W. and K. M. Matteson. 2007. Behavior of nine species of Pacific rockfish after hook-and-line capture, recompression, and release. Transactions of the American Fisheries Society 136:24–33.

Hannah, R. W., S. J. Parker, and K. M. Matteson. 2008. Escaping the surface: the effects of capture depth on submergence success of surface-released Pacific rockfish. North American Journal of Fisheries Management 28:694–700.

Hannon, J. and B. Deason. 2005. American River steelhead (Oncorhynchus mykiss) spawning 2001-2005. Bureau of Reclamation, Mid-Pacific Region.

Hanson, M. B., K. L. Ayres, R. W. Baird, K. C. Balcomb, K. Balcomb-Bartok, J. R. Candy, C. K. Emmons, J. K. B. Ford, M. J. Ford, B. Gisborne, J. Hempelmann-Halos, G. S. Schorr, J. G. Sneva, D. M. Van Doornik, and S. K. Wasser. 2010a. Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. Endangered Species Research. 11:69–82.

Hanson, M. B., J. Hempelmann-Halos, and D. Van Doornik. 2010b. Species and stock identification of scale/tissue samples from southern resident killer whale predation events collected off the Washington coast during PODs 2009 cruise on the McArthur II, March 16, 2010. Unpublished memorandum

Hanson, M. B., and C. K. Emmons. 2010c. Annual Residency Patterns of Southern Resident Killer Whales in the Inland Waters of Washington and British Columbia. Revised Draft - 30 October 10. 11p.

Hanson, M. B., C. K. Emmons, E. J. Ward, J. A. Nystuen, and M. O. Lammers. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. The Journal of the Acoustical Society of America. 134(5): 3486–3495.

Hauser, D. D. W., M. G. Logsdon, E. E. Holmes, G. R. VanBlaricom, and R. W. Osborne. 2007. Summer distribution patterns of Southern Resident Killer Whales *Orcinus orca*: core areas and spatial segregation of social groups. Marine Ecology Process Series. 351: 301-310.

Hay, D. E., P. B. McCarter, R. Joy, M. Thompson, and K. West. 2002. Fraser River Eulachon Biomass Assessments and Spawning Distribution: 1995-2002. Canadian Science Advisory Secretariat Research Document 2002/117. 58pp.

Hayes, M.L. 1983. Active capture techniques. Pages 123-146 in L.A. Nielsen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society. Bethesda, MD.

Hayes, D.B., C.P. Ferreri, and W.W. Taylor. 1996. Active fish capture methods. Pages 193-220 in B.R. Murphy and D.W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society. Bethesda, MD.

Hayhoe, K., D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider, K.N. Cahill, E.E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L. S. Kalkstein, J. Lenihan, C.K. Lunch, R.P. Neilson, S.C. Sheridan, and J.H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences of the United States of America 101: 12422-12427.

Healey, M. C., and W. Ra Heard. 1984. Inter- and intra-population variation in the fecundity of chinook salmon (*Oncorhynchus tshawytscha*) and its relevance to life history theory. Can. J. Fish. Aquat. Sci. 4l:474-483.

Healey, M. C. 1991. The life history of Chinook salmon (*Oncorhynchus tshawytscha*). *In* C. Groot and L. Margolis (eds), Life history of Pacific salmon, p. 311-393. Univ. BC Press.

Hilborn, R., S. P. Cox, F. M. D. Gulland, D. G. Hankin, N. T. Hobbs, D. E. Schindler, and A. W. Trites. 2012. The Effects of Salmon Fisheries on Southern Resident Killer Whales: Final Report of the Independent Science Panel. November 30, 2012. Prepared with the assistance of D.R. Marmorek and A.W. Hall, ESSA Technologies Ltd., Vancouver, B.C. for NMFS, Seattle, Washington and Fisheries and Oceans Canada (Vancouver. BC). 87p.

Hollender, B. A. and R. F. Carline. 1994. Injury to wild brook trout by backpack electrofishing. North American Journal of Fisheries Management. 14:643-649.

HCCC (Hood Canal Coordinating Council). 2005. Hood Canal & Eastern Strait of Juan de Fuca summer chum salmon recovery plan. Hood Canal Coordinating Council. Poulsbo, Washington.

Hochhalter S. J. and D. J. Reed. 2011. The effectiveness of deepwater release at improving the survival of discarded yelloweye rockfish. North American Journal of Fisheries Management 31:852-860.

Hockersmith, E. E., W. D. Muir , S. G. Smith , B. P Sanford , N. S. Adams , J. M. Plumb, R. W. Perry, and D. W. Rondorf. 2000. Comparative performance of sham radiotagged and PIT-tagged juvenile salmon. Report to U.S. Army Corps of Engineers, Contract W66Qkz91521282, 25 p.

Hooton, R. S. 1987. Catch and release as a management strategy for steelhead in British Columbia. *In* R. Barnhart and T. Roelofs, editors. Proceedings of Catch and Release Fishing: a Decade of Experience, a National Sport Fishing Symposium. Humboldt State University, Arcata, California.

Howe, N. R. and P. R. Hoyt. 1982. Mortality of juvenile brown shrimp *Penaeus aztecus* associated with streamer tags. Transactions of the American Fisheries Society. 111:317-325.

Huhn, D. and R. Arlinghaus. 2011. Determinants of hooking mortality in freshwater recreational fisheries: a quantitative meta-analysis. *In* The angler in the environment: social, economic, biological, and ethical dimensions: proceedings of the 5th World Recreational Fishing Conference, number 75 in American Fisheries Society symposium. American Fisheries Society, Bethesda, Md.

IPCC (Intergovernmental Panel on Climate Change). 2014. Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

ISAB (Independent Scientific Advisory Board). 2007. Climate change impacts on Columbia River Basin fish and wildlife. ISAB Climate Change Report, ISAB 2007-2, Northwest Power and Conservation Council, Portland, Oregon.

Isaak, D. J., S. Wollrab, D. Horan, and G. Chandler. 2012. Climate change effects on stream and river temperatures across the northwest US from 1980–2009 and implications for salmonid fishes. Climatic Change. 113(2):499-524.

Jarvis, E. T., and C. G. Lowe. 2008. The effects of barotrauma on the catch-and-release survival of southern California nearshore and shelf rockfish (*Scorpaenidae*, *Sebastes* spp.). Canadian Journal of Fisheries and Aquatic Sciences 65:1286–1296.

Jenkins, W. E. and T. I. J. Smith. 1990. Use of PIT tags to individually identify striped bass and red drum brood stocks. American Fisheries Society Symposium 7:341-345.

Kamler, J. F. and K. L. Pope. 2001. Nonlethal Methods of Examining Fish Stomach Contents. Reviews in Fisheries Science. 9(1):1-11.

Kier, M.C., J. Hileman, and S. Cannata. 2015. Annual Report Trinity River Basin Salmon and Steelhead Monitoring Project.

Kohlhorst, D. W. 1979. Effect of first pectoral fin ray removal on survival and estimated harvest rate of white sturgeon in the Sacramento-San Joaquin estuary. California Department of Fish and Game. 65: 173-177.

Krahn, M. M., P. R. Wade, S. T. Kalinowski, M. E. Dahlheim, B. L. Taylor, M. B. Hanson, G. M. Ylitalo, R. P. Angliss, J. E. Stein, and R. S. Waples. 2002. Status review of southern resident killer whales (*Orcinus orca*) under the Endangered Species Act. NOAA Technical Memorandum NMFS-NWFSC54, U.S. Department of Commerce, Seattle, Washington.

Krahn, M. M., M. J. Ford, W. F. Perrin, P. R. Wade, R. P. Angliss, M. B. Hanson, B. L. Taylor, G. M. Ylitalo, M. E. Dahlheim, J. E. Stein, and R. S. Waples. 2004. 2004 Status Review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act.

December 2004. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-62. NMFS, Seattle, Washington. 95p.

Krahn, M. M., M. B. Hanson, R. W. Baird, R. H. Boyer, D. G. Burrows, C. E. Emmons, J. K. B. Ford, L. L. Jones, D. P. Noren, P. S. Ross, G. S. Schorr, and T.K. Collier. 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident killer whales. Marine Pollution Bulletin. 54:1903-1911.

Kunkel, K. E., L. E. Stevens, S. E. Stevens, L. Sun, E. Janssen, D. Wuebbles, K. T. Redmond, and J. G. Dobson. 2013. Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 6. *Climate of the Northwest U.S. NOAA Technical Report NESDIS 142-6*. 83 pp. National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service, Washington, D.C.

Lacy, R. C., R. Williams, E. Ashe, Kenneth C. Balcomb III, L. J. N. Brent, C. W. Clark, D. P. Croft, D. A. Giles, M. MacDuffee, and P. C. Paquet. 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. Scientific Reports. 7(1): 1-12

Langness, O. 2018. NOAA 2014 Protected Species Studies of Eulachon in Oregon and Washington designed to guide implementation of a monitoring program to track coast-wide status and trends in abundance and distribution - Reporting Period: January 1, 2018 to June 30, 2018. Washington Department of Fish and Wildlife. Vancouver, WA. 76pp.

Lawson, P. W., E. A. Logerwell, N. J. Mantua, R. C. Francis, and V. N. Agostini. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences. 61(3):360-373

Lewis, M., E. Brown, B. Sounhein, M. Weeber, E. Suring, and H. Truemper. 2009. Status of Oregon stocks of coho salmon, 2004 through 2008. Monitoring Program Report Number OPSW-ODFW-2009-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Lewis, M., B. Sounhein, M. Weeber, and E. Brown. 2010. Status of Oregon stocks of coho salmon, 2009. Monitoring Program Report Number OPSW-ODFW-2010-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Lewis, M., M. Weeber, E. Brown, and B. Sounhein. 2011. Status of Oregon stocks of coho salmon, 2010. Monitoring Program Report Number OPSW-ODFW-2011-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Lewis, M., E. Brown, B. Sounhein, and M. Weeber. 2012. Status of Oregon stocks of coho salmon, 2011. Monitoring Program Report Number OPSW-ODFW-2012-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Lewis, M., B. Sounhein, M. Weeber and E. Brown. 2014. Status of Oregon stocks of coho salmon, 2012. Monitoring Program Report Number OPSW-ODFW-2013-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Light, R. W., P. H. Adler, and D. E. Arnold. 1983. Evaluation of Gastric Lavage for Stomach Analyses. North American Journal of Fisheries Management. 3:81-85.

Lindley, S.T., R. S. Schick, E. Mora, P.B. Adams, J.J. Anderson, S. Greene, C. Hanson, B. P. May, D. McEwan, R. B MacFarlane, and C. Swanson. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento–San Joaquin basin. San Francisco Estuary and Watershed Science, 5(1).

Lindsay, R. B., R. K. Schroeder, and K. R. Kenaston. 2004. Hooking mortality by anatomical location and its use in estimating mortality of spring Chinook salmon caught and released in a river sport fishery. North American Journal of Fisheries Management 24:367-378.

Lloret, J., N. Zaragoza, D. Caballero, T. Font, M. Casadevall, and V. Riera. 2008. Spearfishing pressure on fish communities in rocky coastal habitats in a Mediterranean marine protected area. Fisheries Research, 94(1), pp.84-91.

Love, M. S., M. Carr, and L. Haldorson. 1991. The ecology of substrate-associated juveniles of the genus Sebastes. Environmental Biology of Fishes. 30:225-243.

Love, M. S., M. M. Yoklavich, and L. Thorsteinson. 2002. The rockfishes of the Northeast Pacific. University of California Press, Berkeley, California.

Luers, A. L. 2006. Our changing climate: assessing the risks to California. California Energy Commission.

Mantua, N., I. Tohver, and A. Hamlet. 2009. Impacts of Climate Change on Key Aspects of Freshwater Salmon Habitat in Washington State. *in* The Washington Climate Change Impacts Assessment: Evaluating Washington's Future in a Changing Climate, M. M. Elsner, J. Littell, and L. Whitely Binder, Eds. The Climate Impacts Group, University of Washington, Seattle, Washington, pp. 217-253.

Mantua, N., I. Tohver, and A. Hamlet. 2010. Climate change impacts on streamflow extremes and summertime stream temperature and their possible consequences for freshwater salmon habitat in Washington State. Climatic Change. 102(1):187-223.

Matthews, K. R. and R. H. Reavis. 1990. Underwater tagging and visual recapture as a technique for studying movement patterns of rockfish. American Fisheries Society Symposium. 7:168-172.

Mattole Salmon Group. 2011. Spawning Ground Surveys, 2010-2011 Season Mattole River Watershed – Final Report. Petrolia, CA. 41 pp.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Dept. Commer., NOAA Tech. Memo NMFS-NWFSC-42. 156pp.

McEwan, D. and T.A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game, Sacramento, CA.

McEwan, D. 2001. Central Valley steelhead. Contributions to the biology of Central Valley salmonids. California Department of Fish and Game Fish Bulletin 179(1):1-44.

McMahon, T. E. and G. F. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences. 46:1551-1557.

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

McMichael, G. A., L. Fritts, and T. N. Pearsons. 1998. Electrofishing injury to stream salmonids; injury assessment at the sample, reach, and stream scales. North American Journal of Fisheries Management. 18:894-904.

McNeil, F. I. and E. J. Crossman. 1979. Fin clips in the evaluation of stocking programs for muskellunge (*Esox masquinongy*). Transactions of the American Fisheries Society. 108:335-343.

McPherson, S. and J. C. Woodey. 2009. Cedar River and Lake Washington Sockeye Salmon Biological Reference Point Estimates. Prepared for Washington Department of Fisheries and Wildlife. Olympia, WA. 62pp.

Mears, H. C. and R. W. Hatch. 1976. Overwinter survival of fingerling brook trout with single and multiple fin clips. Transactions of the American Fisheries Society 105: 669-674.

Meehan, W.R. and R.A. Miller. 1978. Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. J. Fish. Res. Board Can. 35:1359-1363.

Mellas, E. J. and J. M. Haynes. 1985. Swimming performance and behavior of rainbow trout (*Salmo gairdneri*) and white perch (*Morone americana*): effects of attaching telemetry transmitters. Canadian Journal of Fisheries and Aquatic Sciences 42:488-493.

Metheny, M., and W. Duffy. 2014. Sonar estimation of adult salmonid abundance in Redwood Creek, Humboldt County, California 2012-2013. Report for California Department of Fish and Wildlife Fisheries Restoration Grants Program.

Meyer, J. L., M. J. Sale, P. J. Mulholland, and N. L. Poff. 1999. Impacts of climate change on aquatic ecosystem functioning and health. JAWRA Journal of the American Water Resources Association. 35(6):1373-1386.

Mongillo, P. E. 1984. A summary of salmonid hooking mortality. Washington Department of Game, Olympia.

Moring, J. R. 1990. Marking and tagging intertidal fishes: review of techniques. American Fisheries Society Symposium. 7:109-116.

Morrison, J. and D. Zajac. 1987. Histologic effect of coded wire tagging in chum salmon. North American Journal of Fisheries Management 7:439-441.

Mote, P. W., J. Abatzoglou, and K. Kunkel. 2013. Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities. Island Press, 224 pp.

Mote, P. W, A. K. Snover, S. Capalbo, S. D. Eigenbrode, P. Glick, J. Littell, R. R. Raymondi, and W. S. Reeder. 2014. Ch. 21: Northwest. *in* Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, T.C. Richmond, and G.W. Yohe, Eds., U.S. Global Change Research Program, pp. 487-513.

Mote, P. W., D. E. Rupp, S. Li, D. J. Sharp, F. Otto, P. F. Uhe, M. Xiao, D. P. Lettenmaier, H. Cullen, and M. R. Allen. 2016. Perspectives on the cause of exceptionally low 2015 snowpack in the western United States. Geophysical Research Letters. 43:10980-10988. doi:10.1002/2016GLO69665

Moulton, L. L. and B. S. Miller. 1987. Characterization of Puget Sound marine fishes: survey of available data. Fisheries Research Institute, School of Fisheries, University of Washington. FRI-UW 8716.

Muoneke, M. and W. M. Childress. 1994. Hooking Mortality: A Review for Recreational Fisheries. Reviews in Fisheries Science. 2:123-156.

Nelson, T., M. Rosenau, and N. T. Johnston. 2005. Behavior and Survival of Wild and Hatchery-Origin Winter Steelhead Spawners Caught and Released in a Recreational Fishery. North American Journal of Fisheries Management. 25(3):931-943.

Nickelson, T.E. 1998. A Habit-Based Assessment of Coho Salmon Production Potential and Spawner Escapement Needs for Oregon Coastal Streams. INFORMATION REPORTS NUMBER 98-4. Oregon Department of Fish and Wildlife. April, 1998.

Nicola, S. J. and A. J. Cordone. 1973. Effects of fin removal on survival and growth of rainbow trout (*Salmo gairdneri*) in a natural environment. Transactions of the American Fisheries Society. 102(4):753-759.

Nielsen, L. A. 1992. Methods of marking fish and shellfish. American Fisheries Society Special Publication 23. Bethesda, Maryland.

NMFS (National Marine Fisheries Service). 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act, June 2000. Available at: NOAA Fisheries Guidelines for Electrofishing Waters webpage

NMFS (National Marine Fisheries Service). 2005. Assessment of NOAA Fisheries' critical habitat analytical review teams for 12 evolutionarily significant units of West Coast salmon and steelhead. NMFS, Protected Resources Division, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2006. Final supplement to the Puget Sound Salmon Recovery Plan. Available at: Final supplement to PS Salmon Recovery Plan weblink

NMFS (National Marine Fisheries Service). 2007. Final Supplement to the recovery plan for the Hood Canal and eastern Strait of Juan de Fuca summer chum salmon (*Oncorhynchus keta*). National Marine Fisheries Service, Northwest Region. Portland, Oregon

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

NMFS (National Marine Fisheries Service). 2009a. Recovery Plan For Lake Ozette Sockeye Salmon (*Oncorhynchus nerka*). National Marine Fisheries Service, West Coast Region, Portland, OR. 394 pp.

NMFS (National Marine Fisheries Service). 2009b. Middle Columbia Steelhead ESA Recovery Plan. National Marine Fisheries Service, West Coast Region, Portland, OR. 260 pp.

NMFS (National Marine Fisheries Service). 2011. 5-Year Review: Summary and Evaluation of Central Valley Steelhead. U.S. Department of Commerce, 34 pp.

NMFS (National Marine Fisheries Service). 2012. Final Recovery Plan for Central California Coast coho salmon Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Region, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2013. ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead. National Marine Fisheries Service, West Coast Region, Portland, OR. 503 pp.

NMFS (National Marine Fisheries Service). 2014a. Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead. California Central Valley Area Office. July 2014.

NMFS (National Marine Fisheries Service). 2014b. Final Recovery Plan for the Southern Oregon/Northern California Coast Evolutionarily Significant Unit of Coho Salmon (*Oncorhynchus kisutch*). National Marine Fisheries Service. Arcata, CA. 406 pp.

NMFS (National Marine Fisheries Service). 2015a. ESA Recovery Plan for Snake River Sockeye Salmon (*Oncorhynchus nerka*). National Marine Fisheries Service, West Coast Region, Portland, OR. 431 pp.

NMFS (National Marine Fisheries Service). 2016a. Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, California.

NMFS (National Marine Fisheries Service). 2016b. Final ESA Recovery Plan for Oregon Coast Coho Salmon (*Oncorhynchus kisutch*). National Marine Fisheries Service, West Coast Region, Portland, OR. 230 pp.

NMFS (National Marine Fisheries Service). 2016c. Yelloweye rockfish (*Sebastes ruberrimus*), canary rockfish (*Sebastes pinniger*) and bocaccio (*Sebastes paucispinis*) of the Puget Sound/Georgia Basin – 5-Year Review: Summary and Evaluation. National Marine Fisheries Service. Seattle, WA. 131 pp.

NMFS (National Marine Fisheries Service). 2016d. 2016 5-Year Review: Summary & Evaluation of Ozette Lake Sockeye. NMFS, West Coast Region. Portland, OR. 47 pp.

NMFS (National Marine Fisheries Service). 2016e. Viability Assessment for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Southwest. NOAA Technical Memorandum NOAA-TM-NMFW-SWFSC-564.
Southwest Fisheries Science Center, National Marine Fisheries Service National Oceanic and Atmospheric Administration, U.S. Department of Commerce. July 2016.

NMFS (National Marine Fisheries Service). 2016f. Southern Resident Killer Whales (*Orcinus orca*) 5-Year Review: Summary and Evaluation. December 2016. NMFS, West Coast Region, Seattle, Washington. 74 p.

NMFS (National Marine Fisheries Service). 2017a. ESA Recovery Plan for Snake River Fall Chinook Salmon (*Oncorhynchus tshawytscha*). National Marine Fisheries Service, West Coast Region, Portland, OR. 366 pp.

NMFS (National Marine Fisheries Service). 2017b. ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon (*Oncorhynchus tshawytscha*) & Snake River Basin Steelhead (*Oncorhynchus mykiss*). National Marine Fisheries Service, West Coast Region, Portland, OR. 284 pp.

NMFS (National Marine Fisheries Service). 2017c. Endangered Species Act Recovery Plan for the Southern Distinct Population Segment of Eulachon (*Thaleichthys pacificus*). National Marine Fisheries Service, West Coast Region, Portland, OR. 132 pp.

NMFS (National Marine Fisheries Service). 2017d. Rockfish Recovery Plan: Puget Sound / Georgia Basin yelloweye rockfish (*Sebastes ruberrimus*) and bocaccio (*Sebastes paucispinis*). National Marine Fisheries Service. Seattle, WA. 167 pp.

NMFS (National Marine Fisheries Service). 2018a. Proposed Recovery Plan for the Puget Sound Steelhead Distinct Population Segment (*Oncorhynchus mykiss*). National Marine Fisheries Service. Seattle, WA. 291 pp.

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

ODFW (Oregon Department of Fish and Wildlife). 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. August, 2011.

ODFW (Oregon Department of Fish and Wildlife). 2017. Umpqua River Basin Coho Salmon Program - South Umpqua River/Cow Creek Coho Salmon Hatchery and Genetic Management Plan (HGMP). 64 pp.

ODFW (Oregon Department of Fish and Wildlife) and NMFS (National Marine Fisheries Service). 2011. Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead. 462 pp.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 2014. 2014 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations. Joint Columbia River Management Staff, Oregon Department of Fish & Wildlife, and Washington Department of Fish & Wildlife. January 22, 2014.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 2015. 2015 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations. Joint Columbia River Management Staff, Oregon Department of Fish & Wildlife, and Washington Department of Fish & Wildlife. January 21, 2015.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 2016. 2016 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species, and Miscellaneous Regulations. Joint Columbia River Management Staff, Oregon Department of Fish & Wildlife, and Washington Department of Fish & Wildlife. January 20, 2016.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 2017. 2017 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species. Joint Columbia River Management Staff, Oregon Department of Fish & Wildlife, and Washington Department of Fish & Wildlife. November 9, 2017.

ODFW (Oregon Department of Fish and Wildlife) and WDFW (Washington Department of Fish and Wildlife). 2018. 2018 Joint Staff Report: Stock Status and Fisheries for Spring Chinook, Summer Chinook, Sockeye, Steelhead, and Other Species. Joint Columbia River Management Staff, Oregon Department of Fish & Wildlife, and Washington Department of Fish & Wildlife. February 20, 2018.

Olander, D. 1991. Northwest Coastal Fishing Guide. Frank Amato Publications, Portland, Oregon.

Osgood, K.E. (editor). 2008. Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs. U.S. Dep. Commerce, NOAA Tech. Memo. NMFSF/ SPO-89, 118 pp.

Palsson, W. A., T.-S. Tsou, G. G. Bargmann, R. M. Buckley, J. E. West, M. L. Mills, Y. W. Cheng, and R. E. Pacunski. 2009. The biology and assessment of rockfishes in Puget Sound. FPT 09-04. Washington Dept. Fish and Wildlife, Olympia.

Parker, S. J., H. I. McElderry, P. S. Rankin, and R.W. Hannah. 2006. Buoyancy regulation and barotrauma in two species of nearshore rockfish. Transactions of the American Fisheries Society 135:1213–1223.

Pauley, G. B., B. M. Bortz, and M. F. Shepard. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Northwest) -- steelhead trout. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.62). U.S. Army Corps of Engineers, TR EL-82-4. 24 pp.

Peltz, L. and J. Miller. 1990. Performance of half-length coded wire tags in a pink salmon hatchery marking program. American Fisheries Society Symposium 7:244-252.

Pettit, S. W. 1977. Comparative reproductive success of caught-and-released and unplayed hatchery female steelhead trout (*Salmo gairdneri*) from the Clearwater River, Idaho. Transactions of American Fisheries Society. 106(5):431-435.

PFMC (Pacific Fishery Management Council). 2013. Appendix B, Historical Record of Escapement to Inland Fisheries and Spawning Areas. Review of 2012 Ocean Salmon Fisheries (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, OR 97220-1384.

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

Prentice, E. F. and D. L. Park. 1984. A study to determine the biological feasibility of a new fish tagging system. Annual Report of Research, 1983-1984. Project 83-19, Contract DEA179-83BP11982.

Prentice, E. F., T. A. Flagg, and C. S. McCutcheon. 1987. A study to determine the biological feasibility of a new fish tagging system, 1986-1987. Bonneville Power Administration, Portland, Oregon.

Prentice, E. F., T. A. Flagg, and C. S. McCutcheon. 1990. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. American Fisheries Society Symposium 7: 317-322.

Pribyl, A. L., C. B. Schrek, M. L. Kent, and S. J. Parker. 2009. The differential response to decompression of three species of nearshore Pacific rockfish. North American Journal of Fisheries Management 29:1479–1486.

Pribyl A. L., M. L. Kent, S. J. Parker, and C. B. Schreck. 2011. The response to forced decompression in six species of pacific rockfish. Transactions of the American Fisheries Society 140:374–383.

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

Raymondi, R. R., J. E. Cuhaciyan, P. Glick, S. M. Capalbo, L. L. Houston, S .L. Shafer, and O. Grah. 2013. Water Resources: Implications of Changes in Temperature and Precipitation *in* Climate Change in the Northwest: Implications for Our Landscapes, Waters, and

Communities, M. M. Dalton, P. W. Mote, and A. K. Snover, Eds., Island Press, Washington, DC, pp. 41-58.

Reeder, W. S., P. R. Ruggiero, S. L. Shafer, A. K. Snover, L. L Houston, P. Glick, J. A. Newton, and S. M. Capalbo. 2013. Coasts: Complex Changes Affecting the Northwest's Diverse Shorelines. *in* Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities, M. M. Dalton, P. W. Mote, and A. K. Snover, Eds. Island Press, Washington, DC, pp 41-58.

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

Ricker, S.J , D. Ward, and C.W. Anderson. 2014. Results of Freshwater Creek Salmonid Life Cycle Monitoring Station 2010-2013. California Department of Fish and Game, Anadromous Fisheries Resource Assessment and Monitoring Program, 50 Ericson Ct., Arcata, CA 95521.

Rogers, B. L., C. G. Lowe, E. Fernandez-Juricic, and L. R. Frank. 2008. Utilizing magnetic resonance imaging (MRI) to assess the effects of angling-induced barotrauma on rockfish (*Sebastes*). Canadian Journal of Fisheries and Aquatic Sciences 65:1245-1249.

Rondorf, D. W. and W. H. Miller. 1994. Identification of the spawning, rearing and migratory requirements of fall Chinook salmon in the Columbia River Basin. Prepared for the U.S. Dept. of Energy, Portland, OR. 219 p.

Sandercock, F.K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). In Pacific salmon life histories. Edited by C. Root and L. Marolis. UBC Press, Vancouver, BC. pp. 296 – 445.

Scavia, D., J.C. Field, D.F. Boesch, R.W. Buddemeier, V. Burkett, D.R. Cayan, M. Fogarty, M.A. Harwell, R.W. Howarth, C. Mason, D.J. Reed, T.C. Royer, A.H. Sallenger, and J.G. Titus. 2002. Climate Change Impacts on U.S. Coastal and Marine Ecosystems. Estuaries, volume 25(2): 149-164.

Scheuerell, M. D. and J. G. Williams. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography. 14:448-457.

Schill, D. J., and R. L. Scarpella. 1995. Wild trout regulation studies. Annual performance report. Idaho Department of Fish and Game, Boise.

Schisler, G. J. and E. P. Bergersen. 1996. Post release hooking mortality of rainbow trout caught on scented artificial baits. North American Journal of Fisheries Management. 16(3):570-578.

Schneider, S.H. 2007. The unique risks to California from human-induced climate change. California State Motor Vehicle Pollution Control Standards; Request for Waiver of Federal Preemption, presentation. May 22, 2007.

Scholz, N. L., M. S. Myers, S. G. McCarthy, J. S. Labenia, J. K. McIntyre, G. M. Ylitalo, L. D. Rhodes, C. A. Laetz, C. M. Stehr, B. L. French, B. McMillan, D. Wilson, L. Reed, K. D.

Lynch, S. Damm, J. W. Davis, and T. K. Collier. 2011. Recurrent die-offs of adult coho salmon returning to spawn in Puget Sound lowland urban streams. PLos One. 6(12):1-12

Schroeder, R. K., K. R. Kenaston, and R. B. Lindsay. 2000. Spring Chinook salmon in the Willamette and Sandy Rivers. October 1998 through September 1999. Annual progress report, Fish Research Project Oregon. Oregon Department of Fish and Wildlife, Portland.

Seiler, D., G. Volkhardt, P. Topping, and L. Kishimoto. 2002. 2000 Green River juvenile salmonid production evaluation. Washington Department of Fish and Wildlife.

Seiler, D., G. Volkhardt, P. Topping, L. Fleischer, T. Miller, S. Schonning, D. Rawding, M. Groesbeck, R. Woodard, and S. Hawkins. 2004. 2003 juvenile salmonid production evaluation report. Green River, Wenatchee River, and Cedar Creek. Washington Department of Fish and Wildlife.

Seiler, D., G. Volkhardt, and L. Fleischer. 2005. Evaluation of downstream migrant salmon production in 2004 from the Cedar River and Bear Creek. Washington Department of Fish and Wildlife.

Sharber, N. G. and S. W. Carothers. 1988. Influence of electrofishing pulse shape on spinal injuries in adult rainbow trout. North American Journal of Fisheries Management. 8:117-122.

Sharber, N. G., S. W. Carothers, J. P. Sharber, J. C. DeVos, Jr., and D. A. House. 1994. Reducing electrofishing-induced injury of rainbow trout. North American Journal of Fisheries Management. 14:340-346.

Sharpe, C. S., D. A. Thompson, H. L. Blankenship, and C. B. Schreck. 1998. Effects of routine handling and tagging procedures on physiological stress responses in juvenile Chinook salmon. Progressive Fish-Culturist. 60(2):81-87.

Smith, D.M., Cusack, S., Colman, A.W., Folland, C.K., Harris, G.R., and Murphy, J.M. 2007. Improved surface temperature prediction for the coming decade from a global climate model. Science 317:796-799.

Snyder, D. E. 1995. Impacts of electrofishing on fish. Fisheries. 20(1):26-27.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2014. Status of Oregon stocks of coho salmon, 2013. Monitoring Program Report Number OPSW-ODFW-2014-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2015. Status of Oregon stocks of coho salmon, 2014. Monitoring Program Report Number OPSW-ODFW-2015-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2016. Status of Oregon stocks of coho salmon, 2015. Monitoring Program Report Number OPSW-ODFW-2016-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2017. Status of Oregon stocks of Coho Salmon, 2016. Monitoring Program Report Number OPSW-ODFW-2017-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

Sounhein, B., E. Brown, M. Lewis and M. Weeber. 2018. Western Oregon adult Coho Salmon, 2017 spawning survey data report. Monitoring Program Report Number OPSW-ODFW-2018-3, Oregon Department of Fish and Wildlife, Salem, Oregon.

SSDC (Shared Strategy Development Committee). 2007. Puget Sound Salmon Recovery Plan. Adopted by the National Marine Fisheries Service January 19, 2007. Available on-line at [PS Salmon Recovery Plan weblink]

Stanley, R.D., M. McAllister, and P. Starr. 2012. Updated stock assessment for bocaccio (*Sebastes paucispinis*) in British Columbia waters for 2012. DFO Canadian Scientific Advisory Secretariat Research Document 2012/109. 73pp.

Starr, R. M., J. N. Heine, J. M. Felton, and G. M. Cailliet. 2002. Movements of bocaccio (*Sebastes paucispinis*) and greenspotted (*S. chlorostictus*) rockfishes in a Monterey submarine canyon: implications for the design of marine reserves. U.S. National Marine Fisheries Service Fishery Bulletin 100:324–337.

Stickney, R.R. 1983. Care and handling of live fish. Pages 85-94 in L.A. Nielsen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society. Bethesda, Maryland, 468 pp.

Stolte, L. W. 1973. Differences in survival and growth of marked and unmarked coho salmon. Progressive Fish-Culturist 35: 229-230.

Stout, H.A., P.W. Lawson, D. Bottom, T. Cooney, M. Ford, C. Jordan, R. Kope, L. Kruzic, G.Pess, G. Reeves, M. Scheuerell, T. Wainwright, R. Waples, L. Weitkamp, J. Williams and T. Williams. 2011. Scientific conclusions of the status review for Oregon Coast coho salmon (*Oncorhynchus kisutch*). Draft revised report of the Oregon Coast Coho Salmon Biological Review Team. NOAA/NMFS/NWFSC, Seattle, WA.

Strange, C. D. and G. J. Kennedy. 1981. Stomach flushing of salmonids: a simple and effective technique for the removal of the stomach contents. Fish. Manage. 12:9-15.

Sunda, W. G., and W. J. Cai. 2012. Eutrophication induced CO2-acidification of subsurface coastal waters: interactive effects of temperature, salinity, and atmospheric p CO2. Environmental Science & Technology. 46(19):10651-10659.

Swain, D. L., B. Langenbrunner, J. D. Neelin, and A. Hall. 2018. Increasing precipitation volatility in twenty-first-century California. Nature Climate Change, 8(5): 427-433.

TAC [TAC (U.S. v. Oregon Technical Advisory Committee)]. 2008. Biological assessment of incidental impacts on salmon species listed under the Endangered Species Act in the 2008-2017 non-Indian and treaty Indian fisheries in the Columbia River Basin.

Tague, C. L., J. S. Choate, and G. Grant. 2013. Parameterizing sub-surface drainage with geology to improve modeling streamflow responses to climate in data limited environments. Hydrology and Earth System Sciences. 17(1): 341-354.

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

Taylor, M. J. and K. R. White. 1992. A meta-analysis of hooking mortality of non-anadromous trout. North American Journal of Fisheries Management. 12:760-767.

Teubert, R., Aschbacher, R., Mitchell, M. and District, W.S.R.C. 2011. Video weir technology pilot project final project report 2008-2010 steelhead escapements Cottonwood, Cow, and Bear Creeks, Shasta and Tehama County, CA.

Thompson, K. G., E. P. Bergersen, R. B. Nehring, and D. C. Bowden. 1997. Long-term effects of electrofishing on growth and body condition of brown and rainbow trout. North American Journal of Fisheries Management. 17:154-159.

Tillmann, P., and D. Siemann. 2011. Climate Change Effects and Adaptation Approaches in Marine and Coastal Ecosystems of the North Pacific Landscape Conservation Cooperative Region. National Wildlife Federation.

Tolimieri, N. and P. S. Levin. 2005. The roles of fishing and climate in the population dynamics of bocaccio rockfish. Ecological Applications 15:458-468.

Turley, C. 2008. Impacts of changing ocean chemistry in a high-CO^2 world. Mineralogical Magazine, February 2008, 72(1). 359-362.

USFWS (United States Fish and Wildlife Service) and NMFS (National Marine Fisheries Service). 1998. Endangered Species Consultation Handbook Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act. U.S. Fish &Wildlife Service and National Marine Fisheries Service.

UCSRB (Upper Columbia Salmon Recovery Board). 2007. Upper Columbia Spring Chinook Salmon and Steelhead Recovery Plan. 352 pp.

Vander Haegen, G. E., Ashbrook, C. E., Yi, K. W., and J. F. Dixon. 2004. Survival of spring Chinook salmon captured and released in a selective commercial fishery using gill nets and tangle nets. Fisheries Research, 68(1-3), 123-133.

Volkhardt, G., P. Topping, L. Fleischer, T. Miller, S. Schonning, D. Rawding, M. Groesbeck. 2005. 2004 Juvenile salmonid production evaluation report. Green River, Wenatchee River, and Cedar Creek. Washington Department of Fish and Wildlife.

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

Wallace, J. R. 2007. Update to the status of yelloweye rockfish (*Sebastes ruberrimus*) off the U.S. West Coast in 2007, Pacific Fishery Management Council, Portland, OR.

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

Ward, B. R. and P. A. Slaney. 1993. Egg-to-smolt survival and fry-to-smolt density dependence in Keogh River steelhead trout, p. 209-217. *In* R. J. Gibson and R. E. Cutting [ed.] Production of juvenile Atlantic salmon, *Salmon salar*, in natural waters. Can. Spec. Publ. Fish. Aquat. Sci. 118.

Ward, E. J., M. J. Ford, R. G. Kope, J. K. B. Ford, L. A. Vélez-Espino, C. K. Parken, L. W. LaVoy, M. B. Hanson, and K. C. Balcomb. 2013. Estimating the Impacts of Chinook Salmon Abundance and Prey Removal by Ocean Fishing on Southern Resident Killer Whale Population Dynamics. July 2013. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-123. 85p.

WDFW (Washington Department of Fish and Wildlife). 2017. Draft conservation plan for reducing the impact of selected fisheries on ESA listed species in Puget Sound, with an emphasis on bocaccio and yelloweye rockfish. Prepared for the National Marine Fisheries Service by the Washington Department of Fish and Wildlife.

WDFW (Washington Department of Fish and Wildlife). 2018. 2019 Future Brood Document Final (Tuesday, August 6, 2019). Online at WDFW Future Brood Document 2019

WDFW/PNPTT (Washington Department of Fish and Wildlife and Point No Point Treaty Tribes). 2000. Summer chum salmon conservation initiative. Washington Department of Fish and Wildlife, Olympia.

Welch, H.E. and K. H. Mills. 1981. Marking fish by scarring soft fin rays. Canadian Journal of Fisheries and Aquatic Sciences 38:1168-1170.

Westerling, Anthony Leroy. 2018. Wildfire Simulations for California's Fourth Climate Change Assessment: Projecting Changes in Extreme Wildfire Events with a Warming Climate. California's Fourth Climate Change Assessment, California Energy Commission. Publication Number: CCCA4-CEC-2018- 014.

Wiles, G. J. 2004. Washington State Status Report for the Killer Whale. March 2004. WDFW, Olympia, Washington. 120p.

Williams, T.H., S.T. Lindley, B.C. Spence, and D.A. Boughton. 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest. 17 May 2011 – Update to 5 January 2011 report. National Marine Fisheries Service. Southwest Fisheries Science Center. Santa Cruz, CA.

Williams, T.H., B.C. Spence, D.A. Boughton, R.C. Johnson, L.G. Crozier, N.J. Mantua, M.R. O'Farrell, and S.T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-564.

Winder, M. and D. E. Schindler. 2004. Climate change uncouples trophic interactions in an aquatic ecosystem. Ecology. 85:2100–2106.

Wissmar, R. C., J. E. Smith, B. A. McIntosh, H. W. Li, G. H. Reeves, and J. R. Sedell. 1994. Ecological Health of River Basins in Forested Regions of Eastern Washington and Oregon. Gen. Tech. Rep. PNW-GTR-326. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR. 65 p.

Wydoski, R. S. 1977. Relation of hooking mortality and sublethal hooking stress to quality fishery management. Pages 43-87 in R.A. Barnhart and T.D. Roelofs, editors. Proceedings of a national symposium on catch-and-release fishing as a management tool. Humboldt State University, Arcata, California.

Yamanaka, K. L. and A. R. Kronlund. 1997. Inshore rockfish stock assessment for the West Coast of Canada in 1996 and recommended yields for 1997. Can. Tech. Rep. Fish. Aquat. Sci. 2175:1-80.

Yamanaka, K. L., L. C. Lacko, R. Witheler, C. Grandin, J. K. Lochead, J.-C. Martin, N. Olsen, and S. S. Wallace. 2006. A review of yelloweye rockfish *Sebastes ruberimus* along the Pacific coast of Canada: biology, distribution, and abundance trends. Research Document 2006/076. Fisheries and Oceans Canada. 54pp.

Zabel, R. W., M. D. Scheuerell, M. M. McClure, and J. G. Williams. 2006. The interplay between climate variability and density dependence in the population viability of Chinook salmon. Conservation Biology. 20(1):190-200.

Zabel, R. W. 2014. Memorandum to Donna Weiting: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2014. Northwest Fisheries Science Center. November 4, 2014.

Zabel, R. W. 2015. Memorandum to Donna Weiting: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2015. Northwest Fisheries Science Center. October 5, 2015.

Zabel, R. W. 2017a. Memorandum for Christopher E. Yates: Update, Corrected Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2016. Northwest Fisheries Science Center. January 25, 2017.

Zabel, R. W. 2017b. Memorandum for Chris Yates: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2017. Northwest Fisheries Science Center. November 3, 2017.

Zabel, R. W. 2018. Memorandum for Chris Yates: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2018. Northwest Fisheries Science Center. December 18, 2018.

Zabel, R. W. 2020. Memorandum for Chris Yates: Estimation of Percentages for Listed Pacific Salmon and Steelhead Smolts Arriving at Various Locations in the Columbia River Basin in 2019. Northwest Fisheries Science Center. February 13, 2020.

Zamon, J. E., T. J. Guy, K. Balcomb, and D. Ellifrit. 2007. Winter observations of Southern Resident Killer Whales *(Orcinus orca*) near the Columbia River plume during the 2005 spring Chinook salmon (*Oncorhynchus tshawytscha*) spawning migration. Northwestern Naturalist. 88(3): 193-198.