UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

November 10, 2016

Refer to NMFS No: WCR-2016-5783

John E. Stein, Ph.D.
Science and Research Director
Northwest Fisheries Science Center
2725 Montlake Boulevard East
Seattle, Washington 98112-2097

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Letter of Concurrence for the Fisheries Research Conducted and Funded by the Northwest Fisheries Science Center; Issuance of a Letter of Authorization under the Marine Mammal Protection Act for the Incidental Take of Marine Mammals Pursuant to those Research Activities; and Issuance of a Scientific Research Permit under the Endangered Species Act for Directed Take of ESA-listed Marine Fishes

Dear Dr. Stein:

Thank you for your letter of June 30, 2016, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the Fisheries Research Conducted and Funded by the Northwest Fisheries Science Center; Issuance of a Letter of Authorization under the Marine Mammal Protection Act for the Incidental Take of Marine Mammals Pursuant to those Research Activities; and Issuance of a Scientific Research Permit under the Endangered Species Act for Directed Take of ESA-listed Marine Fishes.

In the enclosed biological opinion, NMFS concludes that the proposed action is not likely to jeopardize the continued existence of Puget Sound (PS) Chinook (*Oncorhynchus tshawytscha*), Lower Columbia River (LCR) Chinook, Upper Columbia River (UCR) spring-run Chinook, Snake River (SnkR) fall-run Chinook, SnkR spring/summer-run Chinook, Upper Willamette River (UWR) Chinook, California coastal (CC) Chinook, Central Valley (CV) spring-run Chinook, Sacramento River (SacR) winter-run Chinook, Hood Canal (HC) summer-run chum (*O. keta*), Columbia River (CR) chum, LCR coho (*O. kistuch*), Oregon Coast (OC) coho, Southern Oregon/Northern California Coast (SONCC) coho, Central California Coast (CCC) coho, Lake Ozette sockeye (*O. nerka*), SnkR sockeye, PS steelhead (*O.mykiss*), LCR steelhead, MCR steelhead, UCR steelhead, SnkR steelhead, UWR steelhead, Northern California (NC) steelhead, CCC steelhead, Central Valley (CV) steelhead, South Central California (SCC) steelhead, Puget Sound/Georgia Basin (PS/GB) bocaccio distinct population segment (DPS) (*Sebastes paucispinis*), PS/GB canary rockfish DPS (*S. pinniger*), PS/GB yelloweye rockfish DPS (*S. ruberrimus*), Southern (S) green sturgeon DPS (*Acipenser medirostris*), S. Pacific eulachon DPS (*Thaleichthys pacificus*), East Pacific green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), North Pacific Ocean DPS loggerhead sea turtle (*Carretta carretta*), and olive ridley sea turtle (*Lepidochelys olivacea*). Furthermore, NMFS also concludes that the proposed action may affect, but is not likely to adversely affect blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), humpback whale (*Megaptera novaeangliae*), North Pacific right whale (*Eubalaena japonica*), sei whale (*B. borealis*), Southern Resident killer whale DPS (*Orcinus orca*), sperm whale (*Physeter macrocephalus*), Western North Pacific gray whale (*Eschrichtius robustus*), Guadalupe fur seal (*Arctocephalus townsendi*), Hawksbill sea turtle (*Eretmochelys imbricate*), Southern California (SC) steelhead, black abalone (*Haliotis cracherodii*), and white abalone (*Haliotis sorenseni*). Additionally, NMFS concludes that the proposed action is not likely to adversely affect designated critical habitat for the above species.

Please contact Teresa Mongillo at (206) 526-4749 or at Teresa.Mongillo@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

FOR Barry A. Thom
Regional Administrator

Enclosure

cc: Administrative File: 151422WCR2016PR00262

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Letter of Concurrence

Fisheries Research Conducted and Funded by the Northwest Fisheries Science Center; Issuance of a Letter of Authorization under the Marine Mammal Protection Act for the Incidental Take of Marine Mammals Pursuant to those Research Activities; and Issuance of a Scientific Research Permit under the Endangered Species Act for Directed Take of ESA-listed Marine Fishes

NMFS Consultation Number: *2016-5783*

Action Agency: National Marine Fisheries Service: Northwest Fisheries Science Center and Office of Protected Resources

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species or Critical Habitat?[1]	Is Action Likely to Jeopardize the Species?	Is Action Likely to Destroy or Adversely Modify Critical Habitat?[1]
Marine Mammals				
Blue whale (*Balaenoptera musculus*)[2]	Endangered	No[1]	N.A.	N.A.
Fin whale (*B. physalus*)[2]	Endangered	No[1]	N.A.	N.A.
Humpback whale (*Megaptera novaeangliae*)[2]	Endangered	No[1]	N.A.	N.A.
North Pacific right whale (*Eubalaena japonica*)	Endangered	No[1]	N.A.	N.A.
Sei whale (*B. borealis*)[2]	Endangered	No[1]	N.A.	N.A.
Southern Resident killer whale DPS (*Orcinus orca*)	Endangered	No[1]	N.A.	No
Sperm whale (*Physeter macrocephalus*)[2]	Endangered	No[1]	N.A.	N.A.

Western North Pacific gray whale (*Eschrichtius robustus*)[2]	Endangered	No[1]	N.A.	N.A.
Guadalupe fur seal (*Arctocephalus townsendi*)[2]	Threatened	No[1]	N.A.	N.A.
Salmonids				
Puget Sound (PS) Chinook (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	No
Lower Columbia River (LCR) Chinook	Threatened	Yes	No	No
Upper Columbia River (UCR) spring-run Chinook	Endangered	Yes	No	No
Snake River (SnkR) fall-run Chinook	Threatened	Yes	No	No
SnkR spring/summer-run Chinook	Threatened	Yes	No	No
Upper Willamette River (UWR) Chinook	Threatened	Yes	No	No
California coastal (CC) Chinook	Threatened	Yes	No	No
Central Valley (CV) spring-run Chinook	Threatened	Yes	No	No
Sacramento River (SacR) winter-run Chinook	Endangered	Yes	No	No
Hood Canal (HC) summer-run chum (*O. keta*)	Threatened	Yes	No	No
Columbia River (CR) chum	Threatened	Yes	No	No
LCR coho (*O. kistuch*)	Threatened	Yes	No	No

Oregon Coast (OC) coho	Threatened	Yes	No	No
Southern Oregon/Northern California Coast (SONCC) coho	Threatened	Yes	No	No
Central California Coast (CCC) coho	Endangered	Yes	No	No
Lake Ozette sockeye (*O. nerka*)	Threatened	Yes	No	No
SnkR sockeye	Endangered	Yes	No	No
PS steelhead (*O. mykiss*)	Threatened	Yes	No	No
LCR steelhead	Threatened	Yes	No	No
MCR steelhead	Threatened	Yes	No	No
UCR steelhead	Threatened	Yes	No	No
SnkR steelhead	Threatened	Yes	No	No
UWR steelhead	Threatened	Yes	No	No
Northern California (NR) steelhead	Threatened	Yes	No	No
CCC steelhead	Threatened	Yes	No	No
Central Valley (CV) steelhead	Threatened	Yes	No	No
South Central California (SCC) steelhead	Threatened	Yes	No	No
Southern California (SC) steelhead	Endangered	No[1]	N.A.	No
Marine Fishes				
Bocaccio, Puget Sound/Georgia Basin (PS/GB) DPS (*Sebastes paucispinis*)[2]	Endangered	Yes	No	No
Canary rockfish, PS/GB DPS (*S. pinniger*)[2]	Threatened	Yes	No	No
Yelloweye rockfish, PS/GB DPS (*S. ruberrimus*)[2]	Threatened	Yes	No	No
Green sturgeon,	Threatened	Yes	No	No

Southern DPS (*Acipenser medirostris*)				
Pacific eulachon, Southern DPS (*Thaleichthys pacificus)*	Threatened	Yes	No	No
Sea Turtles				
East Pacific green sea turtle (*Chelonia mydas*)[2]	Threatened	Yes	No	N.A.
Leatherback sea turtle (*Dermochelys coriacea*)	Endangered	Yes	No	No
North Pacific Ocean DPS Loggerhead sea turtle (*Carretta carretta*)[2]	Endangered	Yes	No	N.A.
Olive ridley sea turtle (*Lepidochelys olivacea*)[2]	Threatened/Endandgered	Yes	No	N.A.
Hawksbill sea turtle (*Eretmochelys imbricate*)[2]	Endangered	No[1]	N.A.	N.A.
Marine Invertebrates				
Black abalone (*Haliotis cracherodii*)	Endangered	No[1]	N.A.	No
White abalone (*H. sorenseni*)[2]	Endangered	No[1]	N.A.	N.A.

[1]Please refer to section 2.12 for the analysis of species or critical habitat that are not likely to be adversely affected.

[2]Critical habitat has not been designated for these species.

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

Issued By:

For Barry A. Thom
Regional Administrator

Date: *November 10, 2016*

TABLE OF CONTENTS

List of Acronyms

AA Action Agency
ADCP Acoustic Doppler Current Profiler
AWT Aleutian wing trawl
BRD Bycatch Reduction Device
BRT Biological Review Team
CA California
CCRA California Current Research Area
CDFG California Department of Fish and Game
CDFW California Department of Fish and Wildlife
CESA California Endangered Species Act
CFR Code of Federal Regulations
CI Confidence Interval
CMP Coastal Monitoring Plan
CNFH Coleman National Fish Hatchery
COSEWIC Committee on the Status for Endangered Wildlife in Canada
CPS Coastal Pelagic Species
CPUE Catch Per Unit of Effort
CRR Cohort Replacement Rate
CS Chief Scientist
CTD Conductivity Temperature Depth
CVP Central Valley Project
CWT Coded Wire Tags
DAS Days at Sea
DFO Department of Fisheries and Oceans Canada
DIDSON Dual Frequency Identification Sonar
DIP Demographically Independent Population
DPEA Draft Programmatic Environmental Assessment
DPS Distinct Population Segment
DQA Data Quality Act
DU Designatable Unit
EA Environmental Assessment
EEZ Exclusive Economic Zone
EFH Essential Fish Habitat
ENSO El Niño Southern Oscillation
ESA Endangered Species Act
ESCA Endangered Species Conservation Act
ESU Evolutionarily Significant Unit
FCRPS Federal Columbia River Power System
FFS French Frigate Shoals
FMP Fisheries Management Plan
FR Federal Register
FRFH Feather River Fish Hatchery
HOR Hatchery Origin
IAT Integrated Acoustic and Trawl

ICTRT Interior Columbia Technical Recovery Team
ID Idaho
IDFG Idaho Department of Fish and Game
IMO International Maritime Organization
IPCC Intergovernmental Panel on Climate Change
ITS Incidental Take Statement
IUCN International Union for Conservation of Nature and Natural Resources
LCFRB Lower Columbia Fish Recovery Board
LCRRA Lower Columbia River Research Area
LHAC Listed Hatchery Adipose Clip
LHIA Listed Hatchery Intact Adipose
LLTK Long Live The Kings
LOA Letter of Authorization
LSNFH Livingston Stone National Fish Hatchery
LSRCP Lower Snake River Compensation Plan
LWD Large Woody Debris
MHHW Mean Higher High Water
MLLW Mean Lower Low Water
MMED Marine Mammal Excluder Device
MMPA Marine Mammal Protection Act
MPG Major Population Group
MSA Magnuson-Stevens Fishery Conservation and Management Act
NEP Nonessential Experimental Population
NLAA Not Likely to Adversely Affect
NOAA National Oceanic and Atmospheric Administration
NOR Natural Origin
NH-Line Newport Hydrographic Line
NWR Northwest Region
NMFS National Marine Fisheries Service
NOAA National Oceanic and Atmospheric Administration
NWFSC Northwest Fisheries Science Center
ODFW Oregon Department of Fish and Wildlife
OOD Officer on Deck
OPR Office of Protected Resources
OR Oregon
PBDEs Polybrominated Diphenyl Ethers
PBFs Physical or Biological Features
PBR Potential Biological Removal
PCBs Polychlorinated Biphenyls
PCE Primary Constituent Element
PCGF Pacific Coast Groundfish Fishery
PFMC Pacific Fishery Management Council
PIT Passive Integrated Transponder
PNE Poly Nor’easter Bottom Trawl
PNW Pacific Northwest
PRD Protected Resources Division

PS/GB Puget Sound/Georgia Basin
PSIT Protected Species Incidental Take
PSRA Puget Sound Research Area
PSTRT Puget Sound Technical Recovery Team
PTS Permanent Threshold Shift
PWSA Port and Waterways Safety Act
RBDD Red Bluff Diversion Dam
RCA Rockfish Conservation Areas
RMS Root Mean Square
ROV Remotely Operated Vehicle
RPA Reasonable and Prudent Alternative
RPMs Reasonable and Prudent Measures
SAR Stock Assessment Report
SARA Species at Risk Act
SJRRP San Joaquin River Restoration Project
SRKW Southern Resident Killer Whale (
SWFSC Southwest Fisheries Science Center
SWP State Water Project
TED Turtle Excluder Devices
TRT Technical Recovery Team
TTS Temporary Threshold Shift
URB Upriver Bright
USCG United States Coast Guard
USFWS United States Fish and Wildlife Service
USGS United States Geological Survey
VSP Viable Salmonid Population
WA Washington
WCR West Coast Region
WDFW Washington Department of Fish and Wildlife
WLC-TRT Willamette/Lower Columbia River Technical Recovery Team
WNP Western North Pacific

List of Tables

List of Figures

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.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through NMFS' Public Consultation Tracking System. A complete record of this consultation is on file at NMFS Protected Resources Division in Seattle, Washington.

1.2 Consultation History

This opinion responds to three requests for consultation on NOAA Fisheries activities including: an application for a research permit renewal under the ESA, a broad set of fisheries and ecosystem assessment activities that impact ESA-listed sea turtles and marine mammals, and the issuance of a Letter of Authorization (LOA) under the Marine Mammal Protection Act (MMPA) to take marine mammals incidental to the fisheries research conducted by NMFS Northwest Fisheries Science Center (NWFSC). The NWFSC provided a Draft Programmatic Environmental Assessment (DPEA) for their fisheries and ecosystem assessment activities that served as a Biological Assessment and consultation was initiated on June 30, 2016. Below, we describe the consultation history for the three components covered in this opinion.

The West Coast Region's Protected Resources Division (PRD) received five applications for permit renewals from the NWFSC. Four of these applications were for research that was not directly researching ESA-listed species; therefore, all of the requested take for ESA-listed species in these applications would be for incidental take (due to required capture methods, ESA-listed fish cannot be avoided). Consequently, the incidental take of ESA-listed species in these four applications will be authorized through Incidental Take Statements (ITSs) in this opinion. These four applicatons to be authorized though ITSs are as follows: (1) the 16337-3R permit renewal request, *Investigations of Hake Ecology, Survey Methods and the California Current Ecosystem*, received on March 11, 2015; (2) the 16338-3R permit renewal request, *Bycatch Reduction Research in West Coast Trawl Fisheries*, received on March 17, 2015; (3) the 16335-3R permit renewal request, *Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey*, received on March 27, 2015; and (4) the 16333-3R permit renewal request, *Groundfish Bottom Trawl Survey*, received on April 7, 2015. On March 30, 2015, PRD received the 1586-4R permit renewal request (hereafter referred to as permit 1586-4R) for directed take of ESA-listed salmonids to conduct scientific research on juvenile salmon use of the nearshore habitats of Puget Sound. This project will be authorized through a section 10 permit.

During a meeting discussing the NWFSC DPEA on July 28, 2015, the West Coast Regional Office and the NWFSC decided to include these permit requests in the associated biological opinion. On December 22, 2015, an extension letter was provided to extend ESA coverage under the conditions of the original Section 10(a)(1)(A) permits authorizing these 5 projects. Requested edits for the 1586-4R permit were sent on April 28, 2016, and all requests were addressed and completed by May 4, 2016. After the application for Section 10(a)(1)(A) permit 1586-4R was determined to be complete, we published notice in the Federal Register on May 20, 2016 asking for public comment on it (81 FR 31912). No comments were received from the public during the comment period. Edits were requested for the other four permits during a phone call on May 25, 2016. All requests were addressed and completed by June 15, 2016.

On December 14, 2015, NMFS WCR received a request from the NWFSC to review and help finalize the DPEA for fisheries and ecosystem assessment activities, and also provide technical assistance prior to initiation of formal consultation under Section 7(a)(2) of the ESA. The letter described the intention of the NWFSC to initiate formal consultation on impacts of their research activities to ESA-listed species and designated critical habitats, in conjunction with an application submitted to the NMFS Office of Protected Resources (OPR) for issuance of an LOA to the NWFSC regarding incidental takes of marine mammals.

On February 4, 2016, the WCR completed its review of the DPEA and provided the NWFSC with initial comments and questions to help finalize the DPEA. Since that time, both WCR and NWFSC have exchanged information pertaining to specific comments or questions needed to help WCR formulate this biological opinion on the effects of NWFSC research. By June 29, 2016, the NWFSC provided all of the information requested that was needed to support the initiation of consultation. In addition, no new information has come forth from any public process associated with the LOA application or DPEA that would significantly change the nature of the proposed action or potential impacts to ESA-listed species or designated critical habitats.

On June 30, 2016, the NWFSC requested formal consultation under Section 7(a)(2) of the ESA to evaluate the incidental impacts of fisheries and ecosystem assessment activities proposed by NWFSC on these ESA-listed species and designated critical habitats: blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), humpback whale (*Megaptera novaeangliae*), North Pacific right whale (*Eubalaena japonica*), sei whale (*B. borealis*), Southern Resident killer whale distinct population segment (DPS) (*Orcinus orca*), sperm whale (*Physeter macrocephalus*), Western North Pacific gray whale (*Eschrichtius robustus*), Guadalupe fur seal (*Arctocephalus townsendi*), Puget Sound (PS) Chinook (*Oncorhynchus tshawytscha*), Lower Columbia River (LCR) Chinook, Upper Columbia River (UCR) spring-run Chinook, Snake River (SnkR) fall-run Chinook, SnkR spring/summer-run Chinook, Upper Willamette River (UWR) Chinook, California coastal (CC) Chinook, Central Valley (CV) spring-run Chinook, Sacramento River (SacR) winter-run Chinook, Hood Canal (HC) summer-run chum (*O. keta*), Columbia River (CR) chum, LCR coho (*O. kistuch*), Oregon Coast (OC) coho, Southern Oregon/Northern California Coast (SONCC) coho, Central California Coast (CCC) coho, Lake Ozette sockeye (*O. nerka*), SnkR sockeye, PS steelhead (*O.mykiss*), LCR steelhead, MCR steelhead, UCR steelhead, SnkR steelhead, UWR steelhead, Northern California (NC) steelhead, CCC steelhead, Central Valley (CV) steelhead, South Central California (SCC) steelhead, Southern California (SC) steelhead, Puget Sound/Georgia Basin (PS/GB) bocaccio DPS (*Sebastes paucispinis*), PS/GB canary rockfish DPS (*S. pinniger*), PS/GB yelloweye rockfish DPS (*Sebastes ruberrimus*), Southern (S) green sturgeon DPS (*Acipenser medirostris*), S. Pacific eulachon DPS (*Thaleichthys pacificus*), East Pacific green sea turtle (*Chelonia mydas*), Leatherback sea turtle (*Dermochelys coriacea*), North Pacific Ocean DPS Loggerhead sea turtle (*Carretta carretta*), Olive ridley sea turtle (*Lepidochelys olivacea*), Hawksbill sea turtle (*Eretmochelys imbricate*), Black abalone (*Haliotis cracherodii*), and White abalone (*Haliotis sorenseni*).

On August 15, 2016, the OPR requested consultation under Section 7 of the ESA for the proposed issuance of anLOA to take marine mammals incidental to the fisheries research conducted by NWFSC in the Pacific Ocean, Puget Sound, and Columbia River. The LOA would be effective for a period of five years from the date of issuance. Prior to requesting consultation, OPR published a proposed rule on June 13, 2016 and provided WCR a copy.

The requests to consult on NWFSC fisheries and ecosystem assessment activities and issuance of an LOA are much broader in scope than the NWFSC request to consult on the five permit actions listed above. Therefore, the action we are analyzing in this biop is all the research conducted by the NWFSC that has the potential to affect marine mammals; while the proposed action we are analyzing under the five permits is specific to the NWFSC activities under those five permits and their potential effects on ESA-listed fish. In addition to the five permit actions included in this opinion, impacts on ESA-listed fish for other permits were analyzed under separate past consultations (see Table 1). These actions are all related to full environmental regulation compliance by the NWFSC while conducting research, with overlapping scope and timelines for completion, such that it is appropriate to include all these actions together in this one opinion.

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 action for this biological opinion contains three distinct but related activities:

1. The NMFS Northwest Fisheries Science Center (NWFSC) proposes to administer and conduct the research program described in section 1.3.1 during

the next 5 years.

2. The NMFS Office of Protected Resources (OPR) proposes to issue a Letter of Authorization (LOA) under the Marine Mammal Protection Act (MMPA) for the incidental take of marine mammals during fisheries surveys and related research activities conducted by the NWFSC (section 1.3.2).
3. The NMFS proposes to renew one section 10 permit to the NWFSC for the directed take of ESA-listed species for a 5-year period (section 1.3.3).
4. The NMFS proposes to continue four projects, described in section 1.3.4, that will incidentally take ESA-listed marine fishes.

There are several activities described in section 1.3.1 that have been previously analyzed for effects to marine fishes in biological opinions and are listed in Table 1. While the impacts of these activities on ESA-listed sea turtles are analyzed in this opinion (see section 2.5.2), and the impacts of these activities on ESA-listed marine mammals are analyzed in the letter of concurrence (see section 2.12), authorizations for take of ESA-listed marine fishes for these activities are already granted under the consultations listed in Table 1 and we are therefore not issuing these authorizations for take of ESA-listed marine fishes again as part of this consultation.

1.3.1 NWFSC Fisheries Research Activities and Mitigation Measures

Here we provide a summary of the NWFSC fisheries research activities and the proposed mitigation measures that are a part of the proposed action and described in the DPEA (NMFS 2015a). The summary below describes the spatial and temporal distribution of the NWFSC fisheries research effort (see Appendix B *in* DPEA) and the gear that the NWFSC proposes to use (see Appendix A *in* DPEA). It is important to note that we describe the full suite of research activities and mitigation here, while in the effects section we evaluate the impacts of the proposed action described in this section only on ESA-listed marine mammals and sea turtles. Our reason for this approach is that the impacts of this action on ESA-listed marine fishes that are a part of existing research were analyzed and authorized in previously approved Section 10(a)(1)(A) scientific research and monitoring permits and our accompanying biological opinions (see Table 1). The components of this action that impact ESA-listed marine fishes that have recently expired Section 10(a)(1)(A) permits and biological opinions (and currently covered by extension letters) are described in the third (section 1.3.3) and fourth (section 1.3.4) proposed actions.

Table 1. Active Section 10(a)(1)(A) and Federal Columbia River Power System (FCRPS) permits for the NWFSC that have been analyzed for effects on marine fishes.

Permit #	Sec 10/ FCRPS	Title	Consultation #	Expiration Date
1410-9A	S	Columbia River basin juvenile salmonids: survival and growth in the Columbia River Plume and northern California Current	WCR/2014/764; WCR/2014/1127; WCR/2014/312	12/31/2018
1525-6R	S	Study of habitat occurrence, diet, contaminant concentrations, and health indicators in juvenile salmonids from the Lower Willamette and Columbia Rivers.	WCR/2014/1852; WCR/2015/2052	12/31/2019

1590-4R	S	Life History of Resident Puget Sound Chinook Salmon	NWR/2011/06218	12/31/2016
16702-2M	S	Monitoring the response of juvenile Puget Sound Chinook salmon (*Oncorhynchus tshawtscha*) to tidal wetland restoration in the Snohomish River estuary	NWR/2011/06218; NWR/2013/10225	12/31/2016
17062-5M	S	Comparing genetic variation of threatened rockfish populations in the Puget Sound DPS with coastal populations	WCR/2014/1819; WCR/2016/5035	12/31/2019
17798	S	Assessment of Chemicals of Emerging Concern on Chinook salmon	NWR/2013/10225	12/31/2017
20058	F	Sampling PIT-tagged juvenile salmonids migrating in the Columbia River estuary	NWR/2005/5883	12/31/2016
20077	F	Development and implementation of pile dike antenna (PDA) systems to detect adult and juvenile PIT-tagged salmonids in the Columbia River Estuary	NWR/2005/5883	12/31/2016
20083	F	Multnomah Channel Wetland Restoration Monitoring Project	NWR/2005/5883	12/31/2016
20103	F	A Study to Evaluate Survival of Adult Spring/Summer Chinook Salmon Migrating from the Mouth of the Columbia River to Bonneville Dam	NWR/2005/5883	12/31/2016
20141	F	Measuring fish condition indices of hatchery spring/summer and fall juvenile Chinook salmon at FCRPS dams throughout outmigration season	NWR/2005/5883	12/31/2016
20246	F	Baitfish/salmonid marine survival relationships in the Columbia River estuary. Role of disease as a factor affecting survival of juvenile salmonids in the estuarine and marine environments	NWR/2005/5883	12/31/2016
20322	F	Importance of the Columbia River Estuary to forage fish populations and salmonid marine survival. Salmon parasites as indicators of life-histories, migration, and habitat use of juvenile salmon	NWR/2005/5883	12/31/2016

1.3.1.1 Surveys conducted in the Puget Sound Research Area (PSRA)

Studies Using Trawl Gear

Beam Trawl Survey to Evaluate Effects of Hypoxia: This survey would occur during the summer and fall (daytime operations only) at five sites in southern Hood Canal and five sites in northern Hood Canal. The purpose is to examine the effects of hypoxia on demersal fishes in Hood Canal. A video camera would be mounted onto a beam trawl and researchers would review the recordings to measure escape response time to the bottom trawl by various bottomfish. The gear would consist of a 2-m wide beam trawl with a video camera, a Conductivity Temperature Depth (CTD) profiler, and either an open or closed cod-end that is towed at three various depths (30, 60, and 90 m) for approximately 10 minutes at about 2 knots. This survey would require approximately 20 days at sea (DAS) and one tow per site per season, meaning there would be 20 tows in total.

Marine Fish Collections Including Flatfish: This annual survey would be conducted monthly in Puget Sound. The purpose is to collect of marine fishes for research including broodstock. The gear would consist of various commercial-sized bottom trawls with various net sizes towed at 1.5-3.5 knots for up to 4 hours at depths of 50-1000 m. This survey requires approximately 15 DAS and 40 bottom trawls per year would be deployed.

Movement Studies of Puget Sound Species: These studies would be conducted year-round in Puget Sound. The purpose is to study fish movement in Puget Sound using telemetry. The researchers would use various types of gear (including SCUBA) to capture the animals alive and tag them. They would also place detection arrays in various places in the Sound. The species may include sixgill shark, Chinook and coho salmon, lingcod, ratfish, steelhead, canary and yelloweye rockfish, English sole, spiny dogfish, sunflower stars, and jellyfish. A variety of small vessels would be used. The gear would include commercial bottom trawls with various net sizes towed at <3.5 knots for 10 minutes at depths > 10 m deploying approximately 12 trawls per year. Researchers would also deploy herring purse seines with a net size of 1500 x 90 ft. and variable mesh sizes. The purse seines would be set for <1 hour at depths < 50 m and a total of 12 sets per year. They may also use hook and line gear with up to 12 lines in the water at once using barbless hooks up to 20 trips per year. Researchers would also deploy demersal longline in about 200 ft. of water with a mainline length of 600 ft. and 30 circle hooks per set. Approximate soak times would be 90-120 minutes and there would be approximately 3 sets per year for a total of 90 hooks. Lastly, researchers would moor VR2 passive acoustic receivers on the bottom with metal weights (no lines) and acoustic releases in deep water near fishing locations (continuous for season). The survey effort would require approximately 25 DAS and daytime operations only.

Puget Sound Marine Pelagic Food Web: This survey would occur in Puget Sound between April and October as funding is available. The purpose is to study the marine pelagic food web in Puget Sound focusing on land use and development effects on the food web. Researchers would use a chartered vessel and a Kodiak surface trawl with net size of 3.1 x 6.1 m towed at 1.8-2.2 knots for 10 min at depths <10 m. Previously, there were about 500 trawls per year when the study was conducted. Future sampling effort would likely be 250 trawls per year. The duration of this survey would be approximately 30 DAS (daytime operations only).

Skagit Bay Juvenile Salmon Survey: This survey would be conducted in Puget Sound between April and September. The purpose is to assess coastal ocean conditions and measure the growth, relative abundance, and survival of juvenile salmon during their first summer at sea. Researchers would use a chartered vessel and a Kodiak surface trawl with net size of 3.1 x 6.1 m towed at 1.8-2.2 knots for 10 min at depths < 10 m. There would be approximately 180 trawls per year, but previous effort was up to 250 trawls per year. The duration of the survey would be approximately 30 DAS with daytime operations only.

Studies Using Other Gears

Elwha Dam Removal: This survey would occur monthly in the Strait of Juan de Fuca. The purpose is to examine the potential effects of dam removal on nearshore fish including ESA-listed species. The researchers would use a 17-foot whaler vessel and a 140-ft x 6-ft beach seine with <0.25-inch mesh that would be deployed for less than 10 minutes, with up to 140 samples per year. Operations would be daytime only and require about 20 DAS.

ESA-listed Rockfish Genetics: This survey would be conducted during the spring, summer, and fall in Puget Sound, the San Juan Islands, and the Strait of Juan de Fuca. The purpose of the survey is to collect size, weight, location, depth, and genetic information from bottomfish species. The researchers would collect fin clips from all bottomfish captured and would use the samples to do genetic analyses focusing on ESA-listed rockfish species (yelloweye rockfish, canary rockfish, and bocaccio). The intent would be to release all fish unharmed. The researchers would use various charter boats and they would use hook-and-line fishing gear baited with herring and squid, or bottom jigs such as darts. Fishing effort would average 18.2 hook-hours per day and 750 hook-hours per year. The duration of the survey would be approximately 35-41 DAS with daytime operations only.

Herring Egg Mortality Survey: This survey would be conducted between February and May in herring spawning locations in Puget Sound in water less than 10m (e.g. Squaxin Pass, Quartermaster Harbor, Elliot Bay, Port Orchard, Quilcene Bay, Holmes Harbor, and Cherry Point). This survey would explore spatial variation and drivers of herring egg loss in Puget Sound. Researchers would investigate if herring egg loss relates to vegetation types used by herring for spawning substrate, the presence of suspected large herring egg predators (diving ducks and large fish), and metrics of shoreline development. SCUBA divers and predator exclusion cages would be used to collect eggs. The cages are modified sablefish pots with 3 x 3-cm mesh openings, and would be deployed for approximately 10 days. Researchers would deploy the five cages at each of the five sites and take approximately 600 small vegetation samples with herring eggs from each site per year. The duration of the survey would be approximately 20 DAS with daytime operations only.

Heterosigma akashiwo Bloom Dynamics and Toxic Effects: This study would occur in Puget Sound, Georgia Strait, and Strait of Juan de Fuca during summer and fall. The purpose of this study is to help identify elements of toxicity and the environmental parameters that promote growth and expression of toxicity in the raphidophyte *Heterosigma akashiwo*. Researchers would collect samples for: marine toxins, chlorophyll a, micro and macro nutrients, phytoplankton species ID and enumeration, and DNA analysis. They would use various vessels and their gear would consist of plankton nets (20 micro meter mesh nets deployed only in surface waters at 0-2m), a CTD profiler, and rosette water sampler that they would deploy at depths from the surface to near bottom or a maximum of approximately 35 m. They would take approximately 70 samples per year and their survey efforts would require 20 DAS (daytime operations only).

Long-term Eelgrass Monitoring: This survey would be conducted quarterly at sites within Puget Sound proper that are paired across a range of urbanization gradients. The purpose of the survey is to conduct long-term monitoring of fringe eelgrass habitats in Puget Sound. The researchers would quantify growth, pressures, and community structure of eelgrass beds over the next 20 years to monitor for potential changes due to climatic/oceanic conditions and management actions related to shoreline armoring and land-use practices. Researchers would collect the seagrass, sediments, and water samples to quantify epiphyte loads and sediment quality, and water chemistry. They would use transects to quantify fish, invertebrate, and eelgrass densities. SCUBA divers would use sediment grabs and Niskin bottles. There would be about 360 transects per year. Their survey effort would require 10 DAS and daytime operations only.

Marine Fish Research including Broodstock Collection, Sampling, and Tagging: These surveys would occur monthly in Puget Sound. The purpose is to collect fish for broodstock, sampling, and tagging. Researchers would use a chartered sportfishing vessel and their gear would include a pelagic longline with an approximate 3 hour soak time. The length of the mainline would be 750-1000 fathoms and would set at 700-3000 ft., with 500 barbed circle hooks baited with squid per set. The researchers would deploy approximately 30 sets per year. Additional protocols would include the use of hook and line gear deployed by rod and reel. Eight anglers with eight lines in the water would fish at a time, and they would use barbed circle hooks. The research would involve approximately 6 hours of fishing per day with eight lines in the water for a total of 90 hours per year or 720 hook-hours. The duration of effort would be approximately 15 DAS each month and daytime operations only.

Puget Sound Salmon Contaminant Study: This survey would be conducted from May to July in Puget Sound. Researchers would study contaminant concentrations in juvenile Chinook salmon from multiple sites in Puget Sound. They would use a 17-ft whaler to deploy a 37-m long x 2.4-m wide beach seine with 10-mm mesh size for less than 10 minutes, with up to 100 sets per year. Their survey effort would require 30 DAS and would occur in the daytime only.

Snohomish Juvenile Salmon Survey: This survey would occur monthly year-round and twice monthly from February to September in the Snohomish estuary. The purpose is to document juvenile salmon use of the Snohomish estuary and pre-restoration conditions at the Qwuloolt levee breach project and adjacent reference areas. Researchers would use a 17-ft whaler or inflatable and their gear would consist of a beach seine with a net size of 140 x 6 ft., mesh size of <1 in, and set for <10 min (up to 200 sets/year), and a fyke net trap with variable net sizes, mesh size of <0.25 in, and set for up to 6 hours (up to 100 sets/year). The fyke nets they would use are basically block nets that have wings that guide fish into a trap box. Researchers would set the nets at high tide and as the tide ebbs, fish would be funneled into the trap. Fyke nets would be fished in estuarine channels that range in width from 3 ft. or less to 15 ft. The survey effort would require 50 DAS and would occur in daytime only.

Urban Gradient Surveys: These surveys would be conducted during the summer at five pairs of study sites in Puget Sound across a range of urbanization. The purpose is to identify relationships between land use practices and the properties of streams and nearshore marine ecosystems around Puget Sound. The goal is to examine how ecosystem structure (the relative abundance of different species) and ecosystem functions (the processes connecting species to one another) vary according to the level of urbanization. Researchers would focus on motile epibenthic invertebrates (e.g. shrimps, gastropods, isopods, and amphipods) from eelgrass habitats. The researchers would use the R/V *Minnow* or conduct their survey from the shore and their gear would consist of an Epibenthic tow sled with a 1 x 1-m mouth opening and 1-mm mesh towed for approximately 10 minutes at 1 m depth. Approximately 3 to 5 samples would be taken per site per year with 30-60 samples total. Their effort would require 10 DAS and would occur in the daytime only.

1.3.1.2 Surveys conducted in the Lower Columbia River Research Area (LCRRA)

Studies Using Trawl Gear

Eulachon Arrival Timing: This survey would occur about 6 times between January and March in the Columbia River Estuary and Plume but would not extend out into the California Current Research Area (CCRA). The purpose is to determine the arrival timing and distribution of spawning eulachon at the mouth of the Columbia River. The researchers would conduct the survey on NOAA research vessels using a modified Cobb trawl with 9.5 mm cod end towed at 2.7 knots for 15 minutes at 30-40 m depth. Samples would be taken for fecundity and other biological data but most fish would be released unharmed. About 60 trawls would occur per year. The effort would require 15 DAS and would occur in the daytime only.

Pair Trawl Columbia River Juvenile Salmon Survey: The survey would take place between March and August in the upper Columbia River Estuary (River Kilometer 65 to 85). The purpose of the survey is to assess passage of tagged juvenile salmon migrating from the upper reaches of the Columbia River basin to the ocean by passively sampling Passive Integrated Transponder (PIT)-tagged juvenile salmonids. Researchers would use two 41-foot utility vessels to deploy the net and tow it plus a small skiff to tend equipment and clear debris and the gear used would consist of a surface pair trawl with an 8 x 10-ft open cod-end and PIT detector array. The trawl would be equipped with 92 x 92-m wings, with a body of 9 m wide x 6 m deep x 18 m long. Researchers would tow the trawl at 1.5 knots for 8-15 hours at depths from surface to 5 m. Towed antennae may replace the pair trawl net for PIT detection if the development is successful. The effort and duration would be 80 DAS, for 800 - 1200 hours per year, and sampling would occur on a 24-hour basis.

Studies Using Other Gears

Benefits of Wetland Restoration to Juvenile Salmon: Action Effectiveness Monitoring: This survey would be conducted bi-weekly from March to October in the Columbia River estuary from the river mouth to Bonneville Dam. The purpose is to study and examine salmon habitat use in the lower Columbia River estuary focusing on determining benefits that juvenile salmon obtain from restoring wetland habitats. Researchers would use a 500 x 30 ft. purse seine deployed for less than one hour (90/year), 150 x 6 ft. beach seine deployed for less than 10 minutes (16 sets per year), trap nets soaked up to six hours (16 sets per year), a CTD profiler (about 90 casts per year), and a 10 x 20 ft. surface trawl that would be towed between skiffs for about 15 minutes. The effort would require 32 DAS and would occur in the daytime only.

Columbia River Estuary Tidal Habitat: This survey would be conducted quarterly to monthly in the Columbia River estuary from the river mouth to Bonneville Dam. The purpose is to study salmon habitat use and genetic stocks of origin. Researchers would use a 150 x 6 ft. beach seine set for <10 minutes (less than 100 per year), Trap nets soaked up to six hours (less than 50 sets per year), CTD (about 100 per year), 24-volt backpack shocker and boat electro-shocker (less than 100 sites per year), 6 stationary PIT antennas, fish holding pens, and water level & temperature logger, and insect fall out traps, emergent insect cone traps, and benthic cores. Their effort would require 25 DAS and would occur in the daytime only.

Effects of Dredging on Crab Recruitment: This survey would be conducted periodically between August and October in the nearshore Columbia River mouth area. The purpose is to study how Dungeness crab respond to dredge spoils being placed in nearshore zone for beach nourishment. Researchers would use a Benthic video sled, acoustic telemetry with moored Vemco VR2 receivers and V9-2H transmitters, and a video drop camera system. The survey duration would be 15 DAS annually and would occur in the daytime only.

Lower Columbia River Ecosystem Monitoring: This survey would be conducted monthly from February through December in the lower Columbia River Estuary. Researchers would study habitat occurrence and the health of juvenile salmon and their prey. They would deploy a 37-m long x 2.4-m wide beach seine with 10-mm mesh size for less than 10 minutes with up to 200 sets per year. Researchers would also deploy a Neuston plankton net for about five minutes, with approximately 50 sets per year. Their effort would require 16 DAS and would occur in the daytime only.

Migratory Behavior of Adult Salmon: This survey would be conducted in the Columbia River Estuary up to the Bonneville dam during spring-fall as needed to meet tagging goals. The objective of the work is to determine the migratory rate of adult Chinook salmon destined for upper river spawning sites. Researchers would charter various commercial fishing vessels to capture fish with 200-foot-long tangle nets (designed for non-lethal capture). Set duration would be 25-45 minutes with up to 75 sets per year. Their effort would require 32 DAS and would occur in the daytime only.

Pile Dike PIT-Tag Detection System: The detection system would be located in the Columbia River Estuary near River Kilometer 70 and would be operated from March to October (but may become year-round). The purpose of the system is to detect migrating adult and juvenile salmon. Researchers would only use vessels for servicing the system. The subsurface deployment would be continuous during the season. The researchers would use a small guidance net (20 ft. x 20 ft.) anchored in place leading to an 8 ft. x 20 ft. (minimum) opening with subsurface PIT-tag detector.

1.3.1.3 Surveys conducted in the California Current Research Area (CCRA)

Studies Using Trawl Gear

Bycatch Reduction Research: This survey would occur from April to October in waters from southern Oregon to Canada. This research effort would be to test gear improvements to reduce bycatch of non-target fish species. Examples would include testing low-rise bottom trawls, flexible sorting grates in bottom and midwater trawls, and open escape window bycatch reduction devices in midwater trawls. Researchers would conduct their surveys on chartered commercial fishing vessels. The protocols for this survey would include deployment of commercial bottom trawls of various net sizes towed at 1.5-3.5 knots for up to 4 hours at depths of 50-1000 m. There would be approximately 40 trawls per year with this type of gear. Protocols would also include deployment of a double rigged shrimp trawl with various net sizes towed at 1.5-3.5 knots for 30-80 minutes at depths of 100-300 m. Up to 60 double-rigged shrimp trawls would occur each year. Researchers would also deploy commercial pelagic midwater trawls with various net sizes towed at 1.5-3.5 knots for an average of two hours but may be towed up to 8 hours at depths of 50-1000m. There would be up to 60 midwater trawls per year. The type of trawl the researchers would use and the duration that it would be fished depends on the fishery (i.e., target species), bycatch species of concern, changing fishing regulations (e.g., annual catch limits, catch shares, bycatch species prohibitions, and ESA listings), vessel, and bycatch reduction engineering methods being evaluated. All these can factor into the trawl gear being fished (studied) and the duration of the haul. Additional protocols would include the use of various models of echosounders and sonars (38-200 kHz, ≤224 dB/1µPa). This research would require 30-90 DAS and would be conducted in the daytime only.

*Camera Trawl Research***:** This survey would be conducted between March and September along the U.S. west coast from southern California to Southeast Alaska, including Canada. These would be research/development and pilot surveys to refine the development of optical-trawl samplers as applied to acoustical and other surveys, including testing of hardware and software, to assess abundance and species composition in trawls used to sample commercially important groundfish. Researchers would deploy a midwater Aleutian wing trawl (AWT) with a headrope of 334 feet (ft.) (101.8 m) towed at 2.8–3.5 knots at depths down to 500 m. The duration of the tows would vary depending on the time it takes to verify the composition of the schools of fish producing acoustic signals. Researchers would deploy approximately 75 trawls/year (in addition to trawls conducted as part of hake survey) or 30-70 DAS and their research would be conducted in the daytime only.

Flatfish Brood Stock Collection: This survey would occur intermittently up to 20 times annually in Puget Sound and the Washington coast. Researchers would collect fish for broodstock for aquaculture development. They would use commercial bottom trawl (6-24 trawls per year) with various net sizes towed at <3.5 knots for 10 min at depths >10 m and hook-and-line (18 collection trips per year with up to 12 lines in the water at once). This survey would require around 40 DAS and in daytime operations only.

Groundfish Bottom Trawl Survey: This survey would occur annually between May and October from the US/Mexico to the US/Canada borders. This would be a fisheries independent survey to monitor groundfish distribution and biomass along the US west coast at depths of 55 to 1280 m. Researchers would use two chartered commercial fishing vessels operating at the same time to cover the necessary stations. There would be two sampling periods, May to July and August to October. The protocols for this survey would include deployment of a modified Aberdeen bottom trawl (and video camera) with a 5 x 15-m opening towed at 2.2 knots for approximately 15 min at depths of 55-1280 m. Additional protocols would include the use of a CTD profiler and various models of echosounders and sonars (27-200 kHz; ≤ 224 dB/1μPa). There would be approximately 737-773 trawls per year and researchers would require about 190 DAS total for all vessels. Their sampling effort would occur only during the daytime.

Hake Acoustic Survey: This survey would be conducted each June-September on the US continental shelf from southern California to Southeast Alaska, including Canada. The purpose of the survey is to measure the abundance of hake. Researchers would use echosounder acoustic gear to locate and assess the size of hake schools and midwater trawls to confirm identification of fish targets. The protocols for this survey would include deployment of a midwater AWT with a headrope of 334 ft. (101.8 m) towed at 2.8-3.5 knots at variable depths. There would be about 150 trawls/year; about five percent of which would be Poly Nor'easter Bottom Trawl (PNE) bottom trawls with 89 ft. headrope and 120 ft. footrope towed at 2.8-3.5 knots for variable lengths of time to sample the fish producing the acoustic signal. Additional protocols would include the use of various models of echosounders and sonars (1.5-200 kHz; ≤ 224 dB/1μPa). Researchers would require about 60-80 DAS and sampling would occur only during the daytime.

Juvenile Salmon Pacific Northwest (PNW) Coastal Survey: This survey would be conducted annually in continental shelf waters during May, June, and September from Newport, OR to Cape Flattery, WA. Researchers would assess ocean condition, and growth and relative abundance of juvenile salmon and their survival during their first summer at sea. The protocols for this survey would include deployment of a Nordic 264 surface trawl (with a marine mammal excluder device) with a net size of 30 x 20 m and towed at approximately 3-4 knots for 30 min at depths down to 30 m. Researchers would use a CTD profiler and Niskin bottle, bongo net, vertical plankton net, and water pump. There would be about 180 trawls per year, and the duration would be 36 DAS (roughly divided equally between May, June, and September). Sampling would occur only during the daytime.

Marine Fish Broodstock Collection, Sampling, and Tagging: This survey would be conducted annually at variable frequencies on the Washington coast. The purpose of the survey would be to collect fish for broodstock for aquaculture development. The researchers would deploy commercial bottom trawls with various net sizes towed at 1.5-3.5 knots for up to 4 hours at depths of 50-1000 m. The survey deploys would be approximately 10 trawls per year. Researchers would also deploy a pelagic longline with a 3 hour soak time. Length of the mainline would be 750-1000 fathoms with 500 circle hooks per set baited with squid. Approximately 30 sets would occur each year. Additionally, researchers would use hook and line gear deployed by rod and reel. Eight anglers with eight lines in the water at a time would fish for approximately 6 hours per day for a total of 90 hours per year. The survey duration would be 10 DAS and sampling would occur only during the daytime.

Northern Juvenile Rockfish Survey: This survey would be conducted annually in May and June from Cape Mendocino, CA to Cape Flattery, WA. Researchers would measure the spatial abundance of juvenile fishes (focusing on rockfish species) in coastal marine waters of the northern California Current ecosystem as an index of recruitment potential. The researchers would use a commercial modified Cobb trawl with a headrope of 26 m and an opening of 12 m height x 12 m width (144 m2), with a 9.5 mm codend. The top of the headrope would be fished at about 30 m depth and is towed at 2.7 knots for 15 minutes. The survey would be deployed about 100 trawls per year. Researchers may also use a CTD profiler, Bongo and Tucker plankton nets, and a Simrad EK60 Multi-frequency echosounder (38, 70, 120, and 200 kHz; 228 dB/1μPa). The survey duration would be 15-30 DAS and all tows would be conducted at night.

Studies Using Other Gears

Coastwide Groundfish Hook and Line Survey in Untrawlable Habitat: This study would be conducted annually in May through October from the US/Mexico border to the US/Canada border. This would be an expansion of research previously conducted only along the Southern California coast. The purpose is to assess abundance of structure-associated rockfishes in untrawlable areas of along the US West Coast. Survey sites would be the same every year unless a site is unavailable due to weather or sea condition. Researchers would use three or four chartered sportfishing vessels and hook-and-line gear would be deployed from rod and reels fished at 15-250 m depth for 5 minutes per set. Other gear they would use may include a camera sled, CTD profiler, and a Furuno echosounder (50 and 200 kHz; 212 dB/1μPa). There would be 1000 sites with up to 75,000 hooks total per year (6,250 hook-hours/year). The duration would be approximately 250 DAS annually and fishing would occur in the daytime only.

Near Coastal Ocean Purse Seining: This study would be conducted monthly between May and September nearshore near the mouth of the Columbia River, OR. The purpose is to study salmon habitat use in nearshore areas of the ocean near the Columbia River. Researchers would use a chartered commercial fishing vessel with purse seines that measure 750 ft. x 60 ft. or 1000 ft. x 40 ft. with mesh size: 0.625" (net body); 1.3" (tow end); 0.45" (bunt). The set duration would generally be less than 1 hour, with about 75 sets/year completed in 12 DAS. Sets would be made in the daytime only.

Newport Line Plankton Survey: This survey would occur biweekly along the Newport Hydrographic Line (NH-Line), a long-term oceanographic sampling line located just north of Newport, Oregon. Sampling would be conducted to assess oceanographic conditions and zooplankton, ichthyoplankton and krill species composition and abundance. Researchers would conduct their survey on the R/V *Elakha* chartered from Oregon State University. The gear types they would use would include Bongo nets, vertical plankton nets, CTD profiler and Niskin bottle, and multi-frequency active acoustics (38, 70, 120, and 200 kHz). About 150 samples would be collected per year and would require 26 DAS. Sampling would occur during both day and night.

Northern California Current Ecosystem Survey: This survey would occur approximately every other year as ship time is available so the season would be variable. It would occur off the coasts of Washington and Oregon out to 200 nm. Researchers would assess oceanographic conditions and plankton composition and abundance. The gear types they would use include Bongo nets, vertical plankton nets, and CTD profiler and rosette water sampler. Sampling effort would depend on ship time available and would occur on a 24-hour basis with an average of 12 DAS.

PNW Harmful Algal Bloom Survey: This survey would be conducted annually during the summer and fall along the Oregon and Washington coasts. The purpose is to measure oceanographic conditions and phytoplankton species composition and abundance with an emphasis on harmful algal species. Researchers would collect: marine toxins, chlorophyll a, micro and macro nutrients, phytoplankton species ID and enumeration, DNA analysis, and dissolved oxygen. Researchers would use a range of vessels from ocean-going research ships to small open skiffs and the gear they would use would consist of plankton nets, CTD profiler, and rosette water sampler. Researchers would take about 200 samples per cruise, and the survey duration would be a minimum of 10 DAS (ocean sampling 2 weeks to 3 months depending on available ship time). Sampling would be conducted on a 24-hour basis.

Technology Development Research: This research would be conducted during the summer and fall from Washington to California. The objective of this study is to develop alternative sampling methodologies using autonomous underwater vehicles to assess groundfish abundance and distribution using video capturing equipment. Autonomous Underwater Vehicles, one of which is called Lucille, would be used because it is not tethered and is piloted remotely. It is also several meters long. Dives can be up to 2000 ft. deep. Up to 17 dives would be made per cruise with approximately up to 20 DAS, and during the daytime only.

Video Beam Trawl Collaborative Research: This survey would be conducted annually along the continental shelf from Washington to Oregon during variable months. The purpose is to assess the seasonal and interannual distribution of young-of-the-year groundfishes and the potential impacts of hypoxia. Researchers would use a two-meter-wide video beam trawl system that would be towed along the bottom at speeds of about

1.0-1.5 knots for 10 minutes during daylight hours, with about 20-40 deployments per year, and approximately 20 DAS.

1.3.1.4 Gear used during NWFSC research

Trawl nets

A trawl net is a funnel-shaped net towed behind a boat to capture fish. The codend, or 'bag,' is the fine-meshed portion of the net most distant from the towing vessel where fish and other organisms larger than the mesh size are retained. The majority of NWFSC trawl surveys involve tow speeds from 1.5 to 3.5 knots and tow durations from 10 to 30 minutes. Active acoustic devices incorporated into the research vessel and the trawl gear monitor the position and status of the net, speed of the tow, and other variables important to the research design. At the end of the tow, the net is retrieved and the contents of the codend are emptied onto the deck or sorting table.

Some NWFSC research surveys use "pelagic" trawls, which are designed to operate either near the surface or at various depths within the water column, and other surveys use "bottom" trawls (see Table 2.2-1 *In* DPEA for survey protocol and net details). Examples of NWFSC trawl gear fished at the surface include the Nordic 264, Kodiak surface trawl, and paired surface trawls. Examples of NWFSC trawl gear fished lower in the water column include the Modified Cobb mid-water trawl and the Aleutian wing mid-water trawl. Examples of NWFSC bottom trawl nets include the modified Aberdeen trawl, Poly Nor'easter trawl, paired shrimp trawl, and beam trawls. Several NWFSC surveys use trawls with an open codend (see Table 2.3-1 *In* DPEA). These surveys have a reduced impact to marine organisms because they use equipment to detect or record target species and eliminate the need to capture organisms.

Plankton nets

NWFSC research activities include the use of several plankton sampling nets which employ very fine mesh (mesh sizes form 20 to 500 µm) to sample plankton from various parts of the water column. Plankton sampling nets usually consist of fine mesh attached to a rigid frame. The frame spreads the mouth of the net to cover a known surface area. Many plankton nets have a removable collection container at the codend where the sample is concentrated. Plankton nets may be towed through the water horizontally (e.g., using Neuston nets), vertically (e.g., using ring nets), or at an oblique angle (e.g., using bongo nets).

Epibenthic tow sled

An epibenthic tow sled is an instrument that is designed to collect organisms that live on bottom sediments. It consists of a fine mesh net attached to a rigid frame with runners to help it move along the substrate. The sled is towed along the bottom at the sediment-water interface, scooping up benthic organisms as it goes. NWFSC uses an epibenthic tow sled with a 1 meter by 1 meter opening and 1-millimeter mesh to collect epibenthic invertebrates in shallow eelgrass beds in Central Puget Sound.

Seine nets

A seine is a fishing net that generally hangs vertically in the water with its bottom edge held down by weights and its top edge buoyed by floats. NWFSC uses several types of seines including purse seines, beach seines, and pole seines. A purse seine is a large wall of netting deployed around an entire area or school of fish. Once a school of fish is located, the vessel encircles the school with the net. The cable is then pulled in, 'pursing' the net closed on the bottom, preventing fish from escaping by swimming downward. The purse seines employed by NWFSC are between 500 and 1,500 feet in length, between 30 and 90 feet in depth, and have mesh sizes ranging from 0.45 inches to 1.3 inches depending on the location in the net. Beach seines are deployed from shore to surround all fish in a nearshore area. A beach seine can be deployed by hand or with the help of a small boat. When the net is set, each side is pulled in simultaneously, herding the fish toward the beach. The beach seines used in NWFSC research are 6 to 8 feet in depth and 120 to 150 feet in length, with mesh sizes of less than 1 inch. A pole seine is a rectangular net that has a pole on either end to keep the net rigid and act as a handle for pulling the net in. The net is pulled along the bottom by hand as two or more people hold the poles and walk through the water. Fish and other organisms are captured by walking the net towards shore or tilting the poles backwards and lifting the net out of the water. The pole seine used by NWFSC is 40 feet long, 6 feet tall, and has mesh smaller than 1 inch.

Tangle nets

Tangle nets are vertical panels of nylon netting and are normally set in a straight line. The top of the net is buoyed with floats and the bottom of the net is weighted to maintain the net's vertical position. Tangle nets are designed for non-lethal capture of fish. The smaller mesh of a tangle net prevents fish from entering the net beyond the operculum (gill cover); instead, fish are caught by the nose or jaw. This allows fish to continue respiring and reduces their risk of injury. NWFSC uses a 600- by 40-foot tangle net with 4.25-inch mesh to catch adult salmon in the Columbia River Estuary.

Fish traps and pots

Fishing pots and traps are structures that permit fish and other organisms to enter the enclosure but make it difficult for them to escape, allowing commercial fishers and researchers to capture live fish and then return bycatch to the water unharmed. They also allow some control over species and sizes of fish that are caught. Fishing traps and pots used by NWFSC include fyke traps and sablefish pots. NWFSC sets fyke traps with 0.25-inch mesh for up to 6 hours in the Snohomish and Columbia river estuaries. The NWFSC traps channels that range in width from less than 3 ft. to 15 ft. The NWFSC also employs a limited number of conical sablefish pots to catch fish for broodstock. The sablefish pots used by NWFSC are 4 feet in diameter, have a soak time of 8 hours, and they are baited with squid and herring to lure fish into the pots. Modified sablefish pots are also used as predator exclusion cages for the Herring Egg Mortality Survey in Puget Sound.

Insect traps and benthic corers

As part of the Columbia River Estuary Tidal Habitats survey, NWFSC uses insect fallout traps, emergent insect cone traps, and benthic corers to sample invertebrate prey items potentially available to juvenile salmon. An insect fallout trap consists of a plastic box filled approximately halfway with soapy water. The containers used by NWFSC measure 50 by 35 by 14 centimeters and have a less than 10 percent dish soap solution. The containers are surrounded by four stakes to prevent the trap from floating away while allowing it to float vertically with the tides (Roegner et al. 2004). Emergent insect cone traps used by NWFSC look like inverted plastic funnels with a collection container attached to the top to contain the emerged insects. Each trap is anchored in the water and collects all insects that emerge in the area directly below the mouth of the funnel. A common type of benthic corer consists of a plastic cylinder that is pressed vertically into the sediment. Then the corer has been inserted far enough into the substrate, the top of the cylinder is capped and the corer along with the sediment sample can be pulled out far enough to cap the bottom of the tube. The corer used by NWFSC collects a sample with a 0.0024-m2 surface area.

Hook-and-line gear

Longline fishing is a type of hook-and-line gear in which baited hooks attached to a mainline or ‘groundline’ are deployed from a vessel. The longline gear NWFSC uses for collection of fish for broodstock consists of 500 hooks attached to a mainline approximately 750-1000 fathoms in length. Hooks are attached to the longline by thinner lines called a ‘gangions’. For NWFSC broodstock collection, the gangions are less than one foot in length and are attached to the mainline at intervals of about 10 feet. Longline research gear can be deployed either suspended in the water column with floats (pelagic gear) or anchored to the bottom with the hooks either resting on the bottom or floating just above the seafloor (demersal gear). The NWFSC uses pelagic gear in the CCRA and demersal gear in the PSRA.

Electrofishing

NWFSC researchers use both backpack electrofishing units and boat-based electrofishing to collect fish. Both types of electrofishing use a power source to create electrical currents that flow from the positive electrode (anode) through the water to the negative electrode (cathode). When stunned fish are immobilized or move toward the anode, they are quickly captured with a dip net and placed in a bucket or holding tank. The fish can then be identified, measured, and released. Electrofishing does not result in permanent harm to the fish, which recover within a few minutes.

Active Acoustic Sources

A wide range of active acoustic sources are used in NWFSC fisheries surveys for

		at
Simrad EK60 narrow beam echosounder	18, 38, 70, 120, 200 kHz	
Simrad ME70 multibeam echosounder	70-120 kHz	
RDI ADCP Ocean Surveyor	75 kHz	2
Simrad ITI trawl monitoring system	27-33 kHz	
Simrad FS70 trawl sonar	330 kHz	
Simrad SX90 omni-directional multibeam sonar	70-120 kHz	

gather information about their schooling behavior, migration patterns, and avoidance reactions to the survey vessel. The use of multiple frequencies allows coverage of a broad range of marine acoustic survey activity, ranging from studies of small plankton to large fish schools in a variety of environments from shallow coastal waters to deep ocean basins. Simultaneous use of several discrete echosounder frequencies facilitates accurate estimates of the size of individual fish, and can be used for species identification based on differences in frequency-dependent acoustic backscattering between species. The NWFSC uses devices that transmit and receive at four frequencies ranging from 30 to 200 kHz.

ADCP: An Acoustic Doppler Current Profiler (ADCP) is a type of sonar used for measuring water current velocities simultaneously at a range of depths. An ADCP instrument can be mounted to a mooring or to the bottom of a boat. The ADCP works by transmitting "pings" of sound at a constant frequency into the water. As the sound waves travel, they ricochet off particles suspended in the moving water, and reflect back to the instrument (WHOI 2011). Sound waves bounced back from a particle moving away from the profiler have a slightly lowered frequency when they return and particles moving toward the instrument send back higher frequency waves. The difference in frequency between the waves the profiler sends out and the waves it receives is called the Doppler shift. The instrument uses this shift to calculate how fast the particle and the water around it are moving. Sound waves that hit particles far from the profiler take longer to come back than waves that strike close by. By measuring the time it takes for the waves to return to the sensor, and the Doppler shift, the profiler can measure current speed at many different depths with each series of pings (WHOI 2011).

Acoustic telemetry

Acoustic telemetry for fisheries research employs acoustic tags which are small, sound-emitting devices allowing the detection of fish or aquatic invertebrates. An acoustic tag, or transmitter, is an electronic device usually implanted or externally attached to an aquatic organism. A tag transmits short ultrasonic signals (typically 69 kHz) either at regular intervals or as a series of several pings that contain a digital identifier code (which allows researchers to identify individual fish) and sometimes physical data (e.g., temperature). An acoustic receiver detects and decodes transmissions from acoustic tags. NWFSC uses Vemco VR2 receivers moored in fixed locations to detect the presence or absence of coded tags. For the Effects of Dredging on Crab Recruitment survey, NWFSC uses V9-2H transmitters to track Dungeness crab movements. These tags have a battery life of 100 to 280 days.

PIT tags and antennas

The passive integrated transponder (PIT) is a type of radio frequency identification used extensively in fisheries research. Generally, PIT tags are cylindrical in shape, about 8-32 mm long, and 1-4 mm in diameter and can be inserted in fish or other organisms via large-gauge hypodermic needles. To activate the tag, a low-frequency radio signal is emitted by a scanning device that generates a close-range electromagnetic field. NWFSC uses stationary PIT detection antennas in the Columbia River Estuary to detect migrating adult and juvenile salmon. NWFSC also uses a PIT detector array attached to a surface pair trawl with an open codend which is towed at a depth of 5 meters for 8 to 15 hours at a speed of 1.5 knots in the Columbia River Estuary to assess the passage of migrating juvenile salmon.

Video cameras

The NWFSC uses a CamPod, a video camera sled, video beam trawls, and a remotely operated vehicle (ROV) to collect underwater videos of benthic habitats and organisms. The CamPod is deployed vertically through the water column on a cable and is intended to view one point on the bottom. A video camera sled consists of a video camera system mounted on a metal frame with runners to allow it to move along the benthic substrate. A research vessel tows the sled along the seafloor, allowing the camera to capture video footage of the benthic environment. Video beam trawls consist of a video camera system attached to a beam trawl which is towed along the seafloor at speeds of 1 to 1.5 knots. NWFSC uses video beam trawls to assess the seasonal and interannual distribution of young of the year groundfishes as well as the potential effects of hypoxia on groundfish. NWFSC uses a video ROV to capture underwater footage of the benthic environment. The ROV is controlled and powered from a surface vessel. Electrical power is supplied through an umbilical or tether which also has fiber optics which carry video and data signals between the operator and the ROV. This enables researchers on the vessel to control the ROV’s position in the water with joysticks while they view the video feed on a monitor.

CTD profiler and rosette water sampler

A conductivity, temperature, and depth (CTD) profiler is the primary research tool for determining chemical and physical properties of seawater. A shipboard CTD is made up of a set of small probes attached to a large (1 to 2 meters in diameter) metal rosette wheel. The rosette is lowered through the water column on a cable, and CTD data are observed in real time via a conducting cable connecting the CTD to a computer on the vessel. The rosette also holds a series of sampling bottles that can be triggered to close at different depths in order to collect a suite of water samples that can be used to determine additional properties of the water over the depth of the CTD cast.

Thermosalinograph and water pump, water level and temperature loggers

Onboard the research vessel for the Juvenile Salmon Pacific Northwest Coastal Survey, NWFSC uses a continuous water pump with an SBE-45 MicroTSG thermosalinograph to measure sea surface conductivity and temperature. The pump continuously pumps seawater from a depth of 3 meters near the bow of the research vessel to the thermosalinograph which sends the temperature and conductivity data to a shipboard computer. To collect physical environmental data in riverine and estuarine habitats, NWFSC uses water level and temperature loggers. These devices are placed underwater at fixed locations where they continuously record data. NWFSC uses a 3 by 4 centimeter device called a TidbiT to measure and record water temperatures. To log water levels, NWFSC uses a Hobo U-model water level data logger. These devices record measurements at user defined intervals and generally have the memory and battery power to record thousands of measurements over several years.

1.3.1.5 Proposed Mitigation

Here we provide a summary of the mitigation measures to reduce impacts to marine mammals that are a part of the proposed action. The summary below includes brief descriptions of the measures based on gear type (for more details see section 2.2.2 *in* DPEA and in the proposed rule for the LOA; 81 FR 38516).

Trawl Survey Visual Monitoring and Operational Protocols: Specific mitigation protocols detailed below are required for all trawl operations conducted by the NWFSC using Nordic 264 surface trawl gear, midwater trawl gear (modified Cobb, Aleutian Wing, and various commercial nets), and bottom trawl gear (double-rigged shrimp, Poly Nor'easter, modified Aberdeen, beam, and various commercial nets). Separate protocols are in place for the Kodiak surface trawl and pair trawl gear.

During trawl surveys, marine mammal watches would be conducted by scanning the surrounding waters for at least ten minutes prior to the beginning of the planned set and throughout the tow and net retrieval. For all surveys, however, the actual monitoring period would be typically longer (typically extending over thirty minutes for all trawl types). Observers would immediately alert the Officer on Deck (OOD) and Chief Scientist (CS) as to their best estimate of the species and number of animals observed and any observed animal's distance, bearing, and direction of travel relative to the ship's position. If marine mammals are sighted before the gear is fully retrieved, the most appropriate response to avoid marine mammal interaction would be determined by the professional judgment of the CS, watch leader, OOD and other experienced crew as necessary. This judgment would be based on past experience operating trawl gears around marine mammals (*i.e.,* best professional judgment) and on NWFSC training (*e.g.,* regarding factors that contribute to marine mammal gear interactions and those that aid in successfully avoiding such events).

During nighttime operations, visual observation may be conducted using the naked eye and available vessel lighting but effectiveness is limited. The visual observation period would typically occur during transit leading up to arrival at the sampling station, rather than upon arrival on station. In some cases, the visual watch would continue until trawl gear is ready to be deployed.

The primary purpose of conducting pre-trawl visual monitoring would be to implement the move-on rule. If marine mammals are sighted within 500 m (or as far as may be observed if less than 500 m) of the vessel and are considered at risk of interacting with the vessel or research gear, or appear to be approaching the vessel and are considered at risk of interaction, NWFSC may elect to either remain onsite to see if the animals move off or may move on to another sampling location. When remaining onsite, the set would be delayed (typically for at least ten minutes) and, if the animals depart or appear to no longer be at risk of interacting with the vessel or gear, a further ten minute observation period would be conducted. If no further observations are made or the animals still do not appear to be at risk of interaction, then the set may be made. If the vessel is moved to a different section of the sampling area, move-on rule mitigation protocols would begin anew. If, after moving on, marine mammals remain at risk of interaction, the CS or watch leader may decide to move again or to skip the station. Marine mammals that are sighted further than 500 m from the vessel would be monitored to determine their position and movement in relation to the vessel. If they appear to be closing on the vessel, the move-on rule protocols may be implemented even if they are initially further than 500 m from the vessel.

For surface trawl surveys (*i.e.*, those surveys deploying the Nordic 264 net), which have historically presented the greatest risk of marine mammal interaction, dedicated crew would be assigned to marine mammal monitoring duty (*i.e.*, have no other tasks). Within several minutes of arriving on station and finishing their sampling duties, two additional observers would be assigned to monitor for marine mammals and, for the remainder of the tow, there would be a minimum of three members of the scientific party watching for marine mammals. Depending on the situation (*e.g.*, numbers of marine mammals seen during the station approach or expected at that particular place and season), additional crew may be assigned to stand watch as necessary to provide full monitoring coverage around the vessel. For midwater and bottom trawl surveys, the pre-set watch period is conducted by the OOD and bridge crew and typically occurs during transit prior to arrival at the sampling station, but may also include time on station if other types of gear or equipment (*e.g.*, bongo nets) are deployed before the trawl. For these trawls, risk of interaction during the tow would be lower and monitoring effort would be reduced to the bridge crew until trawl retrieval.

Standard survey protocols that are expected to lessen the likelihood of marine mammal interactions include standardized tow durations and distances. Standard tow durations of not more than thirty minutes at the target depth would typically be implemented, excluding deployment and retrieval time (which may require an additional thirty minutes, depending on target depth), to reduce the likelihood of attracting and incidentally taking marine mammals. Short tow durations decrease the opportunity for marine mammals to find the vessel and investigate. Trawl tow distances would be less than 3 nautical miles—typically 1–2 nautical miles, depending on the specific survey and trawl speed—which is expected to reduce the likelihood of attracting and incidentally taking marine mammals. In addition, care would be taken when emptying the trawl to avoid damage to marine mammals that may be caught in the gear but are not visible upon retrieval. The gear would be emptied as quickly as possible after retrieval in order to determine whether or not marine mammals are present. The vessel's crew would clean the trawl nets prior to deployment to remove prey items that might attract marine mammals. Catch volumes are typically small with every attempt made to collect all organisms caught in the trawl.

Marine mammal excluder device— Excluder devices are specialized modifications, typically used in trawl nets, which are designed to reduce bycatch by allowing non-target taxa to escape the net. These devices generally consist of a grid of bars fitted into the net that allow target species to pass through the bars into the codend while larger, unwanted taxa (*e.g.*, turtles, sharks, and mammals) strike the bars and are ejected through an opening in the net. For full details of design and testing of the marine mammal excluder device (MMED) designed by the Southwest Fisheries Science Center (SWFSC) for the Nordic 264 net, please see Dotson *et al.* (2010). Although MMEDs have not been proven to be fully effective at preventing marine mammal capture in trawl nets (*e.g.*, Chilvers 2008), the use of MMEDs may reduce the likelihood of a given marine mammal interaction with trawl gear resulting in mortality. Very few marine mammal interactions with NWFSC pelagic trawl gear have involved nets other than the Nordic 264 (one of 37 total incidents since 1999). Therefore, MMED use is not proposed for nets other than the Nordic 264. Additional research will be necessary to calibrate catch levels in tows with the excluder device compared to past tows that did not contain the excluder (*i.e.*, to align the new catchability rates with historical data sets). During these configuration and calibration experiments some nets would be fished without the MMED in order to provide controls for catchability. Once the NWFSC completes these experiments the MMED would be used in all future trawls with the Nordic 264.

Acoustic deterrent devices—Acoustic deterrent devices (pingers) are underwater sound-emitting devices that have been shown to decrease the probability of interactions with certain species of marine mammals when fishing gear is fitted with the devices. Pingers would be deployed during all surface trawl operations (*i.e.*, using the Nordic 264 net), with two pairs of pingers installed near the net opening. The vessel's crew would ensure that pingers are operational prior to deployment. Pinger brands typically used by NWFSC include the Aquatec Subsea Limited model AQUAmark and Fumunda Marine models F10 and F70, with the following attributes: (1) Operational depth of 10–200 m; (2) tones range from 200–400 ms in duration, repeated every five to six seconds; (3) variable frequency of 10–160 kHz; and (4) maximum source level of 145 dB rms re 1 μPa.

Kodiak surface trawl and pair trawl gear—The Kodiak surface trawl, proposed for use only in Puget Sound, has only limited potential for marine mammal interaction. This gear type is a small net that would be towed at slow speeds (about 2 knots) as close to shore as the net can be fished, and these characteristics mean that marine mammals would likely be able to avoid the net or swim out of it if necessary. However, rules for cetaceans would be similar as for other net types (*i.e.*, delay and/or move-on if cetaceans observed within approximately 500 m or clearly approaching from greater distance). If killer whales are observed at any distance, the net would not be deployed and the move-on rule invoked.

The pair trawl would be used only in the Columbia River, and is fished with an open codend. Although unlikely, there is some potential for pinnipeds to become entangled in the net material. NWFSC's practice, which would be allowed under section 109(h) of the MMPA, is to deter pinnipeds from encountering the net using pyrotechnic devices and other measures. Therefore, separate mitigation is not warranted, and we do not discuss NWFSC deterrence of pinnipeds associated with pair trawl surveys further in this opinion. Please see the NWFSC's draft Programmatic Environmental Assessment for further information about this practice.

Longline and Other Hook and Line Survey Visual Monitoring and Operational Protocols- Visual monitoring requirements for all longline surveys would be similar to the general protocols described above for trawl surveys. Other types of hook and line surveys (*e.g.*, rod and reel) generally would use the same protocols as longline surveys. In Puget Sound, the move-on rule would not be required for pinnipeds because they are commonly abundant on shore nearby hook and line sampling locations. Use of the move-on rule in these circumstances would represent an impracticable impact on NWFSC survey operations, and no marine mammals have ever been captured in NWFSC hook and line surveys. However, the NWFSC would implement the move-on rule for hook and line surveys in Puget Sound for any cetaceans that are within 500 m and may be at risk of interaction with the survey operation. If killer whales are observed at any distance, longline and other hook and line fishing would not occur. As for trawl surveys, some standard survey protocols are expected to minimize the potential for marine mammal interactions. Soak times would be typically short relative to commercial fishing operations, measured from the time the last hook is in the water to when the first hook is brought out of the water. NWFSC longline protocols specifically prohibit chumming (releasing additional bait to attract target species to the gear) and spent bait and offal would be retained on the vessel until all gear has been retrieved. Some hook and line surveys would use barbless hooks, which are less likely to badly injure a hooked animal.

Seine Survey Visual Monitoring and Operational Protocols- Visual monitoring and operational protocols for seine surveys would be similar to those described previously for trawl surveys, with a focus on visual observation in the survey area and avoidance of marine mammals that may be at risk of interaction with survey vessels or gear. For purse seine operations, visual monitoring would be focused on avoidance of cetaceans and aggregations of pinnipeds. Individual or small numbers of pinnipeds may be attracted to purse seine operations, especially in Puget Sound, and are frequently observed to enter operational purse seines to depredate the catch and exit the net unharmed. Use of the move on rule in these circumstances would represent an impracticable impact on NWFSC survey operations, and no marine mammals have ever been captured in NWFSC seine surveys.

If pinnipeds are in the immediate vicinity of a purse seine survey, the set may be delayed until animals move away or the move-on rule is determined to be appropriate, but the net would not be opened if already deployed and pinnipeds enter it. However, delay would not be invoked if fewer than five pinnipeds are present and they do not appear to obviously be at risk. If any dolphins or porpoises are observed within approximately 500 m of the purse seine survey location, the set would be delayed. If any dolphins or porpoises are observed in the net, the net would be immediately opened to free the animals. If killer whales or other large whales are observed at any distance the net would not be set, and the move-on rule would be invoked. Beach seines would be typically set nearshore by small boat crews, who would visually survey the area prior to the set.

No set would be made within 200 m of any hauled pinnipeds. Otherwise, marine mammals are unlikely to be at risk of interaction with NWFSC beach seine operations, as the nets are relatively small and would be deployed and retrieved slowly. If a marine mammal is observed attempting to interact with the beach seine gear, the gear would immediately be lifted and removed from the water.

Tangle net protocols—Tangle nets would be used only in the Columbia River. NWFSC would attempt to avoid pinnipeds by rotating sampling locations on a daily basis and by avoiding fishing near haulout areas. However, as was described for NWFSC use of pair trawl gear in the LCRRA, NWFSC would also deter pinnipeds from interacting with tangle net gear as necessary using pyrotechnic devices and visual presence, a practice allowed under section 109(h) of the MMPA. Therefore, we do not discuss NWFSC deterrence of pinnipeds associated with tangle net surveys further in this document.

General Measures— Vessel speed during active sampling would rarely exceed 5 knots, with typical speeds likely being 2–4 knots. Transit speeds would likely vary from 6–14 knots but average 10 knots. These low vessel speeds minimize the potential for ship strike. At any time during a survey or in transit, if a crew member standing watch or dedicated marine mammal observer sights marine mammals that may intersect with the vessel course that individual would immediately communicate the presence of marine mammals to the bridge for appropriate course alteration or speed reduction, as possible, to avoid incidental collisions.

1.3.2 Issuance of a MMPA LOA

Under the MMPA, section 101(a)(5), the Secretary of Commerce shall allow, upon request, for the incidental taking of small numbers of marine mammals, provided such take is found to have a negligible impact on the affected species or stocks affected.

The Permits and Conservation Division (PRl) of OPR proposed to issue a Letter of Authorization (LOA) to the NWFSC, pursuant to section 101(a)(5)(A) of the MMPA (16 U.S.C. 1361 *et seq.)*, for taking marine mammals incidental to fisheries research in the PSRA, LCRRA, and the CCRA (81 FR 38516). The LOA would be effective for a period of five years from the date of issuance. The proposed regulations specify the prescribed mitigation measures (described above), monitoring requirements, and necessary reporting, as well as proposed authorized levels of taking.

The proposed LOA covers all of the research activities (general research activities, and mitigation measures) that are described above in section 1.3.1. The LOA would be effective for a period of five years from the date of issuance. The number of potential Level A (injurious) interactions with marine mammals resulting from incidental capture or entanglement in trawl or longline survey gear, or exposure to active acoustics from NWFSC vessels, has been estimated by the NWFSC (Appendix C *in* DPEA and/or 81 FR 38516 provides a description of estimation process; also summarized in section 2.12 below). The NWFSC does not expect any ESA-listed marine mammals to be injured by their research activities, and therefore did not request Level A MMPA take[1] of ESA-listed marine mammals. The proposed LOA does anticipate that several ESA-listed species would potentially be exposed to sound levels produced by active acoustics from NWFSC vessels that may equate to Level B harassment[1] under the MMPA. However, these MMPA Level B harassment takes are not considered ESA takes and the impacts to sperm whales and Guadalupe fur seals are addressed in the Not Likely to Adversely Affect (NLAA) determinations (section 2.12). Table 3 below describes the extent of Level B harassment for ESA-listed marine mammals in the proposed LOA (see DPEA Appendix C and/or 81 FR 38516 for complete description of the MMPA acoustic harassment estimation process; summarized in section 2.12). All take of ESA-listed marine mammals proposed for authorization is anticipated to occur in the CCRA.

Table 3. Total number of incidents[1] of acoustic harassment under the MMPA proposed for authorization in the NWFSC LOA for ESA-listed species.

Species	Proposed Take Authorization (Level B Harassment)
Sperm whale	6
Guadalupe fur seal	22

As part of the proposed LOA, the NWFSC is required to implement mitigation and monitoring measures to minimize impacts to marine mammals. The NWFSC has adopted these measures as part of their proposed action, and they are described in conjunction with all measures for protected species in section 1.3.1.5. Reporting requirements of the LOA are also reflected, as necessary, in the Terms and Conditions (section 2.9.4) of this opinion.

1.3.3 Issuance of the ESA Section 10 Research Permit

In 2015, the NWFSC applied for the renewal of permit 1586-4R, which would directly research ESA-listed salmonids and would, therefore, be renewed as a Section 10(a)(1)(A) permit.

This permit would authorize the NWFSC to annually take juvenile PS steelhead, HCS chum salmon, and PS/GB bocaccio and juvenile, sub-adult, and adult PS Chinook salmon. The NWFSC research may also result in take of juvenile PS/GB canary rockfish, juvenile PS/GB yelloweye rockfish, and adult eulachon—species for which there are currently no ESA take prohibitions. The purpose of the NWFSC study is to characterize how wild, juvenile PS Chinook salmon and various forage fish species use nearshore

[1] The term "take," as defined in Section 3 (16 U.S. Code [U.S.C.] 1362) of the MMPA, means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture or kill any marine mammal." "Harassment" was further defined in the 1994 amendments to the MMPA, which provided two levels of "harassment," "Level A" (non-serious injury) and "Level B" (disturbance). Level A harassment under the MMPA has the potential to injure a marine mammal or marine mammal stock in the wild. Level B harassment under the MMPA is defined as "any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."

habitats in the oceanographic basins of the Puget Sound, the Straits of Juan de Fuca, and the San Juan Islands (Washington). The project would benefit the listed species by helping managers develop protection and restoration strategies and monitor the effects of recovery actions by determining if nearshore populations are increasing or decreasing. It would also help mangers establish baseline abundance/composition metrics and genetic structures for nearshore populations throughout Puget Sound. The NWFSC proposes to capture fish using beach seines, Nordic surface trawls, lampara nets, purse seines, and hook-and-line angling. Captured fish would be transferred to live-wells, mesh pens, or aerated buckets. They would then be identified to species, counted, measured to length, weighed, checked for tags and fin clips, fin clipped for genetic analysis, and released. The NWFSC researchers would intentionally kill a subset of the captured PS Chinook salmon: For juveniles, they would kill hatchery and natural-origin fish; for subadults, they would only kill listed hatchery fish that have had their adipose fins clipped. The purpose of this activity is to obtain coded-wire tags for hatchery release information, otoliths for saltwater entry information, scales for genetic analysis, tissue samples for chemistry analysis, and stomach contents for diet analysis. These analyses would help managers determine contaminant exposure levels in the listed fish and determine how that exposure relates to nearby land use. The work would also provide information on population distribution and timing. Any fish that are accidentally killed as an unintended result of the overall work would be used to replace any proposed intentional sacrifice.

1.3.4 Issuance of Take for Research Activities Incidentally Taking ESA-listed Marine Fish

Below is a brief summary of the four proposed projects that would incidentally affect ESA-listed marine fish that we propose to authorize through ITSs.

1.3.4.1 Groundfish Bottom Trawl Survey

The Groundfish Bottom Trawl Survey, formerly conducted under a research permit, would annually take sub-adult and adult CC, CVS, LCR, PS SacR winter-run, SnkR fall-run, SnkR sum/spr-run, UCR spring-run, and UWR spring-run Chinook salmon; CR and HCS chum salmon; CCC, LCR, OC, and SONCC coho salmon; OL and SR sockeye salmon; CCC, CV, LCR, MCR, NC, PS, SCCC, SR, UCR, and UWR steelhead; and green sturgeon. The NWFSC research may also result in take of eulachon, for which there are currently no ESA take prohibitions. All green sturgeon and eulachon take would be adult take, but the salmonid take could be either adult or sub-adult. The surveys would range from the US-Canada border to the US-Mexico border, take place at depths of 50m to 1,300m, and run from May through October each year. The purpose of the survey is to generate fisheries-independent indices of stock abundance to support stock assessment models for commercially and recreationally harvested groundfish species. The survey collects data on 90+ species contained in the Pacific Coast Groundfish Fisheries Management Plan (FMP) and is intended to fulfill the mandates included in the Magnuson-Stevens Sustainable Fisheries Act. The objectives of the survey are to: (1) quantify the distribution and relative abundance of commercially valuable groundfish species; (2) obtain biological data from species of interest including length, weight, gender, and maturity; (3) determine age structures for FMP species; (4) record net mensuration and trawl performance data; and (5) collect oceanographic data. The NWFSC proposes to capture fish using bottom trawls. An ‘‘Aberdeen’’ style net with a small-mesh (1 1⁄2″ stretched measure or less) liner in the cod end would be towed for about 15 minutes per tow. Acoustic instruments attached to the nets would record various aspects of their mechanical performance. Catches would be sorted by species or other appropriate taxon and listed species processed first and released as soon as possible. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the activities.

1.3.4.2 Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey

The Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey, formerly conducted under a research permit, would take sub-adult and adult CC, CVS, LCR, PS, SacR winter-run, SnkR fall-run, SnkR sum/spr-run, and UWR spring-run Chinook salmon; CR and HCS chum salmon; CCC, LCR, OC, SONCC coho salmon; and OL and SR sockeye salmon. The NWFSC research may also result in take of adult eulachon, for which there are currently no ESA take prohibitions. The surveys would range from the US-Mexico border to the Dixon Entrance, Alaska/British Columbia—to depths of at least 1,500 m or 35 nmi offshore, whichever is greater between June and September every year. Scientists from the NWFSC and Department of Fisheries and Oceans Canada (DFO) would jointly conduct biennial integrated acoustic and trawl (IAT) surveys on Pacific hake (*Merluccius productus*). The purpose of the IAT survey is to assess the distribution, abundance, and biology of Pacific hake. Age-specific estimates of total population abundance derived from the survey are key data for the joint U.S.-Canada Pacific hake stock assessments; they ultimately act as the foundation for advice on U.S., tribal, and international harvest levels. The NWFSC proposes to capture fish using an Aleutian wing 24/20 mid-water trawl. Surveys would be conducted in a series of transects generally oriented east-west and spaced at 10 nautical-mile intervals. Trawl samples would be used to classify acoustic backscatter readouts by species and size. Catches would be sorted by species or other appropriate taxon and listed species would be processed and released before any other species. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the proposed activities.

1.3.4.3 Investigations of Hake Ecology, Survey Methods, and the California Current Ecosystem

The Investigations of Hake Ecology, Survey Methods, and the California Current Ecosystem, formerly conducted under a research permit, would take sub-adult and adult CC, CVS, LCR, PS, SacR winter-run, SnkR fall-run, SnkR sum/spr-run, UCR spring-run, and UWR spring-run Chinook salmon; CR and HCS chum salmon; CCC, LCR, OC, and SONCC coho salmon; and OL and SR sockeye salmon. The NWFSC research may also result in take of adult eulachon—for which there are currently no ESA take prohibitions. The surveys would range primarily from the Strait of Juan de Fuca Washington down to the central Oregon coast, though additional surveys may be undertaken that would range from the U.S./Mexico border up to the Dixon Entrance, Alaska/British Columbia.

Surveys would be conducted year-round. The purpose of these surveys is to investigate research topics suggested by hake stock assessment scientists, including: inter-vessel calibrations between multiple vessels to compare acoustic estimates of hake; investigate hake target strength, autonomous underwater vehicle use, and multi-frequency and broadband acoustics; sampling a set of fixed areas repeatedly to investigate hake school structure and ecosystem components over time; testing a stereo camera system in a midwater trawl for quantifying fish species and length; confirming that ground-truth tows adequately characterize schools of hake by conducting tows at different depths and locations; exploring the offshore extent of hake sign; using pocket nets attached to a midwater trawl to investigate catches of smaller organisms and verify the identity of acoustic targets suspected to be mesopelagic fish and squid; collecting a variety of other acoustic, optical, biological, and oceanographic samples relevant to the dynamics of the California Current Ecosystem, especially how they relate to hake and their habitat and prey; quantifying trawl metrics for the midwater trawl as improvements are made to its construction and associated equipment; investigating techniques for near-field calibration techniques; and if Humboldt squid (*Dosidicus gigas*) appear in the research area, conducting research on acoustic differentiation between them and hake. The cruises would test automatic underwater vehicles, acoustic systems, plankton sampling, and limited mid-water trawling. The NWFSC proposes to capture fish using an Aleutian wing 24/20 mid-water trawl, a Methot trawl equipped with a fine-mesh net, and a Poly Nor'eastern high-opening bottom trawl equipped with roller gear. Catches would be sorted by species or other appropriate taxon and listed species would be processed and released before any other species. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the proposed capture method.

1.3.4.4 Bycatch Reduction Research in West Coast Trawl Fisheries

The Bycatch Reduction Research in West Coast Trawl Fisheries, formerly conducted under a research permit, take CC, CVS, LCR, PS, SacR winter-run, SnkR fall-run, SnkR sum/spr-run, UCR spring-run, and UWR spring-run Chinook salmon; CR and HCS chum salmon; CCC, LCR, OC, and SONCC coho salmon; OL sockeye salmon; CCC, CV, LCR, MCR, NC, PS, SCCC, SR, UCR, and UWR steelhead; and green sturgeon. The NWFSC research may also result in take of eulachon—a species for which there are currently no ESA take prohibitions. All take for take for green sturgeon and eulachon would be adult take, while salmon and steelhead take may be either sub-adult or adult take. The surveys would range from northern California to Washington over the continental shelf in waters shallower than 1,000m. The purpose of these surveys are to test and evaluate bycatch reduction devices (BRDs) and trawl gear modifications (i.e. headrope/footrope modifications) that are designed to reduce: (1) Chinook salmon and rockfish bycatch in the U.S. Pacific hake fishery; (2) Pacific halibut, sablefish, and rockfish bycatch in the groundfish bottom trawl fishery; (3) and juvenile and unmarketable-sized fish discards in mid-water and bottom trawl groundfish fisheries. The NWFSC proposes to capture fish using mid-water and bottom trawl nets. Catches would be sorted by species or other appropriate taxon and listed species would be processed and released before any other species. The researchers do not intend to kill any listed fish, but some may die as an inadvertent result of the proposed capture method.

Interrelated or Interdependent Actions

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). There are no interdependent or interrelated activities associated with the proposed action.

2. ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

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

The NMFS NWFSC determined the proposed action is not likely to adversely affect the blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), humpback whale (*Megaptera novaeangliae*), North Pacific right whale (*Eubalaena japonica*), sei whale (*B. borealis*), Southern Resident killer whale (*Orcinus orca*), sperm whale (*Physeter macrocephalus*), Western North Pacific gray whale (*Eschrichtius robustus*), Guadalupe fur seal (*Arctocephalus townsendi*), hawksbill sea turtle (*Eretmochelys imbricate*), black abalone (*Haliotis cracherodii*), white abalone (*Haliotis crachersorenseni*), or Southern California steelhead (*Oncorhynchus mykiss*). The proposed action is also not likely to adversely affect designated critical habitat for Southern Resident kiler whales, leatherback sea turtles, green sturgeon, eulachon, rockfish, salmonids, and black abalone. Our concurrence is documented in the "Not Likely to Adversely Affect" Determinations section 2.12.

2.1 Analytical Approach

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

This biological opinion relies on the definition of "destruction or adverse modification," which “means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features” (81 FR 7214).

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

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

- Identify the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on both species and their habitat using an “exposure-response-risk” approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a RPA 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.

One factor affecting the range wide status of ESA-listed species and aquatic habitat at large is climate change. Climate change has received considerable attention in recent years, with growing concerns about global warming and the recognition of natural climatic oscillations on varying time scales, such as long term shifts like the Pacific Decadal Oscillation or short term shifts, like El Niño or La Niña. Evidence suggests that the productivity in the North Pacific (Mackas et al. 1989; Quinn and Niebauer 1995) and other oceans could be affected by changes in the environment. Important ecological factors such as migration, feeding, and breeding locations may be influenced by factors such as ocean currents and water temperature. Any changes in these factors could render currently used habitat areas unsuitable and new use of previously unutilized or previously not existing habitats may be a necessity for displaced individuals. Changes to climate and oceanographic processes may also lead to decreased productivity in different patterns of prey distribution and availability. Such changes could affect sea individuals that are dependent on those affected prey.

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

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

Based upon available information, it is likely that sea turtles may also be affected by climate change. Sea turtle species are likely to be affected by rising temperatures that may affect nesting success and skew sex ratios, as some rookeries are already showing a strong female bias as warmer temperatures in the next chamber leads to more female hatchlings (Chan and Liew 1995; Kaska et al. 2006). Rising sea surface temperatures and sea levels may affect available nesting beach areas as well as ocean productivity. Based on climate change modeling efforts in the eastern tropical Pacific Ocean, for example, Saba et al., (2012) predicted that the Playa Grande (Costa Rica) sea turtle nesting populations would decline 7% per decade over the next 100 years. Changes in beach conditions were the primary driver of the decline, with lower hatchling success and emergence rates (estimated by Tomillo et al., (2012) to be a 50-60% decline over 100 years in that area. Sea turtles are known to travel within specific isotherms and these could be affected by climate change and cause changes in their bioenergetics, thermoregulation, and foraging success during the oceanic phase of their migration and prey availability (Robinson et al. 2008; Saba et al. 2012).

<u>2.2.1 Salmon</u>

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. When a 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: the status review prepared by the NWFSC (Waples et al. 1991); the Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California (Busby et al.1996); the Status Review Update for West Coast Steelhead from Washington, Idaho, Oregon, and California (NMFS 1997); the Preliminary Conclusions Regarding the Updated Status of Listed ESUs of West Coast Salmon and Steelhead (NMFS 2003); the Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead (Good et al. 2005); and most importantly for this opinion, the Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Northwest (Ford 2011). These documents (and other relevant information) may be found at www.nwr.NOAA.gov; the discussions they contain are summarized 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.

2.2.1.1 Puget Sound Chinook

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

Table 4. Expected 2016 Puget Sound Chinook salmon hatchery releases (WDFW 2015).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Deschutes	Tumwater Falls	2015	Fall	3,800,000	-
Dungeness-Elwha	Dungeness	2015	Spring	-	50,000
	Elwha	2014	Fall	-	200,000
		2015	Fall	250,000	2,250,000
	Gray Wolf River	2014	Spring	-	50,000
	Hurd Creek	2014	Spring	-	50,000
	Upper Dungeness Pond	2015	Spring	-	50,000
Duwamish	Icy Creek	2014	Fall	300,000	-
	Soos Creek	2015	Fall	3,000,000	200,000
Hood Canal	Hood Canal Schools	2015	Fall	-	500
	Hoodsport	2014	Fall	120,000	-
		2015	Fall	2,800,000	-
Kitsap	Bernie Gobin	2014	Fall	-	200,000
			Spring	40,000	-
		2015	Summer	2,300,000	100,000
	Chambers Creek	2015	Fall	400,000	-
	Garrison	2015	Fall	450,000	-
	George Adams	2015	Fall	3,575,000	225,000
	Gorst Creek	2015	Fall	1,580,000	-
	Hupp Springs	2014	Fall	120,000	-
		2015	Spring	-	400,000
	Lummi Sea Ponds	2015	Fall	500,000	-
	Minter Creek	2015	Fall	1,400,000	-
Lake Washington	Friends of ISH	2015	Fall	-	1,425
	Issaquah	2015	Fall	2,000,000	-
Nisqually	Clear Creek	2015	Fall	3,300,000	200,000
	Kalama Creek	2015	Fall	600,000	-
Nooksack	Kendall Creek	2015	Spring	800,000	-
	Skookum Creek	2015	Spring	-	1,000,000
Puyallup	Clarks Creek	2015	Fall	400,000	-
	Voights Creek	2015	Fall	1,600,000	-
	White River	2015	Spring	-	395,000
San Juan Islands	Friday Harbor ES	2015	Fall	-	225
	Glenwood Springs	2015	Fall	550,000	-
Skykomish	Wallace River	2015	Summer	1,300,000	200,000

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Stillaguamish	Brenner	2015	Fall	-	45,000
	Whitehorse Pond	2015	Summer	220,000	-
Strait of Georgia	Samish	2015	Fall	3,800,000	200,000
Upper Skagit	Marblemount	2015	Spring	387,500	200,000
		2015	Summer	200,000	-
Total Annual Release Number				**35,792,500**	**6,017,150**

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

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

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

The PS Chinook salmon ESU contains 31 “historically independent populations,” of which nine are believed to be extinct (Ruckelshaus et al. 2006). The extinct populations were mostly composed of early-returning fish from the mid- and southern parts of the Puget Sound and in the Hood Canal/Strait of Juan de Fuca (Table 5).

Table 5. Historical populations of Chinook salmon in the Puget Sound (Ruckelshaus et al. 2006; NWFSC 2015).

Population	MPG	Status	Run Timing
NF Nooksack River	Strait of Georgia	Extant	Early
SF Nooksack River	Strait of Georgia	Extant	Early
Nooksack River late	-	*Extinct*	Late
Lower Skagit River	Whidbey Basin	Extant	Late

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

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

Chinook salmon population diversity can range in scale from genetic differences within and among populations to complex life-history traits. The loss of early-run populations is a leading factor affecting ESU diversity. As stated above, eight of the nine extinct populations were composed of early-returning fish (Table 5). Run-timing is a life-history trait considered to be an adaptation to variable environmental conditions. The early-run populations were an evolutionary legacy of the ESU, and the loss of these populations reduces the overall ESU's diversity.

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

According to recent production estimates, Puget Sound hatcheries release over 40 million juvenile Chinook salmon each year. Most hatchery fish production is for commercial harvest and sport fishing. However, tens of thousands of these fish escape harvest each year and return to spawn in Puget Sound tributaries. From 1990 through 2014, there has been a declining trend in the proportion of natural-origin spawners across the whole ESU (NWFSC 2015). For 2010-2014, more than 70% of the spawners are hatchery fish in eight of the 22 populations (Table 6). For the five majog population groups (MPGs), only the Whidbey Basin MPG had over half of their spawners be of natural origin in the majority of the populations (NWFSC 2015).

Table 6. Five-year means of fraction wild for PS Chinook salmon by population (NWFSC 2015).

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

Lower Sauk River	0.96	0.96	0.95	0.95	0.96
Suiattle River	0.98	0.98	0.98	0.97	0.98
Cascade River	0.98	0.98	0.98	0.98	0.98
Central / South Sound MPG					
Sammamish River	0.24	0.20	0.40	0.23	0.11
Cedar River	0.74	0.70	0.63	0.82	0.82
Green River	0.44	0.32	0.63	0.44	0.43
Puyallup River	0.84	0.70	0.70	0.40	0.57
White River	0.88	0.93	0.95	0.79	0.56
Nisqually River	0.78	0.80	0.68	0.31	0.30

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

NMFS concluded in 1998 (Myers et al. 1998), 2005 (Good et al. 2005), 2011 (Ford 2011), and 2015 (NWFSC 2015) that the Puget Sound ESU was likely to become endangered in the foreseeable future. In the first status review, the biological review team (BRT) estimated the total PS Chinook salmon run size[2] in the early 1990s to be approximately 240,000 Chinook salmon, with the vast majority as hatchery-origin. Based on current estimates, 67,000 of those fish were naturally produced Chinook salmon (Unpublished data, Norma Sands, NWFSC, March 5, 2010). ESU escapement (total spawners) increased to 47,686 (2000-2004), but has since declined to 40,411(2005-2009) and to 32,451 (2010-2014; Tables 7 and 8).

Table 7. Abundance–five-year geometric means for adult (age 3+) natural origin and total spawners (natural and hatchery origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NWFSC 2015).

Population	**Geometric means**					
	1990-1994	**1995-1999**	**2000-2004**	**2005-2009**	**2010-2014**	**% Change**
Strait of Georgia MPG						
NF Nooksack River	52 (102)	97 (476)	229 (3,476)	277 (1,675)	154 (1,167)	-44 (-30)
SF Nooksack River	126 (171)	133 (217)	235 (398)	244 (388)	88 (418)	-64 (8)
Strait of Juan de Fuca MPG						
Elwha River	420 (658)	274 (735)	357 (716)	193 (597)	164 (1,152)	-15 (93)
Dungeness River	20 (117)	18 (104)	71 (527)	162 (508)	119 (447)	-27 (-6)
Hood Canal MPG						
Skokomish River	506 (994)	478 (1,232)	479 (1,556)	500 (1,216)	256 (1,627)	-49 (34)
Mid-Hood Canal	93 (119)	152 (186)	169 (217)	47 (88)	75 (314)	60 (257)
Whidbey Basin MPG						
Skykomish River	1,658 (2,325)	1,494 (3,327)	2,606 (4,842)	2,388 (3,350)	1,693 (2,320)	-29 (-31)
Snoqualmie River	873 (1,035)	739 (1,187)	2,161 (2,480)	1,311 (1,965)	885 (1,143)	-32 (-42)
NF Stillaguamish River	553 (742)	603 (946)	967 (1,225)	550 (984)	574 (976)	4 (-1)
SF Stillaguamish River	150 (150)	241 (241)	219 (219)	101 (102)	71 (87)	-30 (-15)

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

Population	Geometric means					
	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Upper Skagit River	5,389 (5,599)	6,159 (6,267)	12,039 (12,484)	9,975 (10,611)	6,924 (7,194)	-31 (-32)
Lower Skagit River	1,417 (1,473)	1,001 (1,041)	2,765 (2,857)	2,118 (2,216)	1,391 (1,446)	-34 (-35)
Upper Sauk River	394 (409)	258 (268)	413 (428)	498 (518)	836 (867)	68 (67)
Lower Sauk River	399 (414)	414 (433)	812 (853)	546 (572)	413 (432)	-24 (-24)
Suiattle River	295 (302)	373 (382)	405 (415)	254 (261)	351 (360)	38 (38)
Cascade River	185 (189)	208 (213)	364 (371)	334 (341)	338 (345)	1 (1)
Central / South Sound MPG						
Sammamish River	52 (227)	32 (160)	385 (1,040)	289 (1,281)	160 (1,679)	-45 (31)
Cedar River	367 (509)	369 (541)	405 (643)	1,043 (1,275)	881 (1,075)	-16 (-16)
Green River	2,253 (5,331)	2,149 (7,272)	4,099 (6,624)	1,334 (3,187)	897 (2,168)	-33 (-32)
Puyallup River	2,143 (2,543)	1.611 (2,340)	1,171 (1,687)	795 (2,012)	598 (1,186)	-25 (-41)
White River	565 (645)	1,307 (1,415)	3,128 (3,309)	4,170 (5,301)	1,689 (3,471)	-59 (-35)
Nisqually River	630 (806)	596 (748)	891 (1,319)	587 (1,963)	701 (2,577)	19 (31)

In their population viability criteria assessment, the Puget Sound Technical Recovery Team (PSTRT) presented viable spawning abundances for 16 of the 22 populations (PSTRT 2002). For the 2010 status review (Ford 2011), viable spawning abundances for the remaining six populations were extrapolated based on a recovered productivity equal to the average for the 16 populations (recruits per spawner = 3.2). It is important to note that these are viability abundances assuming replacement only productivity – higher productivity would result in lower viable spawning abundances. For this reason, we use the low productivity planning range to evaluate the current abundance trends of PS Chinook salmon (Table 8).

Table 8. Average abundance estimates for PS Chinook salmon natural- and hatchery-origin spawners 2010-2014 (NWFSC 2015).

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	154	1,013	86.80%	16,000	93,360
SF Nooksack River	88	330	78.95%	9,100	33,440
Strait of Juan de Fuca MPG					
Elwha River	164	988	85.76%	15,100	92,160
Dungeness River	119	358	75.05%	4,700	38,160
Hood Canal MPG					
Skokomish River	256	1,371	84.27%	12,800	130,160
Mid-Hood Canal	75	239	76.11%	11,000	25,120
Whidbey Basin MPG					
Skykomish River	1,693	627	27.03%	17,000	185,600
Snoqualmie River	885	258	22.57%	17,000	91,440
NF Stillaguamish River	574	402	41.19%	17,000	78,080
SF Stillaguamish River	71	16	18.39%	15,000	6,960
Upper Skagit River	6,924	270	3.75%	17,000	575,520
Lower Skagit River	1,391	55	3.80%	16,000	115,680

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Minimum Viability Abundance[b]	Expected Number of Outmigrants[c]
Upper Sauk River	836	31	3.58%	3,000	69,360
Lower Sauk River	413	19	4.40%	5,600	34,560
Suiattle River	351	9	2.50%	600	28,800
Cascade River	338	7	2.03%	1,200	27,600
Central / South Sound MPG					
Sammamish River	160	1,519	90.47%	10,500	134,320
Cedar River	881	194	18.05%	11,500	86,000
Duwamish/Green River	897	1,271	58.63%	17,000	173,440
Puyallup River	598	588	49.58%	17,000	94,880
White River	1,689	1,782	51.34%	14,200	277,680
Nisqually River	701	1,876	72.80%	13,000	206,160
ESU Average	**19,258**	**13,223**	**40.71%**		**2,598,480**

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

The average[3] abundance (2010-2014) for PS Chinook salmon populations is 32,481 adult spawners (19,258 natural-origin and 13,223 hatchery origin spawners). Natural-origin spawners range from 71 (in the South Fork Stillaguamish River population) to 6,924 fish (in the Upper Skagit population). No populations are meeting minimum viability abundance targets, and only four of 22 populations average greater than 20% of the minimum viability abundance target for natural-origin spawner abundance (all of which are in the Skagit River watershed). The populations closest to planning targets (the Upper Skagit, Cascade, Upper Sauk, and Suiattle) need to increase substantially just to meet the minimum viability abundance target. The Skykomish population is the second most abundant population, but its natural-origin spawner abundance is only 10% of the minimum viability abundance target.

Juvenile PS Chinook salmon abundance estimates come from escapement data, the percentage of females in the population, and fecundity. Fecundity estimates for the ESU range from 2,000 to 5,500 eggs per female, and the proportion of female spawners in most populations is approximately 40% of escapement. By applying a conservative fecundity estimate (2,000 eggs/female) to the expected female escapement (both natural-origin and hatchery-origin spawners – 12,992 females), the ESU is estimated to produce approximately 26.0 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

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

Creek, Cedar River, and Green River (Beamer et al. 2000; Seiler et al. 2002, 2004, 2005; Volkhardt et al. 2005; Griffith et al. 2004). The average survival rate in these studies was 10%, which corresponds with those reported by Healey (1991). With an estimated survival rate of 10%, the ESU should produce roughly 2.60 million natural outmigrants annually.

Juvenile listed hatchery PS Chinook salmon abundance estimates come from the annual hatchery production goals. Hatchery production varies annually due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. Funding uncertainties and the inability to predict equipment failures, human error, and disease suggest that production averages from previous years is not a reliable indication of future production. For these reasons, abundance is assumed to equal production goals. The combined hatchery production goal for listed PS Chinook salmon is 41,809,650 adipose-fin-clipped and non-clipped juvenile Chinook salmon.

Fifteen-year trends in wild spawner abundance were calculated for each PS Chinook salmon population for two time series – 1990-2005 and 1999-2014 (Table 9). Trends were calculated from a linear regression applied to the smoothed wild spawner log abundance estimate (NWFSC 2015). For the 1990-2005 time series, trends were negative for only two of 22 populations. Recent trends (1999-2014), however, were negative for 17 of the 22 populations (NWFSC 2015).

Table 9. Fifteen year trends for PS Chinook salmon for two time series – 1990-2005 and 1999-2014 (NWFSC 2015).

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

Population	1990-2005		1999-2014	
	Trend	95% CI	Trend	95% CI
Green River	0.02	(-0.02, 0.06)	-0.12	(-0.16, -0.09)
Puyallup River	-0.03	(-0.05, -0.02)	-0.06	(-0.08, -0.03)
White River	0.19	(0.17, 0.21)	-0.03	(-0.08, 0.01)
Nisqually River	0.05	(0.03, 0.06)	-0.01	(-0.05, 0.03)

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

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

2.2.1.2 Lower Columbia River (LCR) Chinook

Description and Geographic Range: We listed Lower Columbia River (LCR) Chinook salmon as threatened on March 24, 1999 (64 FR 14308). When we re-examined the status of these fish in 2005, 2011, and 2016 and we determined that they still warranted listing as threatened (70 FR 37160; 76 FR 50448; 81 FR 33468). We describe the ESU as all naturally spawned populations of Chinook salmon from the Columbia River and its tributaries from its mouth upstream to a transitional point between Washington and Oregon east of the Hood River and the White Salmon River, and includes the Willamette River to Willamette Falls, Oregon, exclusive of spring-run Chinook salmon in the Clackamas River. The ESU includes nineteen artificial propagation programs: the Big Creek Tule Chinook Program; Astoria High School Salmon-Trout Enhancement Program Tule Chinook Program; Warrenton High School Salmon-Trout Enhancement Program Tule Chinook Program; Deep River Net Pens-Washougal; Klaskanine Hatchery;

Cathlamet Channel Net Pens; Cowlitz Tule Chinook Program; North Fork Toutle Tule Chinook Program; Kalama Tule Chinook Program; Washougal River Tule Chinook Program; Spring Creek National Fish Hatchery Tule Chinook Program; Cowlitz Spring Chinook Program in the Upper Cowlitz River and the Cispus River; Friends of the Cowlitz Spring Chinook Program; Kalama River Spring Chinook Program; Lewis River Spring Chinook Program; Fish First Spring Chinook Program; and the Sandy River Hatchery; Bonneville hatchery (79 FR 20802; Jones 2016).

Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) identify 31 historical demographically independent populations in three strata for the LCR Chinook salmon ESU (Table 10). The strata are groups of populations with similar life history traits within the same ecological zone. Within the LCR Chinook salmon ESU, run timing was the predominant life history criteria used in identifying populations. The recovery plans identify three distinct run times, spring, fall, and late fall. The distribution of populations with distinct run times varies among the three ecological subregions. Fall Chinook salmon historically were found throughout the Lower Columbia River Chinook Salmon ESU, while spring Chinook salmon historically were only found in the upper portions of basins with snowmelt driven flow regimes (western Cascade Crest and Columbia Gorge tributaries). Late fall Chinook salmon populations are found in only two basins in the Cascade strata. In general, late fall Chinook salmon also mature at an older average age than either lower Columbia River spring or fall Chinook salmon, and have a more northerly oceanic migration route.

Table 10. Historical Population Structure and Viability Status for Lower Columbia River Chinook Salmon (VL=very low, L=low, M=moderate, H=high, VH=very high) (ODFW 2010; LCFRB 2010).

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

	Big White Salmon	VL	L	L
Cascade (Late Fall)	Sandy	VH	M	M
	North Fork Lewis	VH	H	H
Cascade (Spring)	Upper Cowlitz	VL	L	M
	Cispus	VL	L	M
	Tilton	VL	VL	VL
	Toutle	VL	H	L
	Kalama	VL	H	L
	Lewis	VL	L	M
	Sandy	M	M	M
Gorge (Spring)	Big White Salmon	VL	VL	VL
	Hood	VL	VH	VL

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

The Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) rate diversity as low to very low in 18 out of 31 populations (Table 10). The NWFSC found that diversity of LCR Chinook has been affected by the loss of 80% of the spring run populations, the high proportion of hatchery fish on the spawning grounds, and habitat loss and degradation (Good et al. 2005; Ford 2011; NWFSC 2015). On average fall-run Chinook salmon hatchery programs have released 50 million fish annually, with spring-run and upriver bright (URB) programs releasing a total of 15 million fish annually (NWFSC 2015). Furthermore, due to these high levels of hatchery production and corresponding low levels of natural production, many of the populations contain over 50% hatchery fish among their naturally spawning assemblages (NWFSC 2015).

In addition to the disparity between natural production and hatchery production, the release of out-of-ESU hatchery stocks continues to be an issue in several areas of the ESU. Hatchery programs in Youngs Bay and Big Creek release out-of-ESU stocks from the Rogue River and Upper Willamette River. Hatchery programs in the Gorge release fall Chinook from the upriver bright stock and a program in the Hood River has adopted an out-of-ESU spring-run Chinook stock from the Deschutes River.

The Oregon and Washington recovery plans rate spatial structure as moderate to very high in 24 out of 31 populations (Table 10). The populations that rate lowest have fish passage barriers. Trap and haul operations on the Cowlitz River pass adults upriver, but downstream passage and survival of juvenile fish is very low. This problem also affects spatial structure in the Cispus and Tilton populations. Merwin Dam blocks access to most of the available spawning habitat in the North Fork Lewis populations. However, the relicensing agreement for Lewis River hydroelectric projects calls for reintroduction of Chinook salmon. Condit Dam on the White Salmon River blocked access to most of the historical spawning habitat but was removed in 2011. Thus, the recovery plans rate LCR Chinook salmon spatial structure as moderate to very high for more than two thirds of the populations, and for three populations with low ratings, management actions are underway to improve the situation (fall and spring runs in the White Salmon and the spring run in the Lewis).

Abundance and Productivity: Ford (2011) found that abundance of all LCR Chinook salmon populations increased during the early 2000s but by the end of the decade had declined back to levels observed in 2000 for all but one population. In general, abundance of LCR Chinook salmon populations has not changed considerably since the previous status reviews. Of the 31 populations in this ESU, the NWFSC (2015) found only the 2 late-fall run populations (Lewis River and Sandy River) to be viable or nearly so. With a few exceptions, the remainder of the populations fall far short of their recovery goals in abundance (NWFSC 2015).

In 1998, NMFS assessed the abundance in smaller tributary streams in the range of the species to be in the hundreds of fish (Myers et al. 1998). Larger tributaries (e.g., Cowlitz River basin) contained natural runs of Chinook salmon ranging in size from 100 to almost 1,000 fish. In 2005, NMFS calculated adult abundance using the geometric mean of natural-origin spawners in the five years previous to 2003 (Good et al. 2005). In 2005, NMFS estimated the LCR Chinook salmon abundance at approximately 14,130 fish (Good et al. 2005). Data that are more recent place the abundance of naturally produced LCR Chinook salmon at approximately 13,594 spawners (Table 11).

Table 11. 5-year Average Abundance Estimates for LCR Chinook Salmon Populations (ODFW 2016a; WDFW 2016).

Stratum (Run)	Population	Years	Total	HOR(1)	NOR(2)
Coastal (Fall)	Youngs Bay	2012-2014	5,839	5,606	233
	Grays/Chinook	2010-2014	457	357	100
	Big Creek	2012-2014	1,542	1,510	32
	Elochoman/Skamokowa	2010-2014	696	580	116
	Clatskanie	2012-2014	3,291	3,193	98
	Mill/Abernathy/Germany	2010-2014	897	805	92
Cascade (Fall)	Lower Cowlitz	2010-2013	919	196	723
	Upper Cowlitz	2010-2013	3,834	961	2,873
	Toutle	2010-2014	8,705	5,400	3,305
	Coweeman	2010-2014	1,348	963	385
	Kalama	2010-2014	9,694	8,892	803
	Lewis	2010-2014	3,121	943	2,178
	Washougal	2010-2014	309	116	192
	Clackamas	2012-2014	4,227	2,955	1,272

	Sandy	2012-2014	1,527	320	1,207
Columbia Gorge (Fall)	Lower gorge	2003-2007	146	Unknown	146
	Upper gorge	2010-2012	527	327	200
	White Salmon	2010-2014	1,075	246	829
Cascade (Late Fall)	North Fork Lewis	2010-2014	12,330	0	12,330
Cascade (Spring)	Upper Cowlitz/Cispus	2010-2014	3,893	3,614	279
	Kalama	2011-2014	115	na	115
	North Fork Lewis	2010-2014	217	0	217
	Sandy	2010-2014	3,201	1,470	1,731
Gorge (Spring)	White Salmon	2013-2014	152	140	13
Total			68,061	38,594	29,469

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

The Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) rate all but three Chinook populations as low to very low for abundance and productivity (Table 10). The range of abundance recommended for recovery is from 300 (Kalama spring-run) to 7,300 (North Fork Lewis late fall-run). Current abundance estimates from WDFW and ODFW suggest that only five populations are at or have exceeded abundance goals, and for one of these (the White Salmon), we do not know what portion of the spawners are hatchery origin.

The NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time; however, the average outmigration for the years 2011-2015 is shown in Table 12 (Dey 2012; Zabel 2013, 2014a, 2014b, 2015).

Table 12. Average Estimated Outmigration for Listed LCR Chinook Salmon (2011-2015).

Origin	Outmigration
Natural	12,866,892
Listed hatchery intact adipose	1,150,536
Listed hatchery adipose clip	35,298,675

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

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

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

Hatchery programs can harm salmonid viability in several ways: hatchery-induced genetic change can reduce fitness of wild fish; hatchery-induced ecological effects—such as increased competition for food and space—can reduce population productivity and abundance; hatchery imposed environmental changes can reduce a population's spatial structure by limiting access to historical habitat; hatchery-induced disease conveyance can reduce fish health. Practices that introduce native and non-native hatchery fish can increase predation on juvenile life stages. Hatchery practices that affect natural fish production include removal of adults for broodstock, breeding practices, rearing practices, release practices, number of fish released, reduced water quality, and blockage of access to habitat.

2.2.1.3 Upper Columbia River (UCR) spring-run Chinook

On March 24, 1999, NMFS first listed UCR spring-run Chinook salmon as an endangered species under the ESA (NOAA 1999). In that listing determination, NMFS concluded that the UCR spring-run Chinook salmon were in danger of extinction throughout all or a significant portion of their range. When NMFS re-examined the status of the UCR Chinook in 2005 (70 FR 37160), we came once again to the conclusion that the species warranted listing as endangered. On August 15, 2011, NMFS announced the results of an ESA 5-year review UCR Chinook (76 FR 50448). After reviewing new information on the viability of this species, ESA section 4 listing factors, and efforts being made to protect the species, NMFS concluded that this species should retain its endangered listing classification. Another review was completed in 2015 and, given the same considerations, the 2015 status review team found that while there had been some improvement in a number of areas, the risk categories for this species remained unchanged from the previous review (NWFSC 2015). Further, they rated the species overall risk trend as stable. A recovery plan is available for this species (Upper Columbia Salmon Recovery Board 2007).

Description and Geographic Range: The UCR spring-run Chinook salmon inhabit tributaries upstream from the Yakima River to Chief Joseph Dam. Adult UCR Chinook return to the Wenatchee River from late March through early May, and to the Entiat and Methow Rivers from late March through June. These three areas comprise the species' three populations—there was one other considered, the Okanogan, but it was determined to have been extirpated. Most adults return after spending two years in the ocean, although 20 percent to 40 percent return after three years at sea. Peak spawning for all three populations occurs from August to September. Smolts typically spend one year in freshwater before migrating downstream. There are slight genetic differences between this species and others containing stream-type fish, but more importantly, the ESU boundary was defined using ecological differences in spawning and rearing habitat (Myers et al. 1998).

Currently, approximately 65% of the fish retuning to this ESU are hatchery fish. NMFS originally determined that six hatchery stocks in the UCR basin (Chiwawa, Methow, Twisp, Chewuch, and White Rivers and Nason Creek) should be included as part of the species because they were considered essential for recovering the fish. The artificially propagated stocks changed slightly in the subsequent review, in that the Winthrop composite stocks were listed and the Nason Creek stock was not. As of 2015, the Chewuch stock has been recommended for removal and the Nason Creek stock is recommended to be added back in (NWFSC 2015). The Interior Columbia Technical Recovery Team (ICTRT) identified no MPGs due to the relatively small geographic area affected (IC-TRT 2003; McClure et al. 2005; Ford 2011).

The composite spatial structure and diversity risks are "high" for all three of the extant populations in this MPG. The natural processes component of the SS/D risk is "low" for the Wenatchee River and Methow River populations and "moderate" for the Entiat River (loss of production in lower section increases effective distance to other populations). All three of the extant populations in this MPG are at "high" risk for diversity, driven primarily by chronically high proportions of hatchery-origin spawners in natural spawning areas and lack of genetic diversity among the natural-origin spawners (Ford 2011; NWFSC 2015).

Table 13 -- 5-year mean of fraction natural origin (sum of all estimates divided by the number of estimates). Blanks mean no estimate available in that 5-year range.

Increases in natural origin abundance relative to the extremely low spawning levels observed in the mid-1990s are encouraging; however, average productivity levels remain extremely low. Overall, the viability of Upper Columbia Spring Chinook salmon ESU has likely improved somewhat since the last status review, but the ESU is still clearly at "moderate-to-high" risk of extinction (Ford 2011; NWFSC 2015).

Abundance and Productivity: There are no estimates of historical abundance specific to this species prior to the 1930s. The drainages supporting this species are all above Rock Island Dam on the upper Columbia River. Rock Island Dam is the oldest major hydroelectric project on the Columbia River; it began operations in 1933. Counts of returning Chinook have been made since the 1930s. Annual estimates of the aggregate return of spring Chinook to the upper Columbia are derived from the dam counts based on the nadir between spring and summer return peaks. Spring Chinook salmon currently spawn in three major drainages above Rock Island Dam—the Wenatchee, Methow and Entiat Rivers. Historically, spring Chinook may have also used portions of the Okanogan River.

The 1998 Chinook Status Review (Myers et al. 1998) reported that long-term trends in abundance for upper Columbia spring Chinook populations were generally negative, ranging from -5% to +1%. Analyses of the data series, updated to include 1996-2001 returns, indicated that those trends continued up to that point. The long-term trend in spawning escapement since then is slightly upward for all three systems, but has been highly variable in recent years (NWFSC 2015).

The Upper Columbia Biological Requirements Workgroup (Ford et al. 2001) recommended interim delisting levels of 3,750, 500, and 2,200 spawners for the populations returning to the Wenatchee, Entiat, and Methow drainages, respectively. Five-year geometric mean spawning escapements from 1997 to 2001 were at 8%-15% of these levels. Target levels have not been exceeded since 1985 for the Methow run and the early 1970s for the Wenatchee and Entiat populations (NMFS 2003, NWFSC 2015).

As the following tables illustrate, there have been some adult abundance and productivity improvements in recent years. However, the populations remain well below the delisting levels cited above.

Table 14 5-year geometric mean of raw natural spawner counts. This is the raw total spawner count times the fraction natural estimate. In parentheses, 5-year geometric mean of raw total spawner counts is shown. The geometric mean was computed as the product of counts raised to the power of reciprocal the number of counts available (2 to 5). A minimum of 2 values was used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right (NWFSC 2015).

Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Methow R. SpR	0.84	0.61	0.16	0.27	0.24
Entiat R. SpR	0.86	0.70	0.56	0.47	0.74
Wenatchee R. SpR	0.86	0.66	0.54	0.24	0.35

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the UCR Chinook juvenile outmigration are displayed below.

Table 15. Recent Five-Year Average Projected Outmigrations for UCR Chinook (Ferguson 2010; Dey 2012; Zabel 2013; Zabel 2014a, Zabel 2014b, Zabel 2015).

Origin	Outmigration
Natural	484,538
Listed Hatchery: Adipose Clipped*	516,020
Listed Hatchery: Intact Adipose*	741,415

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

All three existing Upper Columbia River spring-run Chinook salmon populations have exhibited similar trends and patterns in abundance over the past 40 years. The 1998 Chinook salmon status review (Myers et al. 1998) reported that long-term trends in abundance for upper Columbia River spring-run Chinook salmon populations were generally negative, ranging from –5% to +1%. Between 1958 and 2001, Wenatchee River spawning escapements declined at an average rate of 5.6% per year, the Entiat River population at an average of 4.8% per year, and the Methow River population at an average of 6.3% per year Good et al. 2005).

McClure et al. (2003) reported standardized quantitative risk assessment results for 152 listed salmon stocks in the Columbia River basin, including representative data sets (1980–2000 return years) for upper Columbia River spring-run Chinook salmon. Average annual growth rate (λ) for the upper Columbia River spring-run Chinook salmon population was estimated at 0.85, the lowest average reported for any of the Columbia River ESUs analyzed in the study.

Assuming that population growth rates were to continue at the 1980–2000 levels, upper Columbia River spring-run Chinook salmon populations are projected to have a very high probability of a 90% decline within 50 years (0.87 for the Methow River population, 1.0 for the Wenatchee and Entiat runs). However, in more recent year (1995 – 2008) production increased and, depending upon hatchery effectiveness, has varied between .92 and 1.13 (Ford 2011). Updating the data series to include 2009-2014, the short-term (e.g., 15 year) trend in wild spawners has been neutral for the Wenatchee population and positive for the Entiat and Methow populations. In general, both total and natural origin

Population	MPG	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Methow R. SpR	Up. Columbia/East Slope Cascades	722 (867)	44 (75)	292 (2171)	379 (1470)	425 (1828)	12 (24)
Entiat R. SpR	Up. Columbia/East Slope Cascades	153 (179)	37 (56)	148 (280)	129 (278)	265 (360)	105 (29)
Wenatchee R. SpR	Up. Columbia/East Slope Cascades	621 (735)	120 (192)	860 (1652)	385 (1671)	785 (2254)	104 (35)

escapements for all three populations increased sharply from 1999 through 2002 and have shown substantial year to year variations in the years following, with peaks around 2001 and 2010 (NWFSC 2015). But again, average natural origin returns remain well below ICTRT minimum threshold levels.

Limiting Factors: As noted above, UCR spring-run Chinook salmon inhabit tributaries upstream from the Yakima River to Chief Joseph Dam and the Columbia River mainstem upstream from the Yakima River. Though UCR Chinook are rarely intercepted in ocean fisheries, they face other difficulties (Upper Columbia Salmon Recovery Board 2007; NOAA Fisheries 2011):

- Effects related to hydropower system in the mainstem Columbia River, including reduced upstream and downstream fish passage, altered ecosystem structure and function, altered flows, and degraded water quality
- Degradation of floodplain connectivity and function, channel structure and complexity, riparian areas and large woody debris recruitment, stream flow, and water quality
- Degraded estuarine and nearshore marine habitat
- Hatchery-related effects
- Persistence of non-native (exotic) fish species continues to affect habitat conditions for listed species
- Harvest in Columbia River fisheries

Habitat in the area has been degraded by a number of factors, primarily high temperatures, excess sediment, outright habitat loss, degraded channels, impaired floodplains, and reduced stream flow. All of these factors (and others) have negatively affected the ESU's PCEs (see "Approach to the Analysis" above) to the extent that it was necessary to list them under the ESA. Additionally, and as noted above, both passage barriers and hatchery effects have had negative impacts on this species. (Although steps are being taken to improve both those factors through recovery planning.)

2.2.1.4 Snake River fall-run Chinook

Snake River fall Chinook salmon were first listed as threatened on April 22, 1992 (NOAA 1992). The ESU included all natural-origin populations of fall Chinook in the mainstem Snake River and several tributaries including the Tucannon, Grande Ronde, Salmon, and Clearwater Rivers. Fall Chinook salmon from the Lyons Ferry Hatchery were included in the ESU but were not listed. When NMFS re-examined the status of this species in 2005, we determined that it still warranted listing as threatened, but in this instance fish from four hatchery programs were considered part of the listed unit (413) (70 FR 37160). Under the final listing in 2005, the section 4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. This document evaluates impacts on both listed natural and listed hatchery fish. We are developing a recovery plan for this species.

Table 16. Listed Hatchery Stocks for the SR Fall Chinook ESU.

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

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

Fall Chinook salmon returns to the Snake River generally declined through the first half of the 20th century (Irving and Bjornn 1981). Currently, natural spawning is limited to the area from the upper end of Lower Granite Reservoir to Hells Canyon Dam, the lower reaches of the Imnaha, Grande Ronde, Clearwater, and Tucannon Rivers, and small mainstem sections in the tailraces of the lower Snake River hydroelectric dams.

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

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

Table17. 5-year mean of fraction natural origin fish in the population (sum of all estimates divided by the number of estimates).

Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Snake R. Low. Mainstem FR	0.62	0.53	0.48	0.37	0.31

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

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

Table 18. 5-year geometric mean of raw natural spawner counts. This is the raw total spawner count times the fraction natural estimate, if available. In parentheses, 5-year geometric mean of raw total spawner counts is shown. The geometric mean was computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of 2 values were used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right.

Population	MPG	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Snake R. Low. Mainstem FR	Snake R.	333 (581)	548 (980)	3049 (8496)	3662 (10581)	11254 (37812)	207 (257)

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the fall Chinook salmon juvenile outmigration are displayed below.

Table 19. Recent Five-Year Average Projected Outmigrations for SR Fall Chinook Salmon (Ferguson 2010; Dey 2011; Zabel 2013; Zabel 2014a; Zabel 2014b, Zabel 2015).

Origin	Outmigration
Natural	605,921

Origin	Outmigration
Listed Hatchery: Adipose Clipped	2,291,544
Listed Hatchery: Intact Adipose	3,611,961

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

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

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

- Degradation of floodplain connectivity and function and channel structure and complexity
- Harvest-related effects
- Loss of access to historical habitat above Hells Canyon and other Snake River dams

- Impacts from mainstem Columbia River and Snake River hydropower systems
- Hatchery-related effects
- Degraded estuarine and nearshore habitat.

2.2.1.5 Snake River spring/summer–run Chinook

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

Table 20. List of Hatchery Stocks Included in the SR Spr/sum Chinook Salmon ESU.

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

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

Description and Geographic Range: The present range of spawning and rearing habitat for naturally spawned SR spring/summer Chinook salmon is primarily limited to the

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

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

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

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

Table 21. 5-year mean of fraction natural origin spawners (sum of all estimates divided by the number of estimates). Blanks mean no estimate available in that 5-year range.

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

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

Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Imnaha R. Mainstem SSR	0.43	0.53	0.45	0.23	0.35
Minam R. SSR	0.46	0.97	0.98	0.98	0.89
Catherine Cr. SSR	0.32	1.00	0.57	0.35	0.45
Wenaha R. SSR	0.28	0.89	0.96	0.97	0.76
Wallowa/Lostine R. SSR	0.55	0.97	0.56	0.35	0.45
Grande Ronde R. Up. Mainstem SSR	0.37	0.98	0.76	0.27	0.18
Tucannon R. SSR	0.74	0.64	0.61	0.69	0.67
MF Salmon R. Low. Mainstem SSR		1.00	1.00	1.00	1.00
Camas Cr. SSR	1.00	1.00	1.00	1.00	1.00
Chamberlain Cr. SSR	1.00	1.00	1.00	1.00	1.00
Sulphur Cr. SSR	1.00	1.00	1.00	1.00	1.00
Bear Valley Cr. SSR	1.00	1.00	1.00	1.00	1.00
MF Salmon R. Up. Mainstem SSR		1.00	1.00	1.00	1.00
Loon Cr. SSR	1.00	1.00	1.00	1.00	1.00
Big Cr. SSR	1.00	1.00	1.00	1.00	1.00
Marsh Cr. SSR	1.00	1.00	1.00	1.00	1.00
EF SF Salmon R. SSR	0.96	0.99	0.73	0.42	0.61
SF Salmon R. SSR	0.66	0.59	0.64	0.56	0.77
Secesh R. SSR	0.97	0.94	0.97	0.95	0.98
Lemhi R. SSR	1.00	1.00	1.00	1.00	1.00
Salmon R. Up. Mainstem SSR	0.84	0.80	0.63	0.58	0.70
Yankee Fork SSR	1.00	1.00	1.00	0.52	0.39
Valley Cr. SSR	1.00	1.00	1.00	1.00	1.00
Salmon R. Low. Mainstem SSR	1.00	1.00	1.00	1.00	1.00
Pahsimeroi R. SSR		0.71	0.51	0.79	0.93
EF Salmon R. SSR	0.64	0.77	1.00	1.00	1.00

Table 22. 5-year geometric mean of raw natural origin spawner counts. This is the raw total spawner count times the fraction natural origin estimate, if available. In parentheses, 5-year geometric mean of raw total spawner counts is shown. The geometric mean was computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of 2 values were used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right.

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

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the SR spring/summer Chinook salmon juvenile outmigration are displayed below.

Table 23. Recent Five-Year Average Projected Outmigrations for SR spr/sum Chinook Salmon (Ferguson 2010; Dey 2011; Zabel 2013; Zabel 2014a; Zabel 2014b, Zabel 2015).

Origin	Outmigration
Natural	1,428,881
Listed Hatchery: Adipose Clipped*	4,164,942
Listed Hatchery: Intact Adipose*	1,172,097

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

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

Productivity data have been generally lacking since this species was listed. Those data that do exist have been pretty highly variable in terms of methodology, consistency, and coverage. The most recent status review (NWFSC 2015) went to great lengths to compile and codify both the most recent and the historical data for many of the SR spring/summer Chinook populations and they are reflected in the following figure (Figure 1).

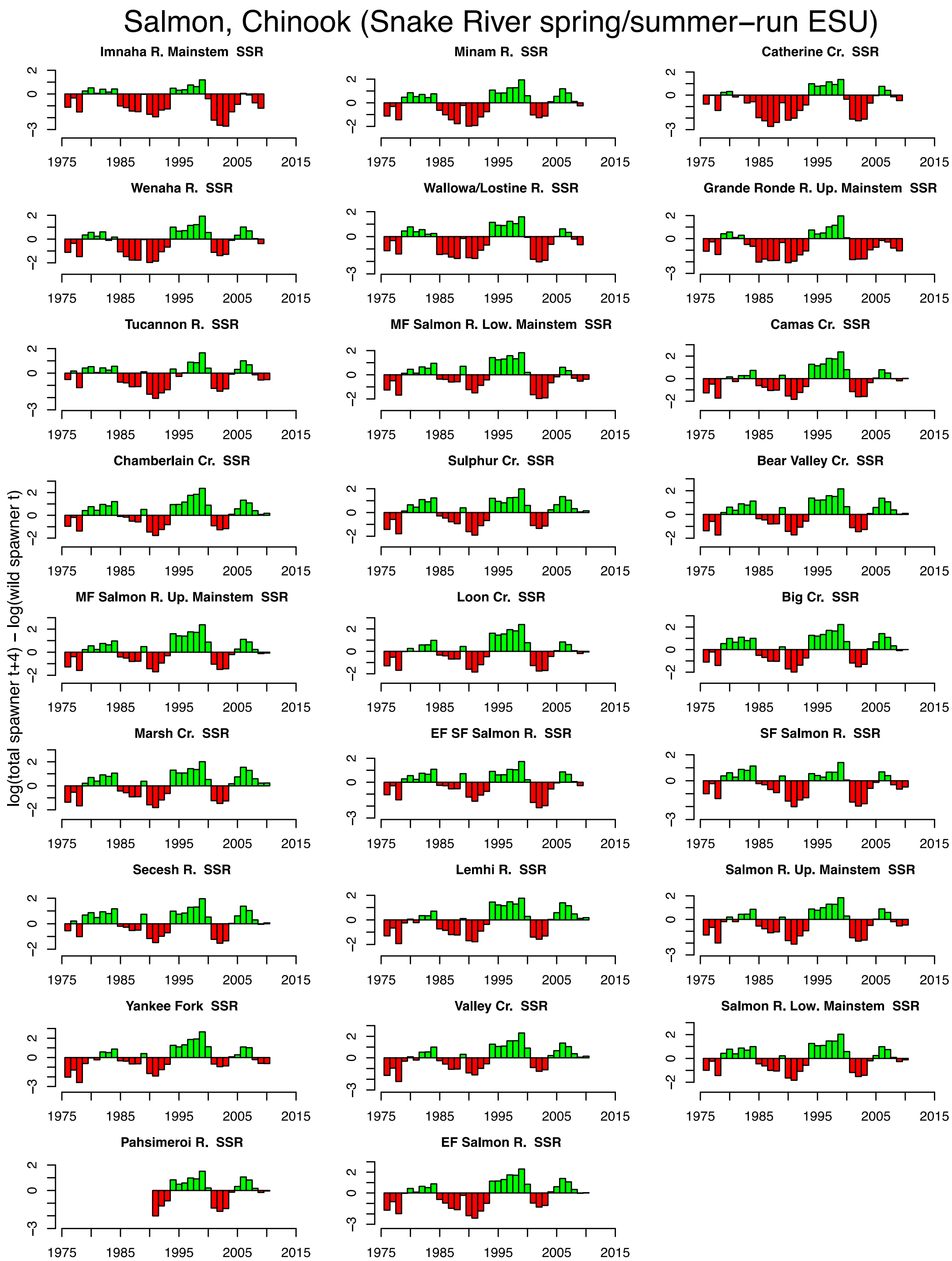

Figure 1 Trends in population productivity, estimated as the log of the smoothed natural spawning abundance. Spawning years on x axis.

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

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

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

2.2.1.6 Upper Willamette River Chinook

Description and Geographic Range: We listed Upper Willamette River (UWR) Chinook salmon as threatened on March 24, 1999 (64 FR 14308). When we re-examined the status of these fish in 2005, 2011, and 2016, we determined that they still warranted listing as threatened (70 FR 37160; 76 FR 50448; 81 FR 33468). We describe the ESU as all naturally spawned populations of spring-run Chinook salmon in the Clackamas River and in the Willamette River and its tributaries above Willamette Falls, Oregon. Also included in the ESU are spring-run Chinook salmon from six artificial propagation programs: the McKenzie River Hatchery Program; Marion Forks Hatchery/North Fork Santiam River Program; South Santiam Hatchery Program; Willamette Hatchery Program; and the Clackamas Hatchery Program (79 FR 20802).

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

Table 24. Historical Population Structure and Viability Status for UWR Chinook Salmon (ODFW 2011).

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

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

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

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

The Oregon recovery plan (ODFW 2011) rates diversity to be moderate to low in the UWR Chinook ESU (Table 24). Loss of habitat above dams and hatchery production are two factors that have had a negative influence on diversity (Good et al. 2005). As described above, dams and other habitat alterations have reduced or eliminated tributary and mainstem areas. Introduction of fall-run Chinook and laddering the falls have increased the potential for genetic introgression between wild spring and hatchery fall Chinook.

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

Abundance and Productivity: The spring run of Chinook has been counted at Willamette Falls since 1946, but “jacks” (sexually mature males that return to freshwater to spawn after only a few months in the ocean) were not differentiated from the total count until 1952. The average estimated run size from 1946 through 1950 was 43,300 fish, compared to an estimate of only 3,900 in 1994. Even though the number of naturally spawning fish has increased gradually in recent years, many are first generation hatchery fish. Juvenile spring Chinook produced by hatchery programs are released throughout the basin and adult Chinook returns to the ESU are typically 80-90% hatchery origin fish. In the recovery plan, ODFW (2011) found the UWR Chinook ESU to be extremely depressed, likely numbering less than 10,000 fish, with the Clackamas and McKenzie populations accounting for most of the production (Table 25).

Table 25. Estimated Recent Abundance, Viability Goals, and Abundance Targets for Upper Willamette Chinook Populations (ODFW 2011).

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

The Oregon recovery plan (ODFW 2011) rates all but two of the populations as very low for abundance and productivity (Table 25). Most populations of the UWR Chinook ESU are far below the recovery goal (Tables 25 and 26). Abundance in the Clackamas population would need to nearly double, and in the North and South Santiam and Middle Fork populations a 100-fold increase is needed to meet recovery goals.

Recent data on returning adults are summarized in Table 26. Abundance of adult UWR spring Chinook has declined since the highs witnessed around the turn of this century. Over the past five years, natural escapement has ranged from a low of 6,341 to a high of 15,416. The 5-year average return for UWR spring Chinook salmon is 11,443 naturally produced adults and 34,454 hatchery adults (2011-2015).

Table 26. Adult Upper Willamette River Spring Chinook Escapement to the Clackamas River and Willamette Falls Fish Ladder (ODFW and WDFW 2012a, 2013a, 2014a, 2015a; ODFW 2016b).

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

The NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time, however the average outmigration for the years 2011-2015 is shown in Table 27 (Dey 2012; Zabel 2013, 2014a, 2014b, 2015).

Table 27. Average Estimated Outmigration for Listed UWR Chinook Salmon (2011-2015).

Natural	1,299,323
Listed hatchery intact adipose	36,253
Listed hatchery adipose clipped	5,792,774

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

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

Impacts of land management on UWR Chinook include current land use practices causing limiting factors, as well as current practices that are not adequate to restore limiting factors caused by past practices (legacy impacts). Past land use (including agricultural, timber harvest, mining and grazing activities, diking, damming, development of transportation, and urbanization) are significant factors now limiting viability of UWR Chinook (ODFW 2011).

These factors severed access to historically productive habitats, and reduced the quality of many remaining habitat areas by weakening important watershed processes and functions that sustained them. Land use practices in the estuary have degraded or eliminated much of the rearing habitat for UWR Chinook. Combined with the effects of the Columbia basin hydropower/flood control systems, the primary activities that have contributed to current estuary and lower mainstem habitat conditions include channel confinement (primarily through diking), channel manipulation (primarily dredging), floodplain development, and water withdrawal for urbanization and agriculture (LCFRB 2004).

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

Harvest impacts from commercial and recreational fisheries on UWR spring Chinook have been substantially reduced in response to extremely low returns in the mid-1990's and subsequent ESA listings in 1999. For spring Chinook, freshwater fishery impacts have been reduced by approximately 75% from 2001 to present compared to the 1980 through the late 1990's (ODFW 2011) by implementing selective harvest of hatchery-origin fish in commercial and recreational fisheries, with all unmarked, wild spring Chinook being released. Current exploitation (mortality) of naturally produced Chinook in ocean fisheries averages 11% (1996-2006) and freshwater fisheries 9% (2000-2010) (ODFW 2011).

Many UWR Chinook populations are characterized by high proportions of hatchery fish on the spawning grounds (ODFW 2011). The vast majority of the UWR Chinook escapement is hatchery fish (Table 26). The major concern with hatcheries is the negative effect hatchery fish spawning in the natural environment have on productivity and long-term fitness of naturally spawning populations.

ODFW identified negative effects of both native and introduced plant and animal species as limiting factors and threats to UWR Chinook (ODFW 2011). Ecosystem alterations attributable to hydropower dams and to modification of estuarine habitat have increased predation on UWR Chinook. In the estuary, habitat modification has increased the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species (LCREP 2006; Fresh et al. 2005).

2.2.1.7 California Coastal Chinook

Description and Geographic Range: On September 16, 1999, NMFS listed the CC Chinook salmon as a threatened species (64 FR 50394). The ESU includes all naturally spawned populations of Chinook salmon in rivers and streams south of the Klamath River to the Russian River in California. Any Chinook salmon found in coastal basins south of this range are considered to be part of this ESU (Myers et al. 1998). The CC ESU constitutes the southernmost coastal portion of the species' range in North America (Bjorkstedt et al. 2005). Currently, no artificial propagation programs are part of this ESU (79 FR 20802).

Only fall-run Chinook salmon currently occur in the CC Chinook ESU. Historically, spring-run Chinook existed in the Mad River and the North and Middle Forks of the Eel River (Myers et al. 1998, Moyle 2002). Low summer flows and high temperatures in many rivers result in seasonal physical and thermal barrier bars that block movement by anadromous fish. Sand bars at the mouths of streams in the southern part of the ESU often prevent access by Chinook until November or December. The ocean-type Chinook salmon in California tend to use estuaries and coastal areas for rearing more extensively than river-type Chinook salmon. The brackish water areas in estuaries provide rich sources of important lipids and moderate the physiological stress that occurs during parr-smolt transitions. CC Chinook generally remain in the ocean for two to five years (Healey 1991), and tend to stay along the California and Oregon coasts.

The ESU historically included fall-run (28 populations) and spring-run (6 populations) Chinook salmon; however, we currently lack substantive information for either run (Bjorkstedt et al. 2005). Therefore, population structure analysis is constrained by the lack of data for this ESU.

CC Chinook occur in four different diversity strata: North Coastal, North Mountain-Interior, North-Central Coastal, and Central Coastal. Each stratum is defined by its unique topography, climatic pattern, and stream dynamics. The North Coastal stratum is influenced strongly by coastal rainfall patterns but does have some higher inland areas. The North Mountain-Interior stratum is characterized by watersheds that penetrate far inland to higher elevations that contribute snowmelt to streamflow. The North-Central Coastal stratum is composed of small to moderate sized, lower elevation watersheds. The Central Coastal stratum is drier and warmer than the stratums to the north. Spring-run Chinook historically occurred in only the North Mountain-Interior stratum while fall-run Chinook occurred in all four (Table 28) (Bjorkstedt et al. 2005).

Table 28. Historical populations of the CC Chinook salmon ESU (Bjorkstedt et al. 2005).

Stratum	Run	Populations
Northern Coastal	Fall	Redwood Creek, Little River, Mad River, Humboldt Bay, Lower Eel River, Bear River, Mattole River
Northern Mountain Interior	Fall	Upper Eel River
	Spring	Redwood Creek, Mad River, Van Duzen River, Upper Eel River, North Fork Eel River, Middle Fork Eel River
North-Central Coastal	Fall	Usal Creek, Cottaneva Creek, DeHaven Creek, Wages Creek, Ten Mile River, Pudding Creek, Noyo River, Hare Creek, Caspar Creek, Big River, Albion River
Central Coastal	Fall	Big Salmon Creek, Navarro River, Greenwood Creek, Elk Creek, Alder Creek, Brush Creek, Garcia River, Gualala River, Russian River

CC Chinook salmon populations remain widely distributed throughout much of the ESU (Bjorkstedt et al. 2005). Notable exceptions include the area between the Navarro River and Russian River and the area between the Mattole and Ten Mile River populations (Lost Coast area). The lack of Chinook salmon populations both north and south of the Russian River (the Russian River is at the southern end of the species' range) makes it one of the most isolated populations in the ESU. Myers et al. (1998) reports no viable populations of Chinook salmon south of San Francisco, California.

Abundance and Productivity: Historic CC Chinook salmon abundance is mostly unknown. In the mid-1960's, California Department of Fish and Wildlife (CDFW) estimated CC Chinook Salmon abundance at 72,550 fish (CDFG 1965; Good et al. 2005). The CDFW estimate, however, is just a midpoint number in the CC Chinook salmon's abundance decline, being a century into commercial harvest and coastal development. By the mid-1980's, Wahle and Pearson (1987) estimated the ESU at 20,750 fish (Good et al. 2005). Coastal Chinook salmon are highly dependent upon seasonal rainfall and stream flows in ascending tributaries to spawn; fish may spawn in the main stems of rivers if they do not have access into tributaries. Chinook occur in relatively low numbers in northern streams, and their presence is sporadic in streams in the southern portion of the geographic region encompassing this ESU. Coastal California streams support small, sporadically monitored populations of Chinook salmon; no estimates of absolute population abundance are available for most populations. Abundance estimates for CC Chinook salmon are only available for 12 of 28 fall-run populations; and from that data, the average abundance for CC Chinook salmon populations is 5,599 adult spawners (Table 29).

Table 29. Geometric mean abundances of CC Chinook salmon spawner escapements by population (Spence 2016).

Population	Location	Natural-origin Spawners[a]	Expected Number of Outmigrants[b]
Northern Coastal Stratum			
Redwood Creek	Redwood Creek	915	73,200
	Prairie Creek	190	15,200
Humboldt Bay	Humboldt Bay	2	160
	Freshwater Creek	8	640
Mattole River	Mattole River	219	17,520
Mad River	Cannon Creek	92	7,360
Lower Eel River	SF Eel River	585	46,800
	Sproul Creek	100	8,000
North Mountain Interior Stratum			
Upper Eel River	Tomki Creek	48	3,840
	Upper Eel River (Van Arsdale Stn)	608	48,640
North-Central Coastal Stratum			
Ten Mile River	Ten Mile River	5	400
Noyo River	Noyo River	8	640
Big River	Big River	8	640
Central Coastal Stratum			
Navarro River	Navarro River	2	160

Population	Location	Natural-origin Spawners[a]	Expected Number of Outmigrants[b]
Garcia River	Garcia River	3	240
Russian River	Russian River	2,806	224,480
ESU Average		**5,599**	**447,920**

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

We can estimate juvenile CC Chinook abundance from adult fish counts, the percentage of females in the population, and fecundity. Fecundity estimates for Chinook salmon range from 2,000 to 5,500 eggs per female and the proportion of female spawners in most populations is approximately 40%. By applying a conservative fecundity estimate of 2,000 to an average return of 2,240 females, the ESU is estimated to produce approximately 4.48 million eggs annually. Survival rates from egg to migrant juvenile Chinook salmon have been reported to be 10% (Healey 1991). With an estimated survival rate of 10%, the ESU should produce roughly 447,920 natural outmigrants annually. This number should be viewed conservatively. If adult counts were available for other watersheds in the ESU, these numbers would be higher.

Of the 16 locations where abundances were estimated, short-term trends could be calculated for 12 locations and long-term trends for four locations (Table 30). For short-term trends, three of the 12 locations (Prairie Creek, Freshwater Creek, and Noyo River) had significantly negative population trends while the other nine locations showed no significance. For long-term trends, one location has a significantly positive trend (Van Arsdale Station) while one location (Tomki Creek) had a significantly negative trend; both of these locations were from the Upper Eel River population (Spence 2016).

Table 30. Short- and long-term trends for CC Chinook salmon abundance. Trends in bold are significantly different from 0 at α=0.05 (Spence 2016).

Population/Location	Short-term		Long-term	
	Trend (95% CI)	# years	Trend (95% CI)	# years
Northern Coastal Stratum				
Prairie Creek	**-0.140 (-0.248, -0.032)**	14	-	-
Cannon Creek	-0.054 (-0.147, 0.039)	16	0.027 (-0.016, 0.069)	34
Freshwater Creek	**-0.240 (-0.349, -0.130)**	15	-	-
Sproul Creek	0.043 (-0.077. 0.453)	16	-0.025 (-0.060, 0.010)	39
North Mountain Interior Stratum				
Tomki Creek	0.013 (-0.125, 0.151)	16	**-0.100 (-0.152, -0.048)**	34
Upper Eel River (Van Arsdale Stn)	0.087 (-0.004, 0.179)	16	**0.078 (0.049, 0.108)**	63
North-Central Coastal Stratum				
Ten Mile River	-0.215 (-1.520, 1.091)	6	-	-
Noyo River	**-0.624 (-0.951, -0.296)**	6	-	-
Big River	-0.588 (-1.476, 0.300)	6	-	-
Central Coastal Stratum				
Navarro River	-0.274 (-1.110, 0.562)	6	-	-
Garcia River	0.048 (-0.888, 0.983)	6	-	-

Population/Location	Short-term		Long-term	
	Trend (95% CI)	# years	Trend (95% CI)	# years
Russian River	0.019 (-0.067, 0.104)	14	-	-

Limiting Factors and Threats: At the ESU level, several areas of concern remain (Bjorkstedt et al. 2005). Within the North-Coastal and North Mountain Interior strata, all independent populations continue to persist, though there is high uncertainty about current abundance in all of these populations. The loss of the spring Chinook life-history type from these two strata represents a significant loss of diversity within the ESU. Additionally, the apparent extirpation of all populations south of the Mattole River to the Russian River (exclusive) means that one diversity stratum (North-Central Coastal) currently does not support any populations of Chinook salmon, and a second stratum (Central Coastal Stratum) contains only one extant population (Russian River) that, while it remains relatively abundant, has shown a declining trend since 2003. The significant gap in distribution diminishes connectivity among strata across the ESU. Additionally, CC Chinook salmon have been the subject of many artificial production efforts, including out-of-basin and out-of-ESU stock transfers (Bjorkstedt et al. 2005). It is, therefore, likely that CC Chinook salmon genetic diversity has been significantly adversely affected despite the relatively wide distribution of populations within the ESU. Concerning habitat, the following issues continue to impede CC Chinook salmon: water quality (i.e. pollution from agriculture, urban/suburban areas, industrial sites), instream flows (i.e. dams and reservoirs, blocked fish passage, diversions), agriculture (i.e. wine production, marijuana cultivation), and timber harvest (NMFS 2016a).

2.2.1.8 Central Valley spring-run Chinook

Description and Geographic Range. Central Valley Spring-run (CVSR) Chinook salmon were originally listed as threatened on September 16, 1999 (64 FR 50394). The listing status has been reaffirmed in three subsequent status reviews (Good et al. 2005, Williams et al. 2011, NMFS 2016a). This ESU consists of spring-run Chinook salmon occurring in the Sacramento and San Joaquin rivers and their tributaries. The Feather River Fish Hatchery (FRFH) spring-run Chinook salmon population has been included as part of the CVSR Chinook salmon ESU. The San Joaquin component of the ESU, previously extirpated, has been reintroduced and designated as a nonessential experimental population (NEP) under Section 10(j) of the ESA. Although FRFH spring-run Chinook salmon production is included in the ESU, these fish do not have a section 9 take prohibition since they are all adipose fin clipped.

In April 2016, NMFS completed a status review and concluded that CVSR Chinook salmon status should remain as previously listed (76 FR 50447). The 2016 Status Review (NMFS 2016a) stated that although the listings remained unchanged since the 2011 and 2005 review, and the original 1999 listing (64 FR 50394), the status of these populations has likely improved since the 2011 status review and the ESU's extinction risk may have decreased, however, the ESU is still facing significant extinction risk and that risk is likely to increase over the next few years as the full effects of the recent drought are realized (NMFS 2016a).

The Central Valley Technical Review Team estimated that historically there were 18 or 19 independent populations of CVSR Chinook salmon, along with a number of dependent populations, all within four distinct geographic regions, or diversity groups (Lindley et al. 2004). Of these 18 populations, only three populations currently exist (Mill, Deer, and Butte creeks tributary to the upper Sacramento River) and they represent only the northern Sierra Nevada diversity group (Table 31).

Table 31. Historical Populations of CVSR Chinook salmon (adapted from Lindley et al. 2004).

Stratum	Population [1]	Status	Comment
Southern Cascades	Little Sacramento River	*Extirpated*	Blocked by Keswick and Shasta dams
	Pit River/Fall River/Hat Creek	*Extirpated*	Blocked by Keswick and Shasta dams
	McCloud River	*Extirpated*	Blocked by Keswick and Shasta dams
	Battle Creek	*Extirpated*	Hydro operations, water diversions
	Mill Creek	Extant	Either two independent populations or a single panmictic population
	Deer Creek	Extant	
	Butte Creek	Extant	-
	Big Chico Creek	Intermittent	-
	Antelope Creek	Intermittent	-
Coast Range	*Clear Creek*	*Extirpated*	-
	Cottonwood / Beegum creeks	Intermittent	Beegum Creek intermittent, Cottonwood Creek extirpated
	Thomes Creek	*Extirpated*	-
	Stony Creek	*Extirpated*	-
Northern Sierra	West Branch Feather River	*Extirpated*	Blocked by Oroville Dam
	North Fork Feather River	*Extirpated*	Blocked by Oroville Dam
	Middle Fork Feather River	*Extirpated*	Blocked by Oroville Dam
	South Fork Feather River	*Extirpated*	Blocked by Oroville Dam
	Yuba River	*Extirpated*	Blocked by Englebright Dam
	North and Middle Fork American River	*Extirpated*	Blocked by Nimbus Dam
	South Fork American River	*Extirpated*	Blocked by Nimbus Dam
Southern Sierra	Mokelumne River	*Experimental reintroduction*	Blocked by Camanche Dam
	Stanislaus River	*Experimental reintroduction*	Blocked by New Melones and Tulloch dams
	Tuolumne River	*Experimental reintroduction*	Blocked by La Grange and Don Pedro dams
	Merced River	*Experimental reintroduction*	Blocked by McSwain and New Exchequer dams
	Middle and Upper San Joaquin River	*Experimental reintroduction*	Blocked by Friant Dam
	Kings River	*Experimental reintroduction*	Blocked by dry streambeds and Pine Flat Dam

[1]Italicized populations are dependent populations

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

Lindley et al. (2007) found that the Mill Creek, Deer Creek, and Butte Creek populations were at or near low risk of extirpation. The ESU as a whole, however, could not be considered viable because there were no extant populations in the three other diversity groups. In addition, Mill, Deer and Butte creeks are close together, decreasing the independence of their extirpation risks due to catastrophic disturbance (Williams et al. 2011; NMFS 2016a).

Central Valley spring-run Chinook salmon escapement increased slightly in recent years (2012-2014), however, abundance dropped dramatically in 2015 (NMFS 2016a). Until 2015, Mill Creek and Deer Creek populations both improved from high extinction risk in 2010 to moderate extinction risk due to recent increases in abundance. Butte Creek continued to satisfy the criteria for low extinction risk. Additionally, since 1996, partly due to increased flows provided in upper Battle Creek, the CV spring-run Chinook salmon population began and are continuing to naturally repopulate Battle Creek, home to a historical independent population in the Basalt and Porous Lava diversity group that was extirpated for many decades. This population has increased in abundance to levels that would qualify it for a moderate extinction risk score. Similarly, the CV spring-run Chinook salmon population in Clear Creek has been increasing, and currently meets the moderate extinction risk score.

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

Abundance and Productivity: Historically CV spring-run Chinook salmon were the second most abundant salmon run in the Central Valley and one of the largest on the west coast (CDFG 1990). These fish occupied the upper and middle elevation reaches (1,000 to 6,000 feet, now blocked by dams) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1872, Rutter 1904, Clark 1929). The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). The San Joaquin River historically supported a large run of spring-run Chinook salmon, suggested to be one of the largest runs of any Chinook salmon on the West Coast with estimates averaging 200,000 – 500,000 adults returning annually (CDFG 1990). Construction of Friant Dam on the San Joaquin River began in 1939, and when completed in 1942, blocked access to all upstream habitat.

The FRFH spring-run Chinook salmon population represents the only remaining evolutionary legacy of the spring-run Chinook salmon populations that once spawned above Oroville Dam, and has been included in the ESU based on its genetic linkage to the natural spawning population, and the potential development of a conservation strategy, for the hatchery program.

Abundance from 1993 to 2004 were consistently over 4,000 (averaging nearly 5,000), while 2005 to 2014 were lower, averaging just over 2,000 (CDFW Grandtab 2015).

Monitoring of the Sacramento River mainstem during spring-run Chinook salmon spawning timing indicates some spawning occurs in the river. Here, the lack of physical separation of spring-run Chinook salmon from fall-run Chinook salmon is complicated by overlapping migration and spawning periods. Significant hybridization with fall-run Chinook salmon makes identification of spring-run Chinook salmon in the mainstem difficult to determine, but counts of Chinook salmon redds in September are typically used as an indicator of spring-run Chinook salmon abundance. Fewer than 15 Chinook salmon redds per year were observed in the Sacramento River from 1989 to 1993, during September aerial redd counts (USFWS 2003). Redd surveys conducted in September between 2001 and 2011 have observed an average of 36 Chinook salmon redds from Keswick Dam downstream to the Red Bluff Diversion Dam, ranging from 3 to 105 redds; 2012 observed zero redds, and 2013, 57 redds in September (CDFW 2015). Therefore, even though physical habitat conditions can support spawning and incubation, spring-run Chinook salmon depend on spatial segregation and geographic isolation from fall-run Chinook salmon to maintain genetic diversity. With the onset of fall-run Chinook salmon spawning occurring in the same time and place as potential spring-run Chinook salmon spawning, it is likely extensive introgression between the populations has occurred (CDFG 1998). For these reasons, Sacramento River mainstem spring-run Chinook salmon are not included in the following discussion of ESU abundance trends.

For many decades, CV spring-run Chinook salmon were considered extirpated from the Southern Sierra Nevada diversity group in the San Joaquin River Basin, despite their historical numerical dominance in the Basin (Fry 1961, Fisher 1994). More recently, there have been reports of adult Chinook salmon returning in February through June to San Joaquin River tributaries, including the Mokelumne, Stanislaus, and Tuolumne rivers (Franks 2014, FISHBIO 2015). These spring-running adults have been observed in several years and exhibit typical spring-run life history characteristics, such as returning to tributaries during the springtime, over-summering in deep pools, and spawning in early fall (Franks 2014, FISHBIO 2015). For example, 114 adult were counted on the video weir on the Stanislaus River between February and June in 2013 with only 7 individuals without adipose fins (FISHBIO 2015). Additionally, in 2014, implementation of the spring-run Chinook salmon reintroduction plan into the San Joaquin River has begun, which if successful will benefit the spatial structure, and genetic diversity of the ESU. These reintroduced fish have been designated as a 10(j) nonessential population when within the defined boundary in the San Joaquin River (78 FR 79622). Furthermore, while the San Joaquin River Restoration Project (SJRRP) is managed to imprint CV spring-run Chinook salmon to the mainstem San Joaquin River, we do anticipate that the reintroduced spring-run Chinook salmon are likely to stray into the San Joaquin tributaries at some level, which will increase the likelihood for CV spring-run Chinook salmon to repopulate other Southern Sierra Nevada diversity group rivers where suitable conditions exist.

Sacramento River tributary populations in Mill, Deer, and Butte creeks are likely the best trend indicators for the CV spring-run Chinook salmon ESU as a whole because these streams contain the majority of the abundance, and are currently the only independent populations within the ESU. Generally, these streams have shown a positive escapement trend since 1991, displaying broad fluctuations in adult abundance, ranging from 1,013 in 1993 to 23,788 in 1998 (Table 32). Escapement numbers are dominated by Butte Creek returns, which averaged over 7,000 fish from 1995 to 2005, but then declined in years 2006 through 2011 with an average of just over 3,000 (although 2008 was nearly 15,000 fish). During this same period, adult returns on Mill and Deer creeks have averaged over 2,000 fish total and just over 1,000 fish total, respectively. From 2001 to 2005, the CV spring-run Chinook salmon ESU experienced a trend of increasing abundance in some natural populations, most dramatically in the Butte Creek population (Good et al. 2005).

Additionally, in 2002 and 2003, mean water temperatures in Butte Creek exceeded 21^{o}C for 10 or more days in July (Williams 2006). These persistent high water temperatures, coupled with high fish densities, precipitated an outbreak of Columnaris (*Flexibacter columnaris*) and Ichthyophthiriasis (*Ichthyophthirius multifiis*) diseases in the adult spring-run Chinook salmon over-summering in Butte Creek. In 2002, this contributed to a pre-spawning mortality of approximately 20 to 30 percent of the adults. In 2003, approximately 65 percent of the adults succumbed, resulting in a loss of an estimated 11,231 adult spring-run Chinook salmon in Butte Creek due to the diseases. In 2015, Butte Creek again experienced severe temperature conditions, with nearly 2,000 fish entering the creek, only 1,081 observed during the snorkel survey, and only 413 carcasses observed, which indicates a large number of pre-spawn mortality.

Declines in abundance from 2005 to 2011, placed the Mill Creek and Deer Creek populations in the high extinction risk category due to the rates of decline, and in the case of Deer Creek, also the level of escapement (NMFS 2011a). Butte Creek has sufficient abundance to retain its low extinction risk classification, but the rate of population decline in years 2006 through 2011 was nearly sufficient to classify it as a high extinction risk based on this criteria. Nonetheless, the watersheds identified as having the highest likelihood of success for achieving viability/low risk of extinction include, Butte, Deer and Mill creeks (NMFS 2011a). Some other tributaries to the Sacramento River, such as Clear Creek and Battle Creek have seen population gains in the years from 2001 to 2009, but the overall abundance numbers have remained low. 2012 appeared to be a good return year for most of the tributaries with some, such as Battle Creek, having the highest return on record (799). Additionally, 2013 escapement numbers increased, in most tributary populations, which resulted in the second highest number of spring-run Chinook salmon returning to the tributaries since 1998. However, 2014 abundance was lower, just over 5,000 fish for the tributaries combined, which indicates a highly fluctuating and unstable ESU abundance. Even more concerning was returns for 2015, which were record lows for some populations. The next several years are anticipated to remain quite low as the effects of the 2012-2015 drought are fully realized.

From 1993 to 2007 the 5-year moving average of the CV spring-run Chinook salmon tributary population CRR remained over 1.0, but then declined to a low of 0.47 in years 2007 through 2011 (Table 32). The productivity of the Feather River and Yuba River populations and contribution to the CV spring-run Chinook salmon ESU currently is unknown, however the FRFH currently produces 2,000,000 juveniles each year. The cohort replacement rate (CRR) for the 2012 combined tributary population was 3.84, and 8.68 in 2013, due to increases in abundance for most populations. Although 2014 returns were lower than the previous two years, the CRR was still positive (1.85). However, 2015 returns were very low, with a CRR of 0.14, when using Butte Creek snorkel survey numbers, the lowest on record. Using the Butte Creek carcass surveys, the 2015 CRR for just Butte Creek was only 0.02.

Table 32. Central Valley Spring-run Chinook salmon population estimates from CDFW Grand Tab (2015) with corresponding cohort replacement rates for years since 1990.

Year	**Sacramento River Basin Escapement Run Size**[a]	**FRFH Population**	**Tributary Populations**	**5-Year Moving Average Tributary Population Estimate**	**Trib CRR**[b]	**5-Year Moving Average of Trib CRR**	**5-Year Moving Average of Basin Population Estimate**	**Basin CRR**	**5-Year Moving Average of Basin CRR**
1990	3,485	1,893	1,592	1,658	5.24		4,948	2.30	
1991	5,101	4,303	798	1,376	0.36		5,240	0.56	
1992	2,673	1,497	1,176	1,551	0.60		5,471	0.38	
1993	5,685	4,672	1,013	1,307	0.64	1.55	4,795	1.63	1.22
1994	5,325	3,641	1,684	1,253	2.11	1.79	4,454	1.04	1.18
1995	14,812	5,414	9,398	2,814	7.99	2.34	6,719	5.54	1.83
1996	8,705	6,381	2,324	3,119	2.29	2.73	7,440	1.53	2.03
1997	5,065	3,653	1,412	3,166	0.84	2.77	7,918	0.95	2.14
1998	30,533	6,746	23,787	7,721	2.53	3.15	12,888	2.06	2.23
1999	9,838	3,731	6,107	8,606	2.63	3.26	13,791	1.13	2.24
2000	9,201	3,657	5,544	7,835	3.93	2.44	12,669	1.82	1.50
2001	16,865	4,135	12,730	9,916	0.54	2.09	14,300	0.55	1.30
2002	17,212	4,189	13,023	12,238	2.13	2.35	16,730	1.75	1.46
2003	17,691	8,662	9,029	9,287	1.63	2.17	14,161	1.92	1.43
2004	13,612	4,212	9,400	9,945	0.74	1.79	14,916	0.81	1.37
2005	16,096	1,774	14,322	11,701	1.10	1.23	16,295	0.94	1.19
2006	10,828	2,061	8,767	10,908	0.97	1.31	15,088	0.61	1.21
2007	9,726	2,674	7,052	9,714	0.75	1.04	13,591	0.71	1.00
2008	6,162	1,418	4,744	8,857	0.33	0.78	11,285	0.38	0.69
2009	3,801	989	2,812	7,539	0.32	0.69	9,323	0.35	0.60
2010	3,792	1,661	2,131	5,101	0.30	0.53	6,862	0.39	0.49
2011	5,033	1,969	3,064	3,961	0.65	0.47	5,703	0.82	0.53
2012	14,724	3,738	10,986	4,747	3.91	1.10	6,702	3.87	1.16
2013	18,384	4,294	14,090	6,617	6.61	2.36	9,147	4.85	2.06
2014	8,434	2,776	5,658	7,186	1.85	2.66	10,073	1.68	2.32
2015	3,074	1,586	1,488	7,057	0.14	2.63	9,930	0.21	2.28
Median	9,775	3,616	6,159	6,541	1.97	1.89	10,220	1.00	1.46

[a] NMFS is only including the escapement numbers from the Feather River Fish Hatchery (FRFH) and the Sacramento River tributaries in this table. Sacramento River Basin run size is the sum of the escapement numbers from the FRFH and the tributaries.
[b] Abbreviations: CRR = Cohort Replacement Rate, Trib = tributary

While we currently lack data on naturally-produced juvenile CVSR Chinook salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. The CDFG (1998) published estimates in which average fecundity of spring-run Chinook salmon is 4,161 eggs per female. By applying the average fecundity of 4,161 eggs per female to the estimated 3,576 females returning (half of the average total number of spawners), and applying an estimated survival rate from egg to smolt of 10 percent, the Sacramento River basin portion of the ESU could produce roughly 1,487,974 natural outmigrants annually. In addition, hatchery managers could produce approximately 2,000,000 listed hatchery juvenile CVSR Chinook salmon each year for the Sacramento River basin, and will produce 120,000 smolts for the experimental San Joaquin River basin in 2016. For the San Joaquin River experimental population, it is possible that some of the 2014 hatchery releases will return to spawn in 2016. However, the outmigration and ocean survival rate of that group is unknown, so no estimate of their abundance is available. Therefore, an estimate of the abundance of the natural outmigrants those fish could produce is also not available.

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

2.2.1.9 Sacramento River winter-run Chinook

Description and Geographic Range: This ESU includes all fish spawning naturally in the Sacramento River (SR) and its tributaries, as well as fish that are propagated at the Livingston Stone National Fish Hatchery (LSNFH) which is operated by the U.S. Fish and Wildlife Service (USFWS) (see 70 FR 37160; June 2005). The SR winter-run Chinook salmon ESU is represented by a single naturally spawning population that has been completely displaced from its historical spawning habitat by the construction of Shasta and Keswick Dams. A few returning adults have been observed passing the Coleman National Fish Hatchery (CNFH) weir on Battle Creek, however, the majority of this ESU's spawning population is confined to spawning habitat on the Sacramento River between Keswick Dam and Red Bluff (approximately 44 miles) which is artificially maintained by cold-water releases from Shasta Dam.

The SR winter-run chinook salmon ESU was first listed as "threatened" in 1989 under an emergency rule (54 FR 32085). In 1994, NMFS reclassified the ESU as an endangered species due to several factors, including: (1) the continued decline and increased variability of run sizes since its listing as a threatened species in 1989; (2) the expectation of weak returns in coming years as the result of two small year classes (1991 and 1993); and (3) continuing threats to the species. On June 14, 2004, NMFS proposed to reclassify the ESU as threatened (69 FR 33102; June 14, 2004) primarily because of increasing run sizes and the implementation of numerous conservation efforts in the Central Valley. Following the comment period on the proposed reclassification and additional analysis, NMFS issued a final listing determination on June 28, 2005 concluding that the ESU was "in danger of extinction" due to risks associated with its reduced diversity and spatial structure, and therefore, warranted continued listing as an endangered species under the ESA (70 FR 37160). This ESU is also listed as "endangered" species under the State of California's endangered species law (California Endangered Species Act or CESA).

The distribution of SR winter-run Chinook salmon spawning and initial rearing historically was limited to the Little Sacramento River (upstream of Shasta Dam), McCloud River, Pitt River, and Battle Creek, where springs provided cold water throughout the summer, allowing for spawning, egg incubation, and rearing during the mid-summer period (Slater 1963) op. cit. (Yoshiyama et al. 1998). The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which currently has its own impediments to upstream migration (i.e., a number of small hydroelectric dams situated upstream of the CNFH barrier weir). Efforts are currently underway to remove these impediments, which should restore spawning and rearing habitat for SR winter-run Chinook salmon in the future. Approximately 299 miles of former tributary spawning habitat above Shasta Dam is inaccessible to SR winter-run Chinook salmon. Most components of the SR winter-run Chinook salmon life history (e.g., spawning, incubation, freshwater rearing) have been compromised by the construction of Shasta Dam.

The greatest risk factor for SR winter-run Chinook salmon lies within its spatial structure (NMFS 2011b). The remnant and remaining population cannot access 95 percent of their historical spawning habitat, and must therefore be artificially maintained in the Sacramento River by: (1) spawning gravel augmentation, (2) hatchery supplementation, and, (3) regulating the finite cold-water pool behind Shasta Dam to reduce water temperatures. SR winter-run Chinook salmon require cold water temperatures in the summer that simulate their upper basin habitat, and they are more likely to be exposed to the impacts of drought in a lower basin environment. Battle Creek is currently the most feasible opportunity for the ESU to expand its spatial structure, but restoration is not scheduled to be completed until 2020. The Central Valley Salmon and Steelhead Recovery Plan includes criteria for recovering the SR winter-run Chinook salmon ESU, including re-establishing a population into historical habitats upstream of Shasta Dam (NMFS 2014a). Additionally, NMFS (2009a) included a requirement for a pilot fish passage program above Shasta Dam, and planning is currently moving forward.

The current SR winter-run Chinook salmon population is the result of the introgression of several stocks (*e.g.*, spring-run and fall-run Chinook) that occurred when Shasta Dam blocked access to the upper watershed. A second genetic bottleneck occurred with the construction of Keswick Dam which blocked access and did not allow spatial separation of the different runs (Good *et al.* 2005). Lindley *et al.* (2007) recommended reclassifying the SR winter-run Chinook salmon population extinction risk from low to moderate, if the proportion of hatchery origin fish from the LSNFH exceeded 15 percent due to the impacts of hatchery fish over multiple generations of spawners. Since 2005, the percentage of hatchery-origin winter-run Chinook salmon recovered in the Sacramento River has been above 15 percent in two years, 2005 and 2012.

Concern over genetic introgression within the SR winter-run Chinook salmon population led to a conservation program at LSNFH that encompasses best management practices such as: (1) genetic confirmation of each adult prior to spawning, (2) a limited number of spawners based on the effective population size, and (3) use of only natural-origin spawners since 2009. These practices reduce the risk of hatchery impacts on the wild population. Hatchery-origin winter-run Chinook salmon have made up more than 5 percent of the natural spawning run in recent years and in 2012, it exceeded 30 percent of the natural run. However, the average over the last 16 years (approximately 5 generations) has been 8 percent, still below the low-risk threshold (15 percent) used for hatchery influence (Lindley *et al.* (2007).

Abundance and Productivity: Historically, SR winter-run Chinook salmon population estimates were as high as 120,000 fish in the 1960s, but declined to fewer than 200 fish by the 1990s (National Marine Fisheries Service 2011b). Adult carcass surveys began in 2001 and the highest adult escapement occurred in 2005 and 2006 with 15,839 and 17,296, respectively. From 2007 to 2013, the population has shown a precipitous decline, averaging 2,486 during this period, with a low of 827 adults in 2011. This recent declining trend is likely due to a combination of factors such as poor ocean productivity (Lindley et al. 2009), drought conditions from 2007-2009, and low in-river survival (NMFS 2011b). Slight increase in 2014, with 3,015 adults, remains below the high (17,296) within the last ten years.

Although impacts from hatchery fish (*i.e.*, reduced fitness, weaker genetics, smaller size, less ability to avoid predators) are often cited as having deleterious impacts on natural in-river populations (Matala *et al.* 2012), the SR winter-run Chinook salmon conservation program at LSNFH is strictly controlled by the USFWS to reduce such impacts. The average annual hatchery production at LSNFH is approximately 176,348 per year (2001–2010 average) compared to the estimated natural production that passes Red Bluff Diversion Dam, which is 4.7 million per year based on the 2002–2010 average, (Poytress and Carrillo 2011). Therefore, hatchery production typically represents approximately 3-4 percent of the total in-river juvenile production in any given year.

ESU productivity was positive over the period 1998–2006, and adult escapement and juvenile production had been increasing annually until 2007, when productivity became negative with declining escapement estimates. The long-term trend for the ESU, therefore, remains negative, as the productivity is subject to impacts from environmental and artificial conditions. The population growth rate based on cohort replacement rate (CRR) for the period 2007–2012 suggested a reduction in productivity and indicated that the SR winter-run Chinook salmon population was not replacing itself. In 2013, and 2014, SR winter-run Chinook salmon experienced a positive CRR, possibly due to favorable in-river conditions in 2011, and 2012 (wet years), which increased juvenile survival to the ocean.

Threats and Limiting Factors: Reviews of this ESU identified a wide range of factors as being responsible for its decline including: blockage of access to historic habitat, other passage impediments, unscreened water diversions, heavy metal pollution from mine runoff, disposal of contaminated dredge sediments in San Francisco Bay, ocean harvest, predation, drought effects, juvenile losses at the CVP (Central Valley Project) and State Water Project (SWP) Delta pumping facilities; and elevated water temperatures in spawning grounds (Good et al. 2005; NMFS 2011e). Since 1994 many factors have been addressed, or at least impacts have been reduced, through regulatory and other mechanisms (e.g., reduced harvest impacts, Iron Mountain Mine clean up, screening of water diversions, altered CVP water operations that improve passage and reduce predation, and construction of a temperature control device on Shasta Dam). In the 2005 status review, Good et al. described numerous threats to this ESU, but chief among them was that it was comprised of only one population which is very small and wholly dependent on artificially created spawning and rearing conditions (i.e., cold water releases below Shasta Dam).

2.2.1.10 Hood Canal summer-run chum

Description and Geographic Range: On June 28, 2005, NMFS listed HCS chum salmon—both natural and some artificially-propagated fish—as a threatened species (70 FR 37160). The species comprises all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington. Under the final listing in 2005, the section 4(d) protections (and limits on them) apply to natural and hatchery HCS chum salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. Four artificial propagation programs were listed as part of the ESU (79 FR 20802; Table 33): Hamma Hamma Fish Hatchery Program, Lilliwaup Creek Fish Hatchery Program, Tahuya River Program; and Jimmycomelately Creek Fish Hatchery Program.

Table 33. Expected 2016 Hood Canal summer-run juvenile chum salmon hatchery releases (WDFW 2015).

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

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

The HCS chum salmon ESU has two populations, each containing multiple stocks or spawning aggregations (Table 34). In the Strait of Juan de Fuca population, state and tribal biologists assessing the species' status in the early 1990s identified small but persistent natural spawning aggregations in three streams (Salmon, Snow, and Jimmycomelately creeks). In the Dungeness River, spawning of unknown aggregations occurred. In Chimacum Creek, HCS chum salmon extirpation occurred in the mid-1980's.

Table 34. Historical populations, spawning aggregations, and the status of summer-run chum salmon in the Hood Canal ESU (Good et al. 2005, Sands et al. 2009; Ford 2011).

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

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

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

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

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

Abundance and Productivity: Historical HCS chum salmon abundance is mostly unknown. Harvest records indicate that chum salmon in the Puget Sound (including the HCS chum salmon ESU) were historically more numerous than Chinook salmon. During the years 1914-1919, four times as many chum salmon were harvested as Chinook salmon in the Puget Sound (WDF 1974). In 1968, spawning escapement records indicate that 45,000 adult HCS chum salmon returned to tributaries (WDF et al. 1993). During the early 1970s, adult chum salmon spawners dropped to about 20,000 annually (Table 35) (Ford 2011). By the 1980s, HCS chum salmon abundance began to decline ever more precipitously with several spawning aggregations extirpated during this period with seven spawning aggregations going extinct (Table 35) (Sands et al. 2009). Spawner abundances in both Hood Canal and Strait of Juan de Fuca populations were lowest throughout the 1990’s but increased in the early 2000’s (NWFSC 2015). Since the late 2000’s, abundances have increased by 25% for the Hood Canal population and 53% for the Strait of Juan de Fuca population (Table 35).

Table 35. Abundance–five-year geometric means for adult natural origin and total spawners (natural and hatchery origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NWFSC 2015).

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

The current average run size of 23,034 adult spawners (20,855 natural-origin and 2,179 hatchery origin spawners; Table 36) 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, Norma Sands, NWFSC, December 19, 2006). From 2010 to 2014, Jimmycomelately Creek averaged 1,670 natural-origin spawners. Salmon and Snow Creeks have improved substantially. Natural-origin spawner abundance was 130 fish in 1999, whereas the average for Salmon and Snow creeks were 2,499 and 476, respectively, for the 2010-2014 period.

Table 36. Abundance of natural-origin and hatchery-origin HCS chum salmon spawners in escapements 2010-2014 (unpublished data, Mindy Rowse, NWFSC, Apr 13, 2016).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[c]
Strait of Juan de Fuca Population				
Jimmycomelately Creek	1,670	1,451	46.49%	456,407
Salmon Creek	2,499	-	0.00%	365,482
Snow Creek	476	1	0.21%	69,746
Chimacum Creek	1,381	-	0.00%	201,944
Population Average[d]	**6,026**	**1,452**	**19.42%**	**1,093,579**
Hood Canal Population				
Big Quilcene River	4,675	-	0.00%	683,769
Little Quilcene River	720	-	0.00%	105,327
Big Beef Creek	76	-	0.00%	11,054
Dosewallips River	2,263	3	0.13%	331,433
Duckabush River	3,989	10	0.26%	584,920
Hamma Hamma River	1,733	17	0.95%	255,873
Anderson Creek	-	-	-	-
Dewatto River	43	6	12.87%	7,247
Lilliwaup Creek	293	210	41.71%	73,518
Tahuya River	176	462	72.39%	93,236
Union River	861	19	2.16%	128,636
Population Average[d]	**14,829**	**727**	**4.67%**	**2,275,013**
ESU Average	**20,855**	**2,179**	**9.46%**	**3,368,592**

[a] Five-year geometric mean of post fishery natural-origin spawners (2010-2014).
[b] Five-year geometric mean of post fishery hatchery-origin spawners (2010-2014).
[c] Expected number of outmigrants=Total spawners*45% proportion of females*2,500 eggs per female*13% survival rate from egg to outmigrant.
[d] Averages are calculated as the geometric mean of the annual totals (2010-2014).

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

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

Escapement data, the percentage of females in the population, and fecundity can estimate juvenile HCS chum salmon abundance. ESU fecundity estimates average 2,500 eggs per female, and the proportion of female spawners is approximately 45% of escapement in most populations (WDFW/PNPTT 2000). By applying fecundity estimates to the expected escapement of females (both natural-origin and hatchery-origin spawners – 10,365 females), the ESU is estimated to produce approximately 25.9 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 3.37 million natural outmigrants annually.

Linear regressions of smoothed log natural spawner abundance were applied to both HCS chum salmon populations for two 15-year time series trend analyses (1990-2005 and 1999-2014) (Table 37) (NWFSC 2015). For both time series, trends were positive for both populations (NWFSC 2015).

Table 37. Fifteen year trends for HCS chum salmon for two time series – 1990-2005 and 1999-2014 (NWFSC 2015).

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

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

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

2.2.1.11 Columbia River chum

Description and Geographic Range: Columbia River (CR) chum salmon was first listed as threatened on March 25, 1999 (64 FR 14507). When we re-examined the status of this species in 2005, 2011, and 2016, we determined that they still warranted listing as threatened (70 FR 37160; 76 FR 50448; 81 FR 33468). The ESU includes all naturally-spawned populations of chum salmon in the Columbia River and its tributaries in Washington and Oregon. Two artificial propagation programs are part of the ESU: the Grays River Program and the Washougal River Hatchery/Duncan Creek Program (79 FR 20802).

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

The Willamette/Lower Columbia River Technical Recovery Team (WLC-TRT) partitioned CR chum salmon into three strata based on ecological zones. Ecological zones range from areas at the mouth of the Columbia River that are influenced by the ocean to the Columbia River gorge above Bonneville Dam. The WLC-TRT analysis suggests that a viable ESU would need multiple viable populations in each stratum. The strata and associated populations are identified in Table 38 (Good et al. 2005).

Table 38. Historical Population Structure and Abundance of CR Chum Salmon.

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

ND = no data

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

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

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

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

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

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

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

The Lower Columbia Fish Recovery Board (LCFRB 2010) developed planning ranges for abundance of viable CR chum salmon populations (Table 39). Some abundance goals were not set; the range of abundance is from less than 100 (in the Salmon population) to 6,000 fish (in the Grays/Chinook population). Two of the populations either reach or exceed abundance targets. However, all of the populations are below the planning targets.

Table 39. Recovery Goals and Adult Escapement for CR Chum Salmon Populations (LCFRB 2010, WDFW 2016).

Population	Viability Goal	Current Viability	Abundance Goal	Adult Escapement		
				Years	Natural	Hatchery
Grays/Chinook	High+	Low+	6,000	2010-2014	6,604	421
Eloch/Skamania	High	Low	1,100	2002-2004	122	
Mill/Aber/Germany	High	V. Low	1,100	2002-2004	40	
Youngs Bay	High	Unknown				
Big Creek	Low	Unknown				

Clatskanie	Med	Unknown				
Scappoose	Low	Unknown				
Cowlitz	Med	V. Low	600			
Kalama	Low	V. Low	150			
Lewis	High	V. Low	1,100	2011-2013	36	
Salmon	V. Low	V. Low	75			
Washougal	High+	Low	5,200	2010-2014	2,440	
Clackamas	Med	Unknown				
Sandy	High	Unknown				
L. Gorge	High+	Med+	2,800	2010-2014	1,600	5
U. Gorge	Med	V. Low	600	2010-2014	106	
Total					10,644	426

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

The NWFSC publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time, however the average outmigration for the years 2011-2015 is shown in Table 40 (Dey 2012; Zabel 2013, 2014a, 2014b, 2015).

Table 40. Average Estimated Outmigration for Listed CR Chum Salmon (2011-2015).

Origin	Outmigration
Natural	3,462,120
Listed hatchery intact adipose	544,214

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

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

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

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

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

2.2.1.12 Lower Columbia River coho

Description and Geographic Range: Lower Columbia River (LCR) coho salmon was first listed as threatened on June 28, 2005 (70 FR 37160). When we re-examined the status of these fish in 2011 and 2016, we determined that they still warranted listing as threatened (76 FR 50448; 81 FR 33468). The listing includes all naturally spawned populations of coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia River up to and including the Big White Salmon and Hood Rivers, and including the Willamette River to Willamette Falls, Oregon. Twenty artificial propagation programs are part of the ESU and are also listed (79 FR 20802; Table 41).

Table 41. Hatchery Stocks Included in the LCR Coho Salmon ESU.

Artificial Propagation Program	Run	Location (State)
Grays River	Type-S	Grays River (Washington)
Peterson Coho Project	Type-S	Grays River (Washington)
Big Creek Hatchery (ODFW stock # 13)	n/a	Big Creek (Oregon)
Astoria High School (STEP) Coho Program	n/a	Youngs Bay (Oregon)

Warrenton High School (STEP) Coho Program	n/a	Youngs Bay (Oregon)
Cowlitz Type-N Coho Program	Type-N	Upper & Lower Cowlitz River (Washington)
Cowlitz Game and Anglers Coho Program	n/a	Lower Cowlitz River (Washington)
Friends of the Cowlitz Coho Program	n/a	Lower Cowlitz River (Washington)
North Fork Toutle River Hatchery	Type-S	Cowlitz River (Washington)
Kalama River Coho Program	Type-N	Kalama River (Washington)
Kalama River Coho Program	Type-S	Kalama River (Washington)
Lewis River Type-N Coho Program	Type-N	North Fork Lewis River (Washington)
Lewis River Type-S Coho Program	Type-S	North Fork Lewis River (Washington)
Fish First Wild Coho Program	n/a	North Fork Lewis River (Washington)
Fish First Type-N Coho Program	Type-N	North Fork Lewis River (Washington)
Syverson Project Type-N Coho Program	Type-N	Salmon River (Washington)
Washougal River Type-N Coho Program	Type-N	Washougal River (Washington
Eagle Creek National Fish Hatchery Program	n/a	Clackamas River (Oregon)
Sandy Hatchery (ODFW stock # 11)	Late	Sandy River (Oregon)
Bonneville/Cascade/Oxbow Complex (ODFW stock # 14)	n/a	Lower Columbia River Gorge (Oregon)

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

The LCR coho salmon ESU includes 25 populations that historically existed in the Columbia River basin from the Hood River downstream (Table 42). Until recently, Columbia River coho salmon were managed primarily as a hatchery stock. Coho were present in all lower Columbia River tributaries but the run now consists of very few wild fish. Twenty-one of the 24 populations in the ESU are at a very high risk of extinction (Table 42). It is possible that some native coho populations are now extinct, but the presence of naturally spawning hatchery fish makes it difficult to ascertain. The strongest remaining populations occur in Oregon and include the Clackamas River and Scappoose Creek (both at moderate risk of extinction).

Table 42. Historical Population Structure and Viability Status for LCR Coho Salmon (ODFW 2010; LCFRB 2010).

Stratum	Population	Viability Status		
		A&P	Spatial	Diversity
Coastal	Grays/Chinook	VL	H	VL
	Elochoman/Skamokawa	VL	H	VL
	Mill/Abernathy/Germany	VL	H	L
	Youngs	VL	VH	VL

	Big Creek	VL	H	L
	Clatskanine	L	VH	M
	Scappoose	M	H	M
Cascade	Lower Cowlitz	VL	M	M
	Upper Cowlitz	VL	M	L
	Cispus	VL	M	L
	Tilton	VL	M	L
	South Fork Toutle	VL	H	M
	North Fork Toutle	VL	M	L
	Coweeman	VL	H	M
	Kalama	VL	H	L
	North Fork Lewis	VL	L	L
	East Fork Lewis	VL	H	M
	Salmon Creek	VL	M	VL
	Washougal	VL	H	L
	Clackamas	M	VH	H
	Sandy	VL	H	M
Gorge	Lower Gorge	VL	M	VL
	White Salmon	VL	M	VL
	Hood	VL	VH	L

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

The Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) rate diversity to be low to very low in most of the coho populations (Table 42). Pervasive hatchery effects and small population bottlenecks have greatly reduced the diversity of coho salmon populations (LCFRB 2010). Hatchery-origin fish typically comprise a large fraction of the spawners in natural production areas. Widespread inter-basin (but within ESU) stock transfers have homogenized many populations. The Oregon and Washington recovery plans state that there were no observations of coho spawning in lower Columbia River tributaries during the 1980s and 1990s (ODFW 2010; LCFRB 2010). While historical population structure likely included significant genetic differences among populations in each watershed, we can no longer distinguish genetic differences in natural populations of coho salmon in the lower Columbia River (excluding the Clackamas and Sandy rivers in Oregon).

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

Table 43 displays the available information on abundance of naturally produced and hatchery LCR coho salmon. Based on the best available data and using a three-year average, the average number of LCR coho salmon spawning in the wild is 32,986 naturally produced fish and 23,082 hatchery produced fish.

Table 43. Estimated Abundance of Adult Lower Columbia River Coho Spawners (ODFW 2016a; WDFW 2016).

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

	Hood	2012-2014	477	367
	Total		23,082	32,986

The Northwest Fisheries Science Center publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time, however the average outmigration for the years 2011-2015 is shown in Table 44 (Dey 2012; Zabel 2013, 2014a, 2014b, 2015).

Table 44. Average Estimated Outmigration for Listed LCR Coho Salmon (2011-2015).

Origin	Outmigration
Natural	729,256
Listed hatchery intact adipose	300,861
Listed hatchery adipose clipped	8,446,649

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

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

Hatchery programs can harm salmonid viability in several ways: hatchery-induced genetic change can reduce fitness of wild fish; hatchery-induced ecological effects—such as increased competition for food and space—can reduce population productivity and abundance; hatchery imposed environmental changes can reduce a population's spatial structure by limiting access to historical habitat; hatchery-induced disease conveyance can reduce fish health. Practices that introduce native and non-native hatchery fish can increase predation on juvenile life stages. Hatchery practices that affect natural fish production include removal of adults for broodstock, breeding practices, rearing practices, release practices, number of fish released, reduced water quality, and blockage of access to habitat.

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

2.2.1.13 Oregon Coast coho

Description and Geographic Range: Oregon Coast (OC) coho salmon was first listed as threatened on August 10, 1998 (63 FR 42587). After a court decision and the delisting of the species, we relisted OC coho as threatened on February 11, 2008 (73 FR 7816). When we re-examined the status of this species in 2011 and 2016, we determined that they still warranted listing as threatened (76 FR 35755; 81 FR 33468). The listing includes all naturally spawned populations of coho salmon in coastal streams south of the Columbia River and north of Cape Blanco. The listing also includes the Cow Creek hatchery coho stock, produced at the Rock Creek Hatchery.

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

The Oregon/Northern California Coast Technical Recovery Team identified 56 historical coho populations for the Oregon Coast coho salmon ESU (Lawson et al. 2007). The Oregon/Northern California Coast Technical Recovery Team classified historical populations into three distinct groups: functionally independent, potentially independent, and dependent (Table 45). In general, Oregon Coast drainage basins of intermediate to large size may have supported a coho population capable of persisting indefinitely in isolation, though some of them may have been demographically influenced by adult coho straying into spawning areas from elsewhere in the ESU. Those persistent populations with minimal demographic influence from adjacent populations are classified as functionally independent (13 populations). Populations that appear to be capable of persisting in isolation but are demographically influenced by adjacent populations are classified as potentially independent (8 populations). Coho salmon populations in smaller coastal basins that may not have been able to maintain themselves continuously for periods as long as hundreds of years without the demographic boost provided by migrating spawners from other populations are classified as dependent (35 populations).

Table 45. Historical coho populations in the Oregon Coast ESU (Lawson et al. 2007).

Population	Population type	Population	Population type
Necanicum	Potentially independent	Alsea	Functionally independent
Ecola	Dependent	Big (near Alsea)	Dependent
Arch Cape	Dependent	Vingie	Dependent
Short Sands	Dependent	Yachats	Dependent
Nehalem	Functionally independent	Cummins	Dependent
Spring	Dependent	Bob	Dependent
Watseco	Dependent	Tenmile Creek	Dependent
Tillamook Bay	Functionally independent	Rock	Dependent
Netarts	Dependent	Big	Dependent
Rover	Dependent	China	Dependent
Sand	Dependent	Cape	Dependent
Nestucca	Functionally independent	Berry	Dependent
Neskowin	Dependent	Sutton (Mercer Lake)	Dependent
Salmon	Potentially independent	Siuslaw	Functionally independent
Devils Lake	Dependent	Siltcoos	Potentially independent
Siletz	Functionally independent	Tahkenitch	Potentially independent
Schoolhouse	Dependent	Threemile	Dependent
Fogarty	Dependent	Lower Umpqua	Functionally independent
Depoe Bay	Dependent	Middle Umpqua	Functionally independent
Rocky	Dependent	North Umpqua	Functionally independent
Spencer	Dependent	South Umpqua	Functionally independent
Wade	Dependent	Tenmile	Potentially independent
Coal	Dependent	Coos	Functionally independent
Moolack	Dependent	Coquille	Functionally independent
Big (near Yaquina)	Dependent	Johnson	Dependent
Yaquina	Functionally independent	Twomile	Dependent
Theil	Dependent	Floras/New	Potentially independent
Beaver	Potentially independent	Sixes	Potentially independent

Spatial structure was identified as a problem in the 1980s and 1990s when it was observed that river systems on the North Coast had substantially lower spawner escapements than those on the

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

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

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

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

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

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

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

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

Table 46. Estimated Abundance of Hatchery and Naturally Produced Adult OC Coho (ODFW 2016a).

Population	Origin	2011	2012	2013	2014	Average
Necanicum R.	Hatchery	39	0	0	98	34
	Natural	2,120	902	798	5,727	2,387
Nehalem R.	Hatchery	64	0	0	764	207
	Natural	15,322	2,963	4,539	30,577	13,350
Tillamook Bay	Hatchery	0	0	304	460	191
	Natural	19,250	1,686	4,402	20,090	11,357
Nestucca R.	Hatchery	0	0	37	0	9
	Natural	7,857	1,751	946	6,369	4,231
NC Dependents	Hatchery	0	0	0	111	28
	Natural	1,341	218	271	4,607	1,609
Salmon R.	Hatchery	0	0	0	27	7
	Natural	3,636	297	1,165	3,680	2,195
Siletz R.	Hatchery	0	0	0	71	18
	Natural	33,094	4,495	7,660	19,496	16,186
Yaquina R.	Hatchery	0	0	0	0	0
	Natural	19,074	6,268	3,553	25,582	13,619
Beaver Cr.	Hatchery	0	0	0	0	0
	Natural	2,389	1,878	2,015	6,564	3,212
Alsea R.	Hatchery	81	0	0	0	20
	Natural	28,337	8,470	9,283	25,786	17,969
Siuslaw R.	Hatchery	803	314	0	0	279
	Natural	28,082	11,946	14,118	38,896	23,261
MC Dependents	Hatchery	0	0	0	118	30
	Natural	4,487	492	1,929	1,890	2,200
Lower Umpqua R.	Hatchery	0	0	0	0	0
	Natural	18,715	3,731	7,792	36,942	16,795
Middle Umpqua R.	Hatchery	71	0	0	0	18
	Natural	19,962	2,447	4,272	13,939	10,155
North Umpqua R.	Hatchery	335	669	622	105	433
	Natural	3,679	3,134	2,774	3,979	3,392
South Umpqua R.	Hatchery	1,130	0	193	1,022	586
	Natural	49,958	11,636	12,178	11,412	21,296
Coos R.	Hatchery	0	0	0	0	0
	Natural	10,999	9,414	6,884	38,880	16,544

Coquille R.	Hatchery	442	0	148	148	185
	Natural	55,667	5,911	23,637	41,660	31,719
Floras Cr.	Hatchery	0	0	0	0	0
	Natural	9,217	2,502	1,936	1,022	3,669
Sixes R.	Hatchery	0	3	0	0	1
	Natural	334	31	567	410	336
Siltcoos Lake	Hatchery	0	0	0	0	0
	Natural	6,352	3,945	3,797	7,178	5,318
Tahkenitch Lake	Hatchery	0	0	3	0	1
	Natural	6,665	5,675	3,413	3,691	4,861
Tenmile Lake	Hatchery	0	0	0	0	0
	Natural	7,284	9,302	6,449	11,141	8,544
Total	Hatchery	2,965	986	1,307	2,924	2,046
	Natural	353,821	99,094	124,378	359,518	234,203

While we currently lack data on how many natural juvenile coho salmon this ESU produces, it is possible to make rough estimates of juvenile abundance from adult return data. The three-year average of natural origin spawners for the years 2010-2012 is estimated at 229,872 total spawners (Table 33). Sandercock (1991) published fecundity estimates for several coho salmon stocks; average fecundity ranged from 1,983 to 5,000 eggs per female. By applying a very conservative value of 2,000 eggs per female to an estimated 115,000 females returning (roughly half of 229,872) to this ESU, one may expect approximately 230 million eggs to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around 7%. Thus, we can estimate that roughly 16 million juvenile coho salmon are produced annually by the Oregon Coast ESU.

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

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

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

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

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

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

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

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

2.2.1.14 Southern Oregon/Northern California Coast coho

Description and Geographic Range: The Southern Oregon/Northern California Coasts (SONCC) coho salmon was first listed as threatened on May 6, 1997. When we re-examined the status of these fish in 2005, 2011, and 2016, we determined that they still warranted listing as threatened (70 FR 37160; 76 FR 50447; 81 FR 33468). The listing includes all naturally spawned populations of coho salmon in coastal streams between Cape Blanco, Oregon, and Punta Gorda, California. The ESU includes coho salmon from three hatchery programs: the Cole Rivers Hatchery Program (ODFW Stock #52); Trinity River Hatchery Program; and the Iron Gate Hatchery Program (79 FR 20802).

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

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

The interior sub-basin strata were divided into substrata representing the three major sub-basins of the Rogue, Klamath, and Eel basins (Table 47). However, sufficient geographical and environmental variability occurs within the Klamath basin, therefore the Klamath basin was split into sub-strata of the Klamath River (upstream of the confluence with the Trinity River) and the Trinity River. The lower portions of these three large basins were included in the coastal basins sub-strata because they are more similar to other coastal basins in terms of the environmental and ecological characteristics examined than interior portions of the large basins.

Table 47. Arrangement of historical populations of the Southern Oregon/Northern California Coast coho salmon ESU. Population types are functionally independent (F), potentially independent (P), dependent (D) and, ephemeral (E).

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

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

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

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

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

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

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

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

Recent returns of naturally-produced adults to the Rogue, Trinity, Shasta, and Scott rivers have been highly variable. Wild coho salmon estimates derived from the beach seine surveys at Huntley Park on the Rogue River ranged from 414 to 24,481 naturally produced adults between

2003 and 2012 (Table 48). Similar fluctuation are noted in the Trinity, Shasta, and Scott river populations. Overall, the average annual abundance, for populations where we have abundance data, of naturally produced fish is only 5,586. However, abundance data is lacking for the Eel, Smith, and Chetco rivers, the other major populations in the ESU, as well as the numerous smaller coastal populations. Actual abundance is therefore likely to be higher than this estimate.

Table 48. Estimates of the Natural and Hatchery Adult Coho Returning to the Rogue, Trinity, and Klamath rivers (ODFW 2016a, Kier et al 2015, CDFW 2012).

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

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

While we currently lack data on naturally-produced juvenile coho salmon production, it is possible to make rough estimates of juvenile abundance from adult return data. Quinn (2005) published estimates for salmonids in which average fecundity for coho salmon is 2,878 eggs per female. By applying the average fecundity of 2,878 eggs per female to the estimated 9,995 females returning (half of the average total number of spawners), approximately 28 million eggs may be expected to be produced annually. Nickelson (1998) found survival of coho from egg to parr in Oregon coastal streams to be around 7%. Thus, we can state that the ESU could produce roughly 2 million juvenile natural SONCC coho salmon each year. In addition, hatchery managers could produce approximately 775,000 listed hatchery juvenile coho each year (Table 49).

Table 49. SONCC Coho Salmon Listed Hatchery Stock Annual Juvenile Production Goals (ODFW 2010f;California HSRG 2012).

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

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

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

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

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

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

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

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

2.2.1.15 Central California Coast coho

Description and Geographic Range: This ESA includes all naturally spawned coho salmon originating from rivers south of Punta Gorda, California to and including Aptos Creek, as well as coho salmon originating from tributaries to San Francisco Bay. The Central California Coast (CCC) coho salmon ESU was originally listed as threatened in 1996 (61 FR 56138). In 2005 following a reassessment of its status and after applying NMFS' hatchery listing policy, we reclassified the ESU as endangered and listed several conservation hatchery programs (Don Clausen Fish Hatchery Captive Broodstock Program; the Scott Creek/King Fisher Flats Conservation Program; and the Scott Creek Captive Broodstock program) that were associated with the ESU (70 FR 37160).

Historically, the Central California Coast (CCC) coho salmon ESU comprised approximately 76 coho salmon populations. Most of these were dependent populations that needed immigration from other nearby populations to ensure their long term survival. Historically, there were 11 functionally independent populations and one potentially independent population of CCC coho salmon (Spence et al. 2008, Spence et al. 2012). Adams et al. (1999) found that in the mid 1990's coho salmon were present in only 51 percent (98 of 191) of the streams where they were historically present, although coho salmon were documented in 23 additional streams within the CCC coho salmon ESU for which there were no historical records. Recent genetic research by the SWFSC and the Bodega Marine Laboratory has documented a reduction in genetic diversity within subpopulations of the CCC coho salmon ESU (Bjorkstedt et al. 2005).

Abundance and Productivity: Brown et al. (1994) estimated that annual spawning numbers of coho salmon in California ranged between 200,000 and 500,000 fish in the 1940's, which declined to about 100,000 fish by the 1960's, followed by a further decline to about 31,000 fish by 1991. More recent abundance estimates vary from approximately 600 to 5,500 adults (Good et al. 2005). Recent status reviews (Good et al. 2005; Williams et al. 2011; NMFS 2016c) indicate that the CCC coho salmon are likely continuing to decline in number and many independent populations that supported the species overall numbers and geographic distributions have been extirpated. The current average run size for the CCC coho salmon ESU is 1,621 fish (1,294 natural-origin; 327 hatchery produced).

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. 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 647 females returning (50% of the run) to this ESU, one may expect approximately 1.3 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 90,000 juvenile coho salmon are produced annually by the CCC coho ESU.

Threats and Limiting Factors: Most of the populations in the CCC coho salmon ESU are currently doing poorly; low abundance, range constriction, fragmentation, and loss of genetic diversity is documented. The near-term (10 - 20 years) viability of many of the extant independent CCC coho salmon populations is of serious concern. These populations may not have enough fish to survive additional natural and human caused environmental change. NMFS has determined that currently depressed population conditions are, in part, the result of the following human-induced factors affecting critical habitat[27]: logging, agriculture, mining, urbanization, stream channelization, dams, wetland loss, and water withdrawals (including unscreened diversions for irrigation). Impacts of concern include altered stream bank and channel morphology, elevated water temperature, lost spawning and rearing habitat, habitat fragmentation, impaired gravel and wood recruitment from upstream sources, degraded water quality, lost riparian vegetation, and increased erosion into streams from upland areas (Weitkamp et al. 1995; Busby et al. 1996; 64 FR 24049; 70 FR 37160; 70 FR 52488). Diversion and storage of river and stream flow has dramatically altered the natural hydrologic cycle in many of the streams within the ESU.

2.2.1.16 Lake Ozette sockeye

Description and Geographic Range: On March 25 1999, NMFS listed the OL sockeye salmon as a threatened species (64 FR 14528). The ESU includes all naturally spawned sockeye salmon originating from the Ozette River and Ozette Lake and its tributaries. Also, sockeye salmon from two artificial propagation programs: the Umbrella Creek Hatchery Program; and the Big River Hatchery Program (79 FR 20802). The Umbrella Creek and Big River sockeye hatchery programs (Table 50) were developed in 1982 to augment the beach spawning population and are limited to releases through 2012, at which time it will be reevaluated (Ford 2011). Under the final listing in 2005, the section 4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

Table 50. Expected 2016 Ozette Lake juvenile sockeye salmon hatchery releases (WDFW 2015).

Subbasin	Artificial propagation program	Brood year	Clipped Adipose Fin	Intact Adipose Fin
Hoh-Quillayute	Stony Creek	2015	45,750	137,250
	Umbrella Creek	2015	-	122,000
Total Annual Release Number			**45,750**	**259,250**

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

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

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

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

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

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

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

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

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

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

Abundance and Productivity: Historical abundance of OL sockeye salmon has been estimated from weir counts and harvest records. The earliest attempt to quantify the size of the OL sockeye salmon run occurred in 1924-1926 when the U.S. Fish and Wildlife Service (FWS) installed and operated a counting weir downstream from the lake's outlet in the Ozette River (Haggerty et al. 2009). However, the weir deployment missed the early part of the run; and weir counts did not account for the number of sockeye salmon harvested. Between 1948 and 1976, the Washington

Department of Fisheries collected harvest data; but no escapement data was collected for those years. Estimates made from these data sets indicate a maximum escapement of a few thousand sockeye salmon in 1926 and a peak harvest of more than 17,000 in 1949 (Gustafson et al. 1997). However, in some years the total run size may have been more than 1949's peak-recorded harvest. Blum (1988) speculated that before the 1940s, the OL sockeye salmon run-size exceeded 50,000 fish.

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

In 1977, the FWS, USGS, and the Makah Tribe installed a counting weir in the Ozette River, near the lake's outlet. The methods used to enumerate and estimate Lake Ozette sockeye run sizes changed several times between 1977 and the present. Methods ranged from nighttime weir counts (1977-1981), 24-hour counts (1982, 1984, 1986), visual – hour counts with an underwater video camera (1998-2003). In 1998, the operation period was expanded to include earlier starting and later ending dates. The changes in 1998 allowed for a more complete count of all fish passing the weir. It is likely that counts for previous years underestimated total spawner abundance, but the magnitude of this bias is unknown. Since 2004, survey data appears to be scantly and of poor quality with the Makah Tribe not making any total spawning estimates for these years. Beginning in 2011, dual frequency identification sonar (ARIS) surveys began along the main spawning beaches in Lake Ozette (Haggerty and Makah Fisheries Management 2013). Due to predation problems at the Ozette River weir and poor visibility at the spawning beaches, the ARIS surveys were chosen to count OL sockeye; and after a few years of data calibration, the goal is to remove the weir from the Ozette River (NMFS 2016c). From 2012 onward, all abundance data is preliminary and has not been published. From 2007 through 2011, the current average run size is 2,321 adult spawners (2,143 natural-origin and 178 hatchery origin spawners; Table 51) for the ESU.

Table 51. Five-year geometric means (2007-2011) for adult natural-origin and hatchery-origin spawners for the OL sockeye salmon ESU (NWFSC 2015).

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

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

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

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

Listed hatchery sockeye abundance can be estimated from the annual hatchery production goals. Hatchery production varies from year to year due to several factors including funding, equipment failures, human error, disease, and adult spawner availability. The uncertainty in funding and the inability to predict equipment failures, human error, and disease suggests that an average production from past years is not a reliable indication of production in the coming years. For these reasons, abundance is assumed to be equal to the production goals. The combined hatchery production goal for listed OL sockeye is 305,000 juvenile sockeye salmon (Table 51).

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

2.2.1.17 Snake River sockeye

Description and Geographic Range: The SR sockeye salmon ESU was listed as endangered on November 20, 1991 (NOAA 1991). It includes all populations of sockeye salmon from the Snake River Basin, Idaho (extant populations occur only in the Salmon River subbasin). Under NMFS' interim policy on artificial propagation (NOAA 1993a), the progeny of fish from a listed population that are propagated artificially are considered part of the listed species and are protected under ESA. Thus, SR sockeye salmon produced in the Idaho Department of Fish and Game's (IDFG's) captive broodstock program are included in the Listed ESU. There is a recovery plan for this species (NMFS 2015b).

Sockeye salmon adults enter the Columbia River primarily during June and July. Arrival of natural-origin adults at the Redfish Lake Creek trap and broodstock-origin adults at the trap and the Sawtooth Hatchery weir peaks in August. Natural spawning occurs only in Redfish Lake and primarily in October (Bjornn et al. 1968). Eggs hatch in the spring between 80 and 140 days after spawning. Fry remain in the gravel for three to five weeks, emerge from April through May, and move immediately into the lake. Once there, juveniles feed on plankton for one to three years before they migrate to the ocean (Bell 1986). Migrants leave Redfish Lake during late April through May (Bjornn et al. 1968) and travel almost 900 miles to the Pacific Ocean. Smolts reaching the ocean remain inshore or within the influence of the Columbia River plume during the early summer months. Later, they migrate through the northeast Pacific Ocean (Hart 1973, Hart and Dell 1986). Sockeye salmon spend two to three years in the Pacific Ocean and return in their fourth or fifth year of life.

Four adult sockeye salmon returned to Redfish Lake in 1991; they were taken into captivity to join several hundred smolts collected in spring 1991 as they outmigrated from Redfish Lake. The adults were spawned and their progeny reared to adulthood along with the outmigrants as part of a captive broodstock program, whose major goal was to perpetuate the gene pool for a short period of time (one or two generations) to give managers a chance to identify and address the most pressing threats to the population. Genetic data collected from the returning adults and the outmigrants showed that they were genetically similar but distinct from the Fishhook Creek kokanee. However, otolith microchemistry data indicated that many of the outmigrants did have a resident female parent. These results inspired a search of Redfish Lake for another population of resident fish that was genetically similar to the sockeye. These efforts led to discovery of a relatively small number (perhaps a few hundred) kokanee-sized fish that spawn at approximately the same time and place as the sockeye. These fish, termed residual sockeye salmon, are considered to be part of the listed ESU. Subsequent genetic analysis (Waples et al. 1991a) established the following relationships between extant populations of *O. nerka* from the Stanley Basin and other populations in the Pacific Northwest:

At present, anadromous returns are dominated by production from the captive spawning component. The ongoing reintroduction program is still in the phase of building sufficient returns to allow for large scale reintroduction into Redfish Lake, the initial target for restoring natural production (NMFS 2015b). Initial releases of adult returns directly into Redfish Lake have been observed spawning in multiple locations along the lake shore as well as in Fishhook Creek (NMFS 2015b). There is some evidence of very low levels of early timed returns in some recent years from outmigrating naturally produced Alturas Lake smolts. At this stage of the recovery efforts, the ESU remains rated at High Risk for both spatial structure and diversity.

Although total sockeye salmon returns to the Sawtooth Basin in recent years have been high enough to allow for some level of spawning in Redfish Lake, the hatchery program remains in its initial phase with a priority on genetic conservation and building sufficient returns to support sustained outplanting (NMFS 2015b).

Abundance and Productivity: Given the dire status of the species under any criteria (a recent peak of 150 natural and 950 hatchery adult sockeye returned to the Stanley basin in 2011), NMFS considers the captive broodstock and its progeny essential for recovery. Between 1997 and 2005, approximately 400 hatchery sockeye returned to the Stanley basin, total. Only 16 naturally produced adults returned to Redfish Lake between the time the Snake River sockeye ESU was listed as an endangered species in 1991 and 2005. Since that time, there has been a considerable improvement in the sockeye returns. From 2009 through 2012, an average of 1,348 adult sockeye (all from the broodstock program) passed Lower Granite Dam on their way to Redfish Lake. The year 2012 saw the lowest numbers of that period—with only 470 fish being counted at Lower Granite Dam. These numbers have been updated somewhat with the 2014 returns—which numbered 2,786 fish. The new four-year average return to Lower Granite Dam (through 2014) is 1,373. The average number of returning adults to the Stanley basin from 2010 to 2014 was 916 (NWFSC 2015). Unfortunately, though, 2015 was a very bad year in which only a few dozen sockeye returned to the basin. The reason was high water temperatures along their migration route.

Each spring, the NWFSC produces a memorandum estimating the number of listed Pacific salmon and steelhead smolts expected to arrive at various locations in the Columbia River basin. The averages of the five most recent projections for the SR sockeye salmon juvenile emigrants are displayed below.

Table 52. Recent Five-Year Average Projected Outmigrations for SR Sockeye (Ferguson 2010; Dey 2012; Zabel 2013; Zabel 2014a; Zabel 2014b).

Origin	Outmigration
Natural	15,960
Listed Hatchery: Adipose Clipped*	136,489

*When the above species was listed, NMFS included fish from a captive broodstock program. Those listed fish have had their adipose fins clipped.

The Biological Review Team (BRT), reviewing the status of the species in 2010 (Ford 2011), found that the recent increase in returns of hatchery-reared Snake River sockeye has reduced the risk of immediate loss, but that levels of naturally produced returns remain extremely low. Although the biological risk status of the ESU appeared to be on an improving trend, the new information did not indicate a change in category (extremely high risk) since the 2005 BRT status review. That assessment remained unchanged in the 2015 review.

Abundance and Productivity: The only real source of productivity for this ESU is the Redfish Lake Captive Broodstock Program. Unfortunately, the BRT's assessment of the effects of artificial propagation on ESU extinction risk concluded that the Redfish Lake Captive Broodstock Program does not substantially reduce the extinction risk of the ESU in-total (70 FR 37160). Nonetheless, The Artificial Propagation Evaluation Workshop noted that the Captive Broodstock Program has *prevented* likely extinction of the ESU. This program has increased the total number of anadromous adults, increased the number of lakes in which sockeye salmon are present in the upper Salmon River (Sawtooth Valley), and preserved what genetic diversity remained in the ESU at the time the population went through a bottleneck (circa 1990). The majority of the ESU resides in the captive program composed of only a few hundred fish. The long-term effects of captive rearing are unknown. The consideration of artificial propagation does not substantially mitigate the BRT's assessment of extreme risks to ESU abundance, productivity, spatial structure, and diversity.

Limiting Factors and Threats: SR sockeye travel further inland—approximately 900 miles—than any other Pacific salmon. They pass through mainstem Snake and Salmon Rivers, the South Fork Salmon River and move up to the Stanley basin to their one remaining spawning ground in Redfish Lake, Idaho. The area is generally a mix of dry forest, upland steppe, and semi-arid grassland. The key factor limiting recovery of SR sockeye salmon ESU is survival outside of the Stanley Basin. Portions of the migration corridor in the Salmon River are impaired by reduced water quality and elevated temperatures (Idaho Department of Environmental Quality 2011). The natural hydrological regime in the upper mainstem Salmon River Basin has been altered by water withdrawals. Survival rates from Lower Granite dam to the spawning grounds are low in some years (e.g., average of 31%, range of 0-67% for 1991-1999) (Keefer et al. 2008). Keefer et al. (2008) conducted a radio tagging study on adult SR sockeye salmon passing upstream from Lower Granite Dam in 2000 and concluded that high in-river mortalities could be explained by "a combination of high migration corridor water temperatures and poor initial fish condition or parasite loads." Keefer et al. (2008) also examined current run timing of SR sockeye salmon versus records from the early 1960s, and concluded that an apparent shift to earlier run timing recently may reflect increased mortalities for later migrating adults. In the Columbia and lower Snake River migration corridor, predation rates on juvenile sockeye salmon are unknown, but terns and cormorants consume 12% of all salmon smolts reaching the estuary, and piscivorous fish consume an estimated 8% of migrating juvenile salmon (NMFS 2011).

2.2.1.18 Puget Sound steelhead

Description and Geographic Range: On August 9, 1996, NMFS determined that the PS steelhead DPS did not warrant listing (61 FR 41541). In response to a petition received on September 13, 2004, NMFS updated the species' status review. On May 7, 2007, NMFS listed PS steelhead—both natural and some artificially-propagated fish—as a threatened species (72 FR 26722). NMFS concluded that the PS steelhead DPS was likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Six artificial propagation programs were listed as part of the DPS (79 FR 20802; Table 53), including: Green River Natural Program, White River Winter Steelhead Supplementation Program, Hood Canal Steelhead Supplementation Off-station Projects in the Dewatto, Skokomish, and Duckabush Rivers, and Lower Elwha Fish Hatchery Wild Steelhead Recovery Program. NMFS promulgated 4(d) protective regulations for PS steelhead on September 25, 2008 (73 FR 55451). The section 4(d) protections (and limits on them) apply to natural and hatchery PS steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed.

Table 53. Expected 2016 Puget Sound steelhead listed hatchery releases (WDFW 2015).

Subbasin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Dungeness/Elwha	Dungeness	2015	Winter	10,000	-
Duwamish/Green	Flaming Geyser	2015	Winter	-	15,000
	Icy Creek	2015	Summer	20,000	-
			Winter	35,000	23,000
	Soos Creek	2015	Summer	30,000	-
			Winter	35,000	-
Hood Canal	LLTK – Lilliwaup	2012	Winter	230	-
		2014	Winter	14,067	-
Puyallup	White River	2015	Winter	-	35,000
Skokomish	LLTK - Lilliwaup	2013	Winter	-	6,000
	McKernan	2013	Winter	21,600	-
Total Annual Release Number				**165,897**	**79,000**

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

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

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

Although Puget Sound DPS steelhead populations include both summer- and winter-run life-history types, winter-run populations predominate. For the PS steelhead DPS, Myers et al. (2015) identified three Major Population Groups (MPGs) and 32 Demographically Independent Populations (DIPs) composed of 27 winter-run and nine summer-run steelhead stocks (Table 54). Summer-run stock statuses are mostly unknown; however, most appear to be small, averaging less than 200 spawners annually (Hard et al. 2007). Summer-run stocks are primarily concentrated in the northern Puget Sound and the Dungeness River (Myers et al. 2015).

Table 54. PS steelhead historical Demographically Independent Populations (DIPs), runs, and estimated capacities (Myers et al. 2015).

Central and South Puget Sound MPG		
Cedar River	Winter	5,949 – 11,899
N Lake Washington/Lake Sammamish	Winter	5,268 – 10,536
Green River	Winter	19,768 – 39,537
Puyallup/Carbon River	Winter	14,716 – 29,432
White River	Winter	17,490 – 34,981
Nisqually River	Winter	15,330 – 30,660
South Puget Sound Tributaries	Winter	9,854 – 19,709
East Kitsap Peninsula Tributaries	Winter	1,557 – 3,115
	TOTAL	**89,932 – 179,869**
Hood Canal and Strait of Juan de Fuca MPG		
East Hood Canal Tributaries	Winter	1,270 – 2,540
South Hood Canal Tributaries	Winter	2,985 – 5,970
Skokomish River	Winter	10,030 – 20,060
West Hood Canal Tributaries	Winter	3,608 – 7,217
Sequim/Discovery Bays Independent Tributaries	Winter	512 – 1,024
Dungeness River	Summer; Winter	2,465 – 4,930
Strait of Juan de Fuca Independent Tributaries	Winter	728 – 1,456
Elwha River	Winter	7,116 – 14,231
	TOTAL	**28,714 – 57,428**
North Cascades MPG		
Drayton Harbor Tributaries	Winter	2,426 – 4,852
Nooksack River	Winter	22,045 – 44,091
SF Nooksack River	Summer	1,137 – 2,273
Samish River and Bellingham Bay Tributaries	Winter	3,193 – 6,386
Skagit River	Summer; Winter	64,775 – 129,551
Nookachamps Creek	Winter	1,231 – 2,462
Baker River	Summer; Winter	5,028 – 10,056
Sauk River	Summer; Winter	23,230 – 46,460
Stillaguamish River	Winter	19,118 – 38,236
Deer Creek	Summer	1,572 – 3,144
Canyon Creek	Summer	121 - 243
Snohomish/Skykomish River	Winter	21,389 – 42,779
Pilchuck River	Winter	5,193 – 10,386
NF Skykomish River	Summer	663 – 1,325
Snoqualmie River	Winter	16,740 – 33,479

Demographically Independent Populations	Run(s)	Population Capacity
Tolt River	Summer	321 - 641
	TOTAL	**188,182 – 376,364**
	GRAND TOTAL	**306,828 – 613,661**

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

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

Artificial propagation is a major factor affecting the genetic diversity of both summer- and winter-run steelhead in the Puget Sound DPS. Although offsite releases and releases of steelhead fry and parr have largely ceased in the DPS, annual hatchery steelhead smolt releases derived from non-local steelhead (Skamania summer-run steelhead) or domesticated steelhead originally found within the DPS (Chambers Creek winter-run steelhead) persist in most systems. And several of these releases are still composed of tens or hundreds of thousands of fish. This sustained hatchery management practice has increased the likelihood of interbreeding and ecological interaction between wild and hatchery fish—in spite of the apparent differences in average spawning time and its associated adverse fitness consequences for both summer- and winter-run steelhead. As NMFS (2005a) noted, even low levels (e.g., <5%) of gene flow per year from a non-DPS hatchery stock to a naturally spawning population can have a significant genetic impact after several generations. For 2016, 1.15 million hatchery steelhead are expected to be released throughout the range of the PS steelhead DPS (WDFW 2015).

Abundance and Productivity: Historical Puget Sound steelhead abundance is largely based on catch records. Catch records from 1889 to 1920 indicate that catch peaked at 163,796 steelhead in 1895. Using harvest rates of 30-50%, the estimated peak run size for Puget Sound would range from 327,592 to 545,987 fish. Myers et al. (2015) estimated historic PS steelhead abundance at 306,828 to 613,661 based upon geographic, hydrologic, and ecological characteristics (Table 54). In the 1980s, Light (1987) estimated the steelhead run size at approximately 100,000 winter-run and 20,000 summer-run steelhead. However, as many as 70% of the run were first generation hatchery fish (Hard et al. 2007). By the mid-1990s, Busby et al. (1996) estimated a total run of 45,000 (winter- and summer-run combined). Since then, DPS escapement (total spawners) has decreased to 17,363 (2000-2004), 15,926 (2005-2009), and 13,422 (2010-2014; Tables 55 and

56).

Steelhead are most abundant in the North Cascades MPG, with the Skagit and Nooksack rivers supporting the two largest winter-run steelhead DIPs (Table 56). The Snohomish/Snoqualmie DIP used to support the second largest DIP for the DPS, but this DIP has declined by 83% during the last five years (NWFSC 2015). Currently, neither the Central and South Puget Sound MPG nor the Hood Canal and Strait of Juan de Fuca MPG DIPs have averaged greater than 600 spawners annually.

Table 55. Abundance–five-year geometric means for adult (age 3+) natural origin and total spawners (natural and hatchery origin – in parenthesis) for the ESU with percent change between the most recent two 5-year periods shown on the far right column (NWFSC 2015).

Demographically Independent Populations	Geometric means					
	1990-1994	**1995-1999**	**2000-2004**	**2005-2009**	**2010-2014**	**% Change**
Central and South Puget Sound MPG						
Cedar River	(321)	(298)	(37)	(12)	(4)	(-67)
Green River	1,566 (1,730)	2,379 (2,505)	1,618 (1,693)	(716)	(552)	(-23)
Nisqually River	1,201 (1,208)	759 (759)	394 (413)	278 (375)	(442)	(18)
N. Lake WA/Lake Sammamish	321 (321)	298 (298)	37 (37)	12 (12)	-	-
Puyallup/Carbon River	1,156 (1,249)	1,003 (1,134)	428 (527)	315 (322)	(277)	(-14)
White River	696 (696)	519 (519)	466 (466)	225 (225)	531 (531)	136 (136)
Hood Canal and Strait of Juan de Fuca MPG						
Dungeness River	356 (356)	-	38 (38)	24 (25)	-	-
East Hood Canal Tribs.	110 (110)	176 (176)	202 (202)	62 (62)	60 (60)	-3 (-3)
Elwha River	206 (358)	127 (508)	(303)	-	(237)	-
Sequim/Discovery Bay Tribs	(30)	(69)	(63)	(17)	(19)	(12)
Skokomish River	385 (503)	359 (359)	205 (259)	351 (351)	(580)	(65)
South Hood Canl Tribs	89 (89)	111 (111)	103 (103)	113 (113)	64 (64)	-43 (-43)
Strait of Juan de Fuca Tribs	89 (89)	191 (191)	212 (212)	101 (101)	147 (147)	46 (46)
West Hood Canal Tribs	-	97 (97)	210 (210)	149 (174)	(74)	(-50)
North Cascades MPG						
Nooksack River	-	-	-	-	1,693 (1,745)	-
Pilchuck River	1,225 (1,225)	1,465 (1,465)	604 (604)	597 (597)	614 (614)	3 (3)
Samish River/ Bellingham Bay Tribs	316 (316)	717 (717)	852 (852)	534 (534)	846 (846)	58 (58)
Skagit River	7,189 (7,650)	7,656 (8,059)	5,424 (5,675)	4,767 (5,547)	(5,123)	(7)
Snohomish/Skykomish Rivers	6,654 (7,394)	6,382 (7,200)	3,230 (3,980)	4,589 (5,399)	(930)	(-83)
Snoqualmie River	1,831 (1,831)	2,056 (2,056)	1,020 (1,020)	944 (944)	680 (680)	-28 (-28)
Stillaguamish River	1,078 (1,078)	1,024 (1,166)	401 (550)	259 (327)	(392)	(20)
Tolt River	112 (112)	212 (212)	119 (119)	73 (73)	105 (105)	44 (44)

Table 56. Abundance of PS steelhead spawner escapements (natural-origin and hatchery production combined) from 2010-2014 (NWFSC 2015).

Central and South Puget Sound MPG		
Cedar River	4	455
Green River	552	62,790
Nisqually River	442	50,278
N. Lake WA/Lake Sammamish	-	-
Puyallup/Carbon River	277	31,509
White River	531	60,401
Hood Canal and Strait of Juan de Fuca MPG		
Dungeness River	-	-
East Hood Canal Tribs.	60	6,825
Elwha River	237	26,959
Sequim/Discovery Bay Tribs.	19	2,161
Skokomish River	580	65,975
South Hood Canal Tribs.	64	7,280
Strait of Juan de Fuca Tribs.	147	16,721
West Hood Canal Tribs.	74	8,418
North Cascades MPG		
Nooksack River	1,745	198,494
Pilchuck River	614	69,843
Samish River/ Bellingham Bay Tribs.	846	96,233
Skagit River	5,123	582,741
Snohomish/Skykomish Rivers	930	105,788
Snoqualmie River	680	77,350
Stillaguamish River	392	44,590
Tolt River	105	11,944
TOTAL	**13,422**	**1,526,753**

[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.

The average abundance (2010-2014) for the PS steelhead DPS is 13,422 adult spawners (natural-origin and hatchery production combined). Juvenile PS steelhead abundance estimates is calculated from the escapement data (Table 56). 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 (6,711 females), 23.49 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 1.53 million natural outmigrants annually.

Linear regressions of smoothed log natural spawner abundance were applied to PS steelhead DIPs for two 15-year time series trend analyses (1990-2005 and 1999-2014) (NWFSC 2015). For the 1990-2005 time series, trends were negative for 12 of 17 DIPs; and for the 1999-2014 time series, seven of eight DIPs had negative trends (Table 57). Only the Samish River/Bellingham Bay tributaries DIP had a positive trend for both time series (NWFSC 2015).

Table 57. Fifteen year trends for PS steelhead for two time series – 1990-2005 and 1999-2014 (NWFSC 2015).

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

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

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

2.2.1.19 Lower Columbia River steelhead

Description and Geographic Range: The Lower Columbia River (LCR) steelhead DPS was first listed as a threatened species on March 19, 1998 (63 FR 13347). When we re-examined the status of this species in 2006, 2011, and 2016 we determined that it still warranted listing as threatened (71 FR 834, 76 FR 50448, 81 FR 33468). The listing included all naturally spawned populations of steelhead in streams and tributaries to the Columbia River between the Cowlitz and Wind Rivers, Washington (inclusive) and the Willamette and Hood Rivers, Oregon (inclusive). Steelhead in the upper Willamette River basin above Willamette Falls and steelhead from the Little and Big White Salmon Rivers in Washington are excluded. This DPS includes steelhead from seven artificial propagation programs: the Cowlitz Trout Hatchery Late Winter-run Program; Kalama River Wild Winter-run and Summer-run Programs; Clackamas Hatchery Late Winter-run Program; Sandy Hatchery Late Winter-run Program; Hood River Winter-run Program; and the Lewis River Wild Late-run Winter Steelhead Program.

The LCR steelhead DPS includes 30 historical populations in five strata (Table 58). LCR steelhead have both winter and summer runs, and several river basins have both (e.g., Kalama River, Sandy River, Clackamas River, and Hood River). Most steelhead in the Lower Columbia River smolt at two years and spend two years in salt water before re-entering fresh water, where they may remain up to a year before spawning. Juvenile life stages (i.e., eggs, alevins, fry, and parr) inhabit freshwater/riverine areas throughout the range of this listed species. Parr usually undergo a smolt transformation as 2-year-olds, at which time they migrate to the ocean. Subadults and adults forage in coastal and offshore waters of the North Pacific Ocean before returning to spawn in their natal streams.

Table 58. Historical Population Structure and Viability Status for LCR Steelhead (ODFW 2010; LCFRB 2010).

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

	Washougal	L	VH	M
	Clackamas	M	VH	M
	Sandy	L	M	M
Cascade (Summer)	Kalama	H	VH	M
	North Fork Lewis	VL	VL	VL
	East Fork Lewis	VL	VH	M
	Washougal	M	VH	M
Gorge (Winter)	Lower Gorge	L	VH	M
	Upper Gorge	L	M	M
	Hood	M	VH	M
Gorge (Summer)	Wind	VH	VH	H
	Hood	VL	VH	M

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

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

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

The Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) rate diversity to be moderate to high in all but one population (Table 58). One of the leading factors affecting the diversity of this DPS is the loss of habitat associated with construction of dams. As described above, many of the historical populations were affected by dams built 60 to 90 years ago in upper tributaries.

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

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

The recovery plans identified 16 populations as currently at low to very low viability and five with moderate viability. The Wind River and Kalama River summer-run populations are the only ones that rated high to very high for abundance and productivity. The Oregon and Washington recovery plans (ODFW 2010; LCFRB 2010) developed planning ranges for abundance of viable LCR steelhead populations (Table 59). Some abundance goals were not set; the range of abundance is from 322 in the Upper Gorge to 10,655 in the Clackamas. The viability ratings are based on long-term trends whereas recent abundance estimates show a slightly different picture (Table 59). Several populations appear to be approaching the abundance targets, and one (the E.F. Lewis) exceeded it.

Data availability for abundance of naturally spawning adult steelhead is highly variable (Table 59). The years of record vary considerably for each population and for some populations we could only find one data year. Based on the best available data, the estimated spawning population of LCR steelhead is 22,297 hatchery origin and 12,920 natural origin adult spawners.

Table 59. Abundance Estimates for LCR Steelhead Populations (Streamnet 2016; WDFW 2016; ODFW 2016a).

Stratum (Run)	Population	Years	Total	HOR(1)	NOR(2)	Recovery Target(3)
Cascade (Winter)	Lower Cowlitz	2009	4,559	4559		
	Upper Cowlitz/Cispus	2010-2014	489	51	438	500
	Tilton	2010-2013	279	0	279	200
	South Fork Toutle	2010-2014	508	7	501	500
	North Fork Toutle	2010-2014	507	121	387	600
	Coweeman	2010-2014	462	166	296	600

	Kalama	2011-2015	930	455	475	600
	North Fork Lewis	2007-2011	2,355	2,126	129	400
	East Fork Lewis	2010-2014	364	0	364	500
	Washougal	2010-2014	362	195	167	350
	Clackamas	2014-2015	5,483	1,876	3,607	10,655
	Sandy	2013-2015	4,094	284	3,810	1,510
Cascade (Summer)	Kalama	2011-2015	626	499	127	500
	North Fork Lewis	2009	10,508	10,508		
	East Fork Lewis	2011-2015	928	168	760	500
	Washougal	2012-2015	723	621	102	500
Gorge (Winter)	Upper Gorge	2010-2014	36		36	322
	Hood	2003-2007	818	380	438	1,633
Gorge (Summer)	Wind	2010-2014	805	42	763	1,000
	Hood	2003-2007	480	239	241	1,988
	Total		35,316	22,297	12,920	

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

The Northwest Fisheries Science Center publishes juvenile abundance estimates each year in the annual memorandum estimating percentages of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. Numbers for 2015 are not available at this time; however the average outmigration for the years 2011-2015 is shown in Table 60 (Dey 2012; Zabel 2013, 2014a, 2014b, 2015).

Table 60. Average Estimated Outmigration for Listed LCR Steelhead (2011-2015).

Origin	Outmigration
Natural	393,641
Listed hatchery intact adipose	449
Listed hatchery adipose clipped	1,079,744

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

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

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

Hatchery programs can harm salmonid viability in several ways: hatchery-induced genetic change can reduce fitness of wild fish; hatchery-induced ecological effects—such as increased competition for food and space—can reduce population productivity and abundance; hatchery imposed environmental changes can reduce a population's spatial structure by limiting access to historical habitat; hatchery-induced disease conveyance can reduce fish health. Practices that introduce native and non-native hatchery fish can increase predation on juvenile life stages. Hatchery practices that affect natural fish production include removal of adults for broodstock, breeding practices, rearing practices, release practices, number of fish released, reduced water quality, and blockage of access to habitat.

2.2.1.20 Middle Columbia River steelhead

MCR steelhead were first listed as a threatened species on March 5, 1999 (64 FR 14517). That status was reaffirmed on January 5, 2006 (71 FR 834); the listing includes all naturally spawned steelhead populations beginning upstream from the Wind River in Washington and the Hood River in Oregon and proceeding to the Yakima River, Washington. It does not include fish from the Snake River basin. Fish from seven artificial propagation programs were also listed—the Touchet River, Satus Creek, Toppenish Creek, Naches River, Upper Yakima River, Umatilla River, and Deschutes River stocks, that listing was reaffirmed on April 14, 2014 (79 FR 20802). A recovery plan is available for this species (NMFS 2009).

Description and Geographic Range: MCR steelhead are predominantly summer steelhead, but winter-run fish are found in the Klickitat River. Most MCR steelhead smolt at two years and spend one to two years in salt water before re-entering fresh water, where they may remain for up to a year before spawning. Historically, the species was made up of five major population groups (MPGs), one of which—Willow Creek—has been extirpated. The four remaining MPGs comprise 17 extant populations and two that have been extirpated (see Table 61).

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

Nonetheless, most populations remain at low to moderate risk with respect to spatial structure and diversity—the one exception being the upper Yakima River population (see Table 61).

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

The species' populations are generally considered to be at medium to low risk with respect to abundance and productivity, but a few populations remain at high risk (see Table 61), though both the Touchet River and Westside Deschutes do remain at high risk.

Table 61. 5-year geometric mean of raw natural spawner counts. This is the raw total spawner count times the fraction wild estimate, if available. In parentheses, 5-year geometric mean of raw total spawner counts is shown. The geometric mean was computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of 2 values were used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right.

Population	MPG	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% C
Deschutes R. Eastside SuR	Cascades E. Slope Tribs.	607 (761)	693 (1439)	3823 (4848)	1872 (2354)	1540 (1803)	-18
Deschutes R. Westside SuR	Cascades E. Slope Tribs.	248 (323)	226 (341)	742 (950)	477 (578)	935 (993)	96
Fifteenmile Cr. WR	Cascades E. Slope Tribs.	405 (405)	396 (396)	941 (941)	264 (264)	471 (490)	78
John Day R. Low. Mainstem Tribs. SuR	John Day R.	1235 (1248)	968 (1017)	3487 (4052)	1024 (1382)	1745 (2059)	70
John Day R. Up. Mainstem SuR	John Day R.	1019 (1029)	350 (368)	695 (777)	471 (512)	1050 (1072)	123
MF John Day R. SuR	John Day R.	1210 (1225)	545 (572)	1229 (1375)	634 (689)	4776 (4864)	653
NF John Day R. SuR	John Day R.	785 (793)	1142 (1200)	2247 (2514)	1488 (1618)	3011 (3073)	10
SF John Day R. SuR	John Day R.	398 (402)	135 (142)	493 (551)	586 (637)	1077 (1099)	84
Touchet R. SuR	Umatilla/Walla Walla R.	392 (438)	342 (395)	354 (387)	337 (446)	489 (615)	45
Umatilla R. SuR	Umatilla/Walla Walla R.	1068 (1344)	919 (1660)	2341 (3312)	1931 (2498)	3214 (3921)	66
Walla Walla R. SuR	Umatilla/Walla Walla R.	995 (995)	516 (522)	957 (997)	717 (739)	1239 (1274)	73
Naches R. SuR	Yakima R. Group	285 (313)	260 (293)	855 (868)	823 (846)	1775 (1829)	116
Satus Cr. SuR	Yakima R. Group	343 (377)	266 (300)	640 (652)	807 (829)	1585 (1624)	96
Toppenish Cr. SuR	Yakima R. Group	103 (113)	135 (153)	693 (705)	468 (481)	575 (588)	23
Yakima R. Up. Mainstem SuR	Yakima R. Group	55 (56)	49 (50)	145 (149)	155 (157)	390 (410)	152

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the MCR juvenile outmigration are displayed below.

Table 62. Recent Five-Year Average Projected Outmigrations for MCR Steelhead (Ferguson 2010; Dey 2012; Zabel 2013; Zabel 2014a; Zabel 2014b, Zabel 2015).

Origin	Outmigration
Natural	479,860
Listed Hatchery: Adipose Clipped*	324,253
Listed Hatchery: Intact Adipose*	315,353

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

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

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

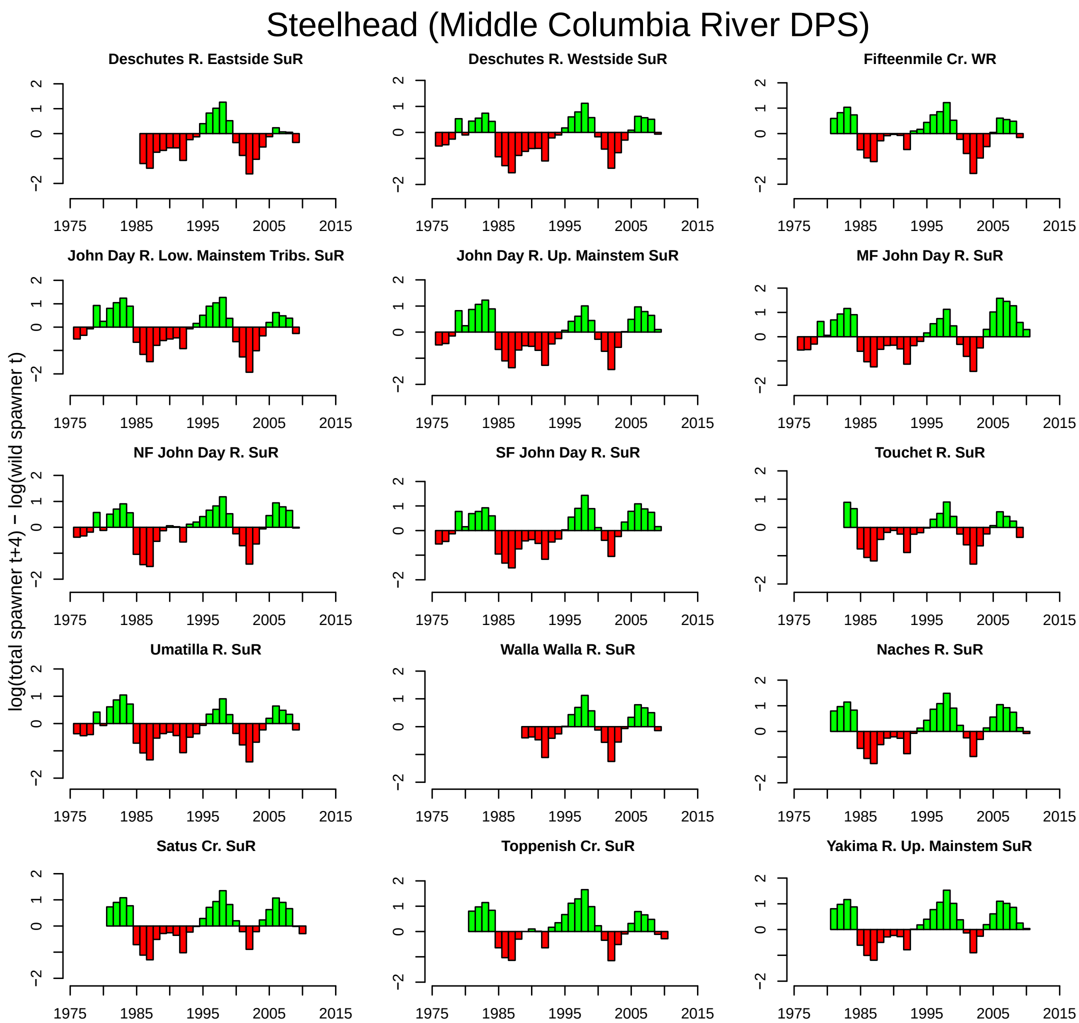

Figure 2 Trends in population productivity, estimated as the log of the smoothed natural spawning abundance. Spawning years on x axis.

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

Deschutes River (NMFS 2009).

The limiting factors identified in the recovery plan are:

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

2.2.1.21 Upper Columbia River steelhead

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

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

Table 63. List of Hatchery Stocks Included in the UCR Steelhead DPS.

Artificial Propagation Program	Run	Location (State)
Wenatchee River Steelhead *	Summer	Wenatchee River (Washington)
Wells Hatchery Steelhead *	Summer	Methow River (Washington)
	Summer	Okanogan River (Washington)
Winthrop NFH Steelhead (Wells Steelhead)	Summer	Methow River (Washington)
Omak Creek Steelhead	Summer	Okanogan River (Washington)
Ringold Hatchery (Wells Steelhead)	Summer	Middle Columbia River (Washington)

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

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

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

Table 64. 5-year mean of fraction natural origin (sum of all estimates divided by the number of estimates)(NWFSC 2015).

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

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

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

The most recent estimates (5-year geometric mean) of total and natural-origin spawner abundance have increased relative to the prior review for all four populations (Table 35). The abundance series for the aggregate return monitored at Priest Rapids Dam and for all four populations generally reflect a common pattern in annual returns for both hatchery and natural origin fish. Although the magnitudes vary among the individual populations, each series shows three peaks in annual returns occurring in the mid-1980s, the early 2000s and 2010/2011. That pattern appears to be largely driven by variations in smolt to adult return rates. In spite of the recent increases, natural-origin returns remain well below target levels.

Table 65. 5-year geometric mean of raw natural spawner counts. This is the raw total spawner count times the fraction natural estimate. In parentheses, 5-year geometric mean of raw total spawner counts is shown. Percent change between the most recent two 5-year periods is shown on the far right.

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the UCR Steelhead juvenile outmigration are displayed below.

Table 66. Recent Five-Year Average Projected Outmigrations for UCR Steelhead (Ferguson 2010; Dey 2012; Zabel 2103; Zabel 2014a; Zabel 2014b, Zabel 2015).

Origin	**Outmigration**
Natural	280,338
Listed Hatchery: Adipose Clipped*	642,033
Listed Hatchery: Intact Adipose*	165,584

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

The natural abundance number should be viewed with caution, however, as it only addresses one of several juvenile life stages. Moreover, deriving any juvenile abundance estimate is

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

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

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

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

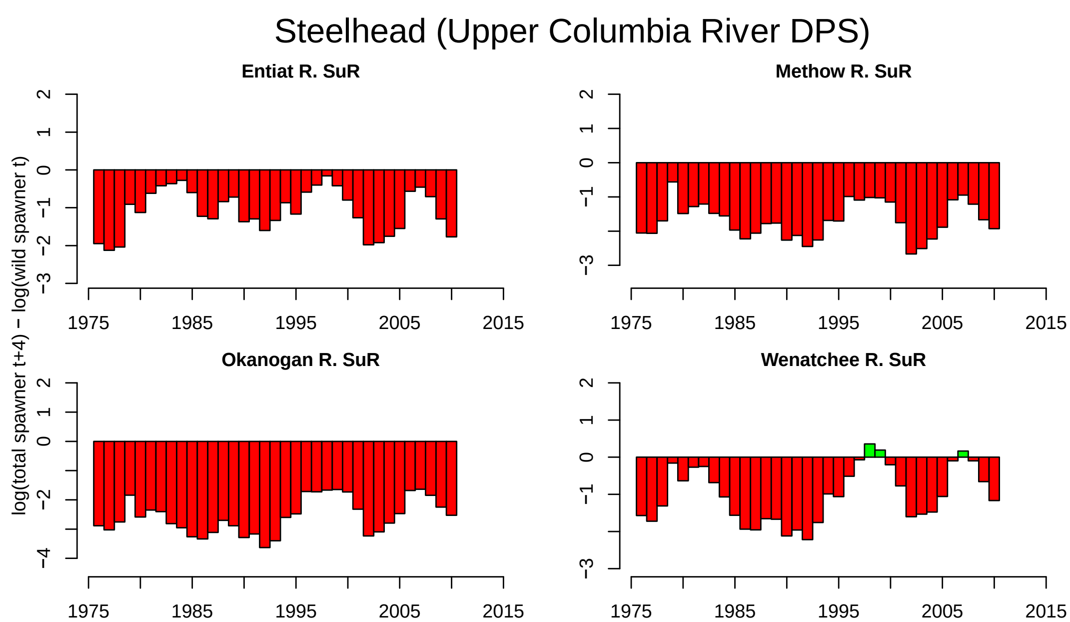

Figure 3. Trends in population productivity, estimated as the log of the smoothed natural spawning abundance. Spawning years on x-axis.

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

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

2.2.1.22 Snake River steelhead

Description and Geographic Range: Snake River (SR) steelhead were listed as a threatened species on January 5, 2006 (71 FR 834); the listing includes all naturally spawning populations of steelhead in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho. Six artificial propagation programs are considered part of the listed species (Table 67). Under the final listing in 2006, the section 4(d) protections, and limits on them, apply to natural and hatchery threatened salmon with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. This document evaluates impacts on both listed natural and listed hatchery fish. We are developing a recovery plan for this species.

Table 67. Listed Hatchery Populations of SR Steelhead.

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

Artificial Propagation Program	Run	Location (State)
		Hatchery (Idaho)
Little Salmon River**	B Run	Dworshak NFH Program and SF Clearwater Hatchery (Idaho)
SF Clearwater**	B Run	Dworshak NFH Program and SF Clearwater Hatchery (Idaho)

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

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

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

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

Given the range of conditions and the number of populations in these major groups, the status of the species with regard to structure and diversity risk factors is highly variable. Generally though, the structure and diversity risks for all populations is considered low to moderate. The most recent assessments (NWFSC 2015) of this species' risk with regard to these factors is found in Table 68, below.

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

Juvenile abundance estimates are published each spring in an annual memorandum estimating percentage of listed Pacific salmon and steelhead smolts arriving at various locations in the Columbia River basin. The averages of the five most recent projections for the SR steelhead juvenile outmigration are displayed below.

Table 68. Recent Five-Year Average Projected Outmigrations for SR Steelhead (Ferguson 2010; Dey 2012; Zabel 2013; Zabel 2014a; Zabel 2014b, Zabel 2015).

Origin	**Outmigration**
Natural	1,142,126
Listed Hatchery: Adipose Clipped	3,289,351
Listed Hatchery: Intact Adipose	1,155,044

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

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

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

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

2.2.1.23 Upper Willamette River steelhead

Description and Geographic Range: The Upper Willamette River steelhead DPS was first listed as a threatened species on August 18, 1997 (62 FR 43937). When we re-examined the status of this species in 2006, 2011, and 2016 we determined that it still warranted listing as threatened (71 FR 834, 76 FR 50448, 81 FR 33468). The listing included all naturally spawned populations of winter-run steelhead in the Willamette River, Oregon, and its tributaries upstream from Willamette Falls to the Calapooia River, inclusive. No artificially propagated steelhead stocks are considered part of the listed species. The hatchery summer-run steelhead in the basin are an out-of-basin stock and not considered part of the DPS.

UWR steelhead are late-migrating winter steelhead, entering fresh water primarily in January through April (ODFW 2011). This atypical run timing appears to be an adaptation for ascending

Willamette Falls, which functioned as an isolating mechanism for the Upper Willamette basin before the falls were laddered. Reproductive isolation resulting from passing above the falls may explain the genetic distinction between steelhead from the upper Willamette River and those in the lower river. A resident form of *O. mykiss* co-occurs with the anadromous form and juvenile life stages of the two forms can be very difficult to differentiate.

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

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

The Upper Willamette River Conservation and Recovery Plan for Chinook Salmon and Steelhead (ODFW 2011) identifies four demographically independent populations of steelhead: Molalla, North Santiam, South Santiam, and Calapooia (Table 69). Winter steelhead have been reported spawning in the west-side tributaries to the Willamette River, but these tributaries were not considered to have constituted an independent population historically. The west-side tributaries may serve as a population sink for the DPS (Myers et al. 2006). Additionally, although a naturally reproducing population of UWR steelhead became established in the Middle Fork Willamette in the 1950's following introductions of hatchery produced fish from the North Santiam, it is generally agreed that steelhead historically did not emigrate farther upstream than the Calapooia River (Dimick and Merryfield 1945; Fulton 1970); and these fish are not included in the DPS.

Table 69. Historical Population Structure and Viability Status for UWR Chinook Salmon (ODFW 2011).

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

For the spatial structure analysis, the Oregon recovery plan evaluated the proportion of stream miles currently accessible to the species relative to the historical miles accessible (ODFW 2010). Oregon adjusted the rating downward if portions of the currently accessible habitat were qualitatively determined to be seriously degraded. Oregon also adjusted the rating downward if the portion of historical habitat lost was a key production area. The Oregon recovery plan rates the viability of spatial structure to be low to very low in the North Santiam and Calapooia populations, and moderate in the other two populations (Table 69). The low ratings are due to fish passage barriers, stream channel modifications, and water quality problems limiting survival of the species.

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

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

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

The majority of the UWR winter steelhead run return to freshwater in January through April, pass Willamette Falls from mid-February to mid-May, and spawn in March through June. Adult winter-run steelhead are counted at the Willamette Falls fishway ladder where the counts begin in November and end mid-May of the following year (Table 70). The number of winter-run steelhead passing over Willamette Falls during the winter of 2014-15 was 4,503 and the most recent five-year average is only at 5,971.

Table 70. Upper Willamette Winter-run Steelhead Abundance (ODFW 2016b).

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

The Oregon recovery plan (ODFW 2011) rates the populations as moderate to high viability potential. However, there is a considerable amount of uncertainty in these ratings. In their assessment of these populations, McElhany et al. (2007) found that while most of these populations probably fell into the ‘moderate’ extinction risk classification; there was a large degree of uncertainty in this result.

It is difficult to accurately estimate juvenile UWR steelhead abundance during the coming year. However, the average estimated outmigration (2011-2015) of naturally-produced smolts is 207,853 (Dey 2012; Zabel 2013, 2014a, 2014b, 2015). As with other species, it is reasonable to assume that this figure could be substantially higher when other juvenile life stages are included. In addition, non-listed juvenile rainbow trout and unlisted juvenile steelhead occur in the same areas as the listed UWR steelhead; and it is very difficult to distinguish between them.

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

Impacts of land management on UWR steelhead include current land use practices causing limiting factors, as well as current practices that are not adequate to restore limiting factors caused by past practices (legacy impacts). Past land use (including agricultural, timber harvest, mining and grazing activities, diking, damming, development of transportation, and urbanization) are significant factors now limiting viability of UWR steelhead (ODFW 2011). These factors severed access to historically productive habitats, and reduced the quality of many remaining habitat areas by weakening important watershed processes and functions that sustained them. Land use practices in the estuary have degraded or eliminated much of the rearing habitat for UWR steelhead. Combined with the effects of the Columbia basin hydropower/flood control systems, the primary activities that have contributed to current estuary and lower mainstem habitat conditions include channel confinement (primarily through diking), channel manipulation (primarily dredging), floodplain development, and water withdrawal for urbanization and agriculture (LCFRB 2004).

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

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

There are no winter-run steelhead hatchery programs in the Upper Willamette subbasin. Non-native summer steelhead are raised at most of the rearing facilities in the upper Willamette River subbasins, and released as smolts in the North and South Santiam, McKenzie and Middle Fork Willamette subbasins. Differences in spawn timing among these stocks may limit (but not eliminate) the potential for interbreeding. The negative effects of releasing large numbers of an out-of-ESU steelhead stock are not limited to the potential effects on genetic diversity, but include ecological impacts as well (see review in Kostow 2009). For example, Kostow and Zhou (2006) suggested that because adult hatchery summer steelhead typically spawn earlier than do wild winter steelhead and their offspring emerge earlier, they may have a competitive advantage in occupying choice feeding territories prior to the emergence of winter steelhead. In addition, when large hatchery releases result in the localized carrying capacity to be exceeded-which is presumed to be the case in UWR sub-basins-there is increased potential for density-dependent mortality on wild fish for early life stages.

ODFW identified negative effects of both native and introduced plant and animal species as limiting factors and threats to UWR steelhead (ODFW 2011). Ecosystem alterations attributable to hydropower dams and to modification of estuarine habitat have increased predation on UWR steelhead. In the estuary, habitat modification has increased the number and/or predation effectiveness of Caspian terns, double-crested cormorants, and a variety of gull species (LCREP 2006; Fresh et al. 2005).

2.2.1.24 Northern California steelhead

Description and Geographic Range: On June 7, 2000, NMFS listed NC steelhead as a threatened species (65 FR 36074). NMFS concluded that the NC steelhead DPS was likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. The species includes all naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers in California coastal river basins from Redwood Creek to and including the Gualala River (79 FR 20802). The Central California Coast steelhead DPS begins at the Russian River and extends south to Aptos Creek. This leaves several *O. mykiss* populations in small watersheds between the Gualala and Russian rivers that are not currently assigned to either DPS. NMFS promulgated 4(d) protective regulations for NC steelhead on January 5, 2006 (71 FR 834). The section 4(d) protections (and limits on them) apply to natural NC steelhead.

The NC steelhead DPS was historically comprised of 42 independent, winter-run populations (19 functionally independent and 23 potentially independent) and 10 independent, summer-run populations (all functionally independent; two extirpated) (Bjorkstedt et al. 2005; Spence et al. 2008). In addition, this DPS likely contained a minimum of 65 (and likely more) dependent populations of winter-run steelhead in smaller coastal watersheds, as well as small tributaries to the Eel River (Bjorkstedt et al. 2005). Steelhead populations were assigned to five geographically based diversity strata, with two of these strata further subdivided into winter-run and summer-run life history types (Table 71).

Table 71. Historical NC steelhead independent populations (Spence et al. 2008).

Strata	Run	Populations
Northern Coastal	Summer	Redwood Creek[a], Mad River[a], SF Eel River, Mattole River
	Winter	Redwood Creek[a], Maple Creek/Big Lagoon, Little River, Mad River[a], Humboldt Bay, Price Creek, SF Eel River, Bear River, Mattole River

Strata	Run	Populations
Lower Interior	Winter	Jewett Creek, Pipe Creek, Chamise Creek, Bell Springs Creek, Woodman Creek, Outlet Creek, Tomki Creek, Bucknell Creek, Soda Creek
Northern Mountain Interior	Summer	Redwood Creek[a], Mad River[a], Van Duzen River, Larabee Creek, NF Eel River, Upper Middle Mainstem Eel River[b], MF Eel River, Upper Mainstem Eel River[b]
	Winter	Redwood Creek[a], Mad River[a], Van Duzen River, Larabee Creek, Dobbyn Creek, Kekawaka Creek, NF Eel River, MF Eel River, Upper Mainstem Eel River
North-Central Coastal	Winter	Usal Creek, Cottaneva Creek, Wages Creek, Ten Mile River, Pudding Creek, Noyo River, Hare Creek, Caspar Creek, Russian Gulch, Big River, Albion River, Big Salmon Creek
Central Coastal	Winter	Navarro River, Elk Creek, Brush Creek, Garcia River, Gualala River

[a] Populations that are listed under multiple diversity strata and occupy environmentally diverse basins.
[b] Extirpated populations

Abundance and Productivity: Historic NC steelhead abundance is mostly unknown. CDFW estimated historic NC steelhead abundance at 198,000 fish (CDFG 1965; Good et al. 2005). At the time of the last assessment, population-level estimates of abundance were available for less than 10% of independent populations of winter- and summer-run steelhead within the DPS (Williams et al. 2011; Spence 2016). Since that time, the Coastal Monitoring Plan (CMP) has been broadly implemented in Mendocino County as well as selected watersheds in Humboldt County. Data from the CMP are now available for 17 independent populations, as well as six dependent populations or partial populations (most associated with life-cycle monitoring stations). The majority of these datasets span a period of six or fewer years; however, they do provide the first comprehensive estimates of adult abundance or redds for a number of populations. Significant data gaps do remain, however, particularly in the Lower Interior and North Mountain Interior diversity strata, which encompass most of the Eel River populations, excluding the South Fork Eel River (Spence 2016). Based upon available data, the average abundance for NC steelhead populations is 5,929 adult spawners (Table 72).

Table 72. Geometric mean abundances of NC steelhead spawners escapements by population (Spence 2016).

Population	Location	Run	Natural-origin Spawners[a]	Expected Number of Outmigrants[c]
Northern Coastal Stratum				
Redwood Creek	Redwood Creek	Summer	7	796
		Winter	112	12,740
	Prairie Creek	Winter	20	2,275
Humboldt Bay	Humboldt Bay	Winter	62	7,053
	Freshwater Creek	Winter	146	16,608
SF Eel River	SF Eel River	Winter	574	65,293
Mattole River	Mattole River	Summer	67	7,621
		Winter	279	31,736
Mad River	Mad River	Summer	414	47,093
North Mountain Interior Stratum				

Population	Location	Run	Natural-origin Spawners[a]	Expected Number of Outmigrants[c]
Upper Mainstem Eel River	Upper Eel River/Soda Creek	Winter	278	31,623
Van Duzen River	Van Duzen River	Summer	115	13,081
MF Eel River	MF Eel River	Summer	601	68,364
North-Central Coastal Stratum				
Usal Creek	Usal Creek	Winter	42	4,778
Cottaneva Creek	Cottaneva Creek	Winter	28	3,185
Wages Creek	Wages Creek	Winter	33	3,754
Ten Mile River	Ten Mile River	Winter	153	17,404
Pudding Creek	Pudding Creek	Winter	66	7,508
Noyo River	Noyo River	Winter	307	34,921
	SF Noyo River	Winter	72	8,190
Big River	Big River	Winter	323	36,741
Big/Albion	Little River	Winter	13	1,479
Albion River	Albion River	Winter	37	4,209
Big Salmon Creek	Big Salmon Creek	Winter	41	4,664
Hare Creek	Hare Creek	Winter	14	1,593
Caspar Creek	Caspar Creek	Winter	37	4,209
Central Coastal Stratum				
Navarro River	Navarro River	Winter	302	34,353
	NF Navarro River	Winter	342	38,903
Navarro/Elk	Greenwood Creek	Winter	4	455
Elk Creek	Elk Creek	Winter	13	1,479
Brush Creek	Brush Creek	Winter	6	683
Garcia River	Garcia River	Winter	258	29,348
Gualala River	WhF Gualala River	Winter	1,163	132,291
DPS Average		**-**	**5,929**	**674,424**

[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.

Juvenile NC steelhead abundance estimates come from the escapement data (Table 73). 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 spawner escapement – 2,965 females), 10.38 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 674,424 natural outmigrants annually.

For the DPS, short-term trends have been calculated for 17 locations and long-term trends for one location (Table 73). Significant positive trends were calculated at four locations, and significantly negative trends were calculated for three locations. At the Van Arsdale Station on the upper Eel River, long-term trends have been significantly negative while short-term trends have been significantly positive. These opposite trends are believed to be the result of a long history of unmarked hatchery fish being released within the basin (Spence 2016). The Pudding Creek population has a significant negative trend driven by a four consecutive years (2009-2012) of returns with fewer than 30 spawners. Both the Big River and Albion River populations have significantly positive trends; however, both populations have dipped below their high-risk depensation thresholds. The Hare Creek population has negative short-term trend. While the Navarro River population has a significantly positive short-term trend, but the population remains at 5% of its viability target (Spence 2016).

Table 73. Short- and long-term trends for NC steelhead abundance. Trends in bold are significantly different from 0 at α=0.05 (Spence 2016).

Population/Location	Short-term		Long-term	
	Trend (95% CI)	# years	Trend (95% CI)	# years
Northern Coastal Stratum				
Prairie Creek	0.051 (-0.126, 0.227)	14	-	-
Freshwater Creek	-0.055 (-0.124, 0.014)	15	-	-
North Mountain Interior Stratum				
Upper Eel River (Van Arsdale Stn)	**0.068 (0.011, 0.125)**	16	**-0.033 (-0.043, -0.022)**	78
North-Central Coastal Stratum				
Usal Creek	0.366 (-0.271, 1.002)	6	-	-
Ten Mile River	1.069 (-0.084, 2.222)	6	-	-
Pudding Creek	**-0.170 (-0.305, -0.034)**	13	-	-
Noyo River	0.027 (-0.047, 0.101)	13	-	-
Big River	**0.714 (0.435, 0.993)**	6	-	-
Albion River	**0.457 (0.023, 0.892)**	6	-	-
SF Noyo River	0.018 (-0.052, 0.087)	15	-	-
Hare Creek	**-0.451 (-0.686, -0.215)**	9	-	-
Caspar Creek	-0.113 (-0.253, 0.027)	13	-	-
Little River	-0.092 (-0.212, 0.028)	13	-	-
Central Coastal Stratum				
Navarro River	**0.338 (0.099, 0.577)**	6	-	-
Brush Creek	0.421 (-0.574, 1.417)	6	-	-
Garcia River	0.193 (-0.332, 0.717)	6	-	-
WhF Gualala River	-0.102 (-0.407, 0.202)	9	-	-

Limiting Factors and Threats: Many stressors have contributed to their decline, including, (1) dams and other barriers, (2) logging, (3) agriculture, (4) ranching, (5) fisheries, and (6) hatcheries. Two of the largest rivers, Eel and Mad rivers, in the DPS are dammed. Scott Dam blocks 90% of the habitat on the Upper Eel River and reduces the flows into the mainstem Eel River. Ruth Dam block 36% of potential steelhead habitat in Mad River. Elsewhere throughout the DPS, culverts and bridges create impassable barriers (Moyle et al. 2008). Logging throughout the region has increased stream sedimentation and temperatures, reduced canopy cover, destroyed instream habitat, and altered flow timing and volume (Moyle et al. 2008). Agriculture and ranching land practices can lead to destabilized and denuded stream banks, stream channelization, large woody debris removal, increased sedimentation, and water pollution

(Spence et al. 1996, Moyle et al. 2008). Though fishery take on NC steelhead is prohibited, hatcheries produce steelhead for the fishery resulting in incidental captures of and competition with natural-origin steelhead (Moyle et al. 2008). Other threats to NC steelhead include gravel extraction, streambed alteration, predation from introduced species (i.e. Sacramento pikeminnow), poaching, and human disturbance (Moyle et al. 2008). Concerning habitat, the following issues continue to impede NC steelhead: water quality (i.e. pollution from agriculture, urban/suburban areas, industrial sites), instream flows (i.e. dams and reservoirs, blocked fish passage, diversions), agriculture (i.e. wine production, marijuana cultivation), and timber harvest (NMFS 2016a).

2.2.1.25 Central California Coast steelhead

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

The previous viability assessment that included CCC steelhead (Williams *et al.* 2011) considered studies and genetic data not available at the time of listing, and determined that available information suggested boundary changes may be warranted for coastal California steelhead DPSs, including the CCC steelhead DPS (Williams *et al.* 2016). Subsequent to the 2011 viability assessment, relevant data analyzed by Bjorkstedt *et al.* (2005) was published by Garza *et al.* (2014) and, based on this new information, it was recommended that a Biological Review Team (BRT) form to assess the best available information relevant to DPS boundaries and potential changes (Williams *et al.* 2016). The BRT review has not yet been conducted so current boundaries remain unchanged.

Bjorkstedt et al. (2005) concluded that the CCC steelhead DPS historically comprised 37 independent populations (11 functionally independent and 26 potentially independent) and perhaps 30 or more dependent populations of winter-run steelhead (Table 74). These populations were placed in five geographically based diversity strata (Bjorkstedt et al. 2005; modified in Spence et al. 2008). Most of the coastal populations are assumed to be extant, however many of the Coastal San Francisco Bay and Interior San Francisco Bay populations are likely at high risk of extirpation due to the loss of historical spawning habitat and the heavily urbanized nature of these watersheds (Williams et al. 2011; NMFS 2016d).

Table 74. Historical CCC Steelhead Populations (NMFS 2011a).

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

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

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile CCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCC steelhead abundance estimates come from the escapement data (Table 75). All returnees to the hatcheries do not contribute to the natural population and are not used in this calculation. For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of natural-origin spawners – 1,094 females), 3.8 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 248,771 natural outmigrants annually (Table 75).

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

Table 75. Geometric Mean Abundances of CCC Steelhead Spawners Escapements by Population (Ettlinger et al. 2012, Jankovitz 2013, Source: http://marinwater.org/documents/1_WalkerCreekReportandRefs_March2010.pdf, Natural abundance: Manning and Martini-Lamb (ed.) 2012; Hatchery abundance source: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=44269&inline=true, Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoU%3D&tabid=1772, Atkinson

2010, Williams et al. 2011, Koehler and Blank 2012, additional unpublished data provided by the NMFS SWFSC).

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

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

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

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

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

2.2.1.26 Central Valley steelhead

Description and Geographic Range: The Central California Valley (CCV) steelhead DPS includes naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Sacramento and San Joaquin rivers and their tributaries. Two artificial propagation programs were listed as part of the DPS—Coleman National Fish Hatchery and Feather River Hatchery winter-run steelhead hatchery stocks (Table 76).

On March 19, 1998, NMFS listed CCV steelhead—both natural and some artificially-propagated fish—as a threatened species (63 FR 13347). NMFS concluded that the CCV steelhead DPS was likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. On January 5, 2006, NMFS reaffirmed the threatened status of the CCV steelhead and applied the DPS policy to the species because the resident and anadromous life forms of *O. mykiss* remain “markedly separated” as a consequence of physical, ecological and behavioral factors, and therefore warranted delineation as a separate DPS and promulgated 4(d) protective regulations for CCV steelhead (71 FR 834). The section 4(d) protections (and limits on them) apply to natural and hatchery CCV steelhead with an intact adipose fin, but not to listed hatchery fish that have had their adipose fin removed. On August 15, 2011 and April 2016, NMFS completed 5-year status reviews of CCV steelhead and recommended that the CCV steelhead DPS remain classified as a threatened species (NMFS 2011a; NMFS 2016e). Based on new genetic evidence, the 2016 status review recommended that Mokelumne River Hatchery be added CCV steelhead DPS (NMFS 2016e).

Table 76. 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**

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

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

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

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

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

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

The genetic diversity of CCV steelhead is also compromised by hatchery origin fish, which likely comprise the majority of the annual spawning runs, placing the natural population at a high risk of extirpation (Lindley et al. 2007). There are four hatcheries (Coleman National Fish Hatchery, Feather River Hatchery, Nimbus Fish Hatchery, and Mokelumne River Fish Hatchery) in the Central Valley which combined release approximately 1.6 million yearling steelhead smolts each year. These programs are intended to mitigate for the loss of steelhead habitat caused by dam construction, but hatchery origin fish now appear to constitute a major proportion of the total abundance in the DPS. Two of these hatchery stocks (Nimbus and Mokelumne River hatcheries) originated from outside the DPS (primarily from the Eel and Mad rivers) and are not presently considered part of the DPS. A new analysis of genetic relationships among the four Central Valley steelhead hatcheries shows that fish from the Mokelumne River Hatchery are nearly genetically identical to fish from the Feather River Hatchery (Pearse and Garze 2015). Given the new genetic evidence, Mokelumne River hatchery will be added to the CCV steelhead DPS following a federal register rule making slated for the fall of 2016.

Steelhead in the Central Valley historically consisted of both summer-run and winter-run migratory forms, based on their state of sexual maturity at the time of river entry and the duration of their time in freshwater before spawning. Only winter-run (ocean maturing) steelhead currently are found in California Central Valley rivers and streams (Moyle 2002, McEwan and

Jackson 1996). Summer-run steelhead have been extirpated due to a lack of suitable holding and staging habitat, such as cold-water pools in the headwaters of CCV streams, presently located above impassible dams (Lindley et al. 2006).

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

Population trend data remain extremely limited for CCV steelhead. Current abundance data is limited to returns to hatcheries and redd surveys conducted on a few rivers. The hatchery data is the most reliable, as redd surveys for steelhead are often made difficult by high flows and turbid water usually present during the winter-spring spawning period. The best population-level trend data come from Battle Creek, where Coleman National Fish Hatchery operates a weir. The 10-year trend is -0.17, placing the population in the high extirpation risk category (Table 77). The percentage of fish passing the weir that were of hatchery origin has been highly variable, ranging from five percent to 70 percent, with an average of 29 percent over the 2002-2010 period. This level of hatchery influence corresponds to a moderate risk of extirpation (Williams et al. 2011).

Table 77. Viability Metrics for CCV Steelhead (Williams et al. 2011).

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

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

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile CCV steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. Juvenile CCV steelhead abundance estimates come from the escapement data (Table 78). 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 – 743 females), 2.6 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 169,033 natural outmigrants annually. In addition, hatchery managers could produce approximately 1.6 million listed hatchery juvenile CCV steelhead each year (Table 12).

Table 78. 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	23,660
Antelope Creek	2007	140	-	15,925
Battle Creek	2010-2014	410	1,563	46,638
Bear Creek	2008-2009	119	-	13,536
Cottonwood Creek[f]	2008-2009	27	-	3,071
Clear Creek	2011-2015	455	-	51,756
Cow Creek	2008-2009	2	-	228
Feather River	2011-2015	-	1,058	-
Mill Creek	-	15	-	1,706
Mokelumne River	2006-2010	110	133	12,513
Total		**1,486**	**3,822**	**169,033**

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

egg to outmigrant
[b] Based upon number of natural-origin spawners

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

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

2.2.1.27 South Central California steelhead

Description and Geographic Range: The South-Central California Coast (SCCC) steelhead occupy rivers from the Pajaro River (Santa Cruz County, California), inclusive, south to, but not including, the Santa Maria River (San Luis Obispo County, California). Most rivers in this DPS drain from the San Lucia Mountain range, the southernmost section of the California Coast Ranges. Many stream and river mouths in this area are seasonally closed by sand berms that form during the low water flows of summer.

On August 18, 1997, NMFS listed SCCC steelhead as a threatened species (62 FR 43937). NMFS concluded that the SCCC steelhead DPS was likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. NMFS promulgated 4(d) protective regulations for SCCC steelhead on January 5, 2006 (71 FR 834). The section 4(d) protections (and limits on them) apply to natural and hatchery SCCC steelhead with an intact adipose fin, but do not apply to listed hatchery fish that have had their adipose fin removed. Good *et al.* (2005) updated the status of SCCC, and additional updates were conducted in 2010 and 2015 (Williams *et al.* 2011; NMFS 2016f). None of these updates led to changes in the status of the listed DPS, which has remained threatened.

The last five years have seen little progress in developing better scientific information on population fluctuations, but significant progress on maintenance of life-history diversity. However, there has been no work on how the ecological and biological factors that maintain life-history diversity at the population level bear on the viability criterion for the anadromous fraction of the *O. mykiss* complex. Data on population fluctuations will emerge over time with the implementation of the California Coastal Monitoring Plan (CMP). The California CMP emphasizes annual estimates of abundance of anadromous adults which is intended to provide data on abundance and productivity metrics, including abundance fluctuations. Missing from the California CMP, but just as important with respect to any future revision of viability criteria, are ongoing monitoring of abundance and fluctuations of the resident life-history type in each population over time, and the lagoon-anadromous form (Boughton *et al.* 2006).

SCCC steelhead populations are broken into four population groups: Interior Coast Range, Carmel River Basin, Big Sur Coast, and San Luis Obispo Terrace (Table 79). The Interior Coast Range population group is the furthest north population containing long alluvial valleys and montane summer climate refugia. The Carmel River Basin population group resides in a medium valley with a montane/marine summer climate refugia. The Big Sur Coast population group uses short, steep canyons with a marine refugia. And the southernmost population group, San Luis Obispo Terrace, uses coastal terrace with a marine/montane refugia. In 2002, NMFS surveyed 36 watersheds and found that between 86 and 94 percent of the historic watersheds were still occupied. Also, occupancy was determined for 18 watershed basins with no historical record of steelhead (NMFS 2012b).

Table 79. Historical SCCC Steelhead Populations (NMFS 2012b).

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

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

Both adult and juvenile abundance data is limited for this DPS. While we currently lack data on naturally-produced juvenile SCCC steelhead, it is possible to make rough estimates of juvenile abundance from the available adult return data. The estimated average adult run size is 695

(Table 80). Juvenile SCCC steelhead abundance estimates come from the escapement data (Table 80). For the species, fecundity estimates range from 3,500 to 12,000; and the male to female ratio averages 1:1 (Pauley et al. 1986). By applying a conservative fecundity estimate of 3,500 eggs to the expected escapement of females (half of the escapement of spawners – 348 females), 1.2 million eggs are expected to be produced annually. With an estimated survival rate of 6.5 percent (Ward and Slaney 1993), the DPS should produce roughly 79,057 natural outmigrants annually.

Table 80. Geometric Mean Abundances of SCCC Steelhead Spawners Escapements by Population.

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

[a]Expected number of outmigrants=Total spawners*50% proportion of females*3,500 eggs per female*6.5% survival rate from egg to outmigrant
[b]Source: http://scceh.com/LinkClick.aspx?fileticket=dRW_AUu1EoU%3D&tabid=1772
[c]Kraft et al. 2013
[d]Sources: http://www.mpwmd.dst.ca.us/fishcounter/fishcounter.htm and http://www.mpwmd.dst.ca.us/wrd/lospadres/lospadres.htm.
[e]Allen and Riley 2012
[f]Garrapata Creek Watershed Council 2006
[g]Source: http://www.coastalrcd.org/zone1-1a/Fisheries%20Studies/AG_Steelhead_Report_Draft-small.pdf
[h]Source: http://www.coastalrcd.org/images/cms/files/MB%20Steelhead%20Abund%20and%20Dist%20Report.pdf
[i]City of San Luis Obispo 2006
[j]Baglivio 2012
[k]Stillwater Sciences et al. 2012

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

Two dams and reservoirs (Los Padres and San Clemente) were built in the drainage and have monitored fish abundance. In 2015, the San Clemente dam was removed, and while improving steelhead habitat, this will remove one of the few locations where steelhead are monitored within the DPS. Overall, this steelhead DPS is too data poor for abundance to statistically test abundance trends.

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

2.2.2 Puget Sound/Georgia Basin (PS/GB) Bocaccio, Canary Rockfish, and Yelloweye Rockfish

Description and Geographic Range: On April 27, 2010, NMFS listed the PS/GB DPS of bocaccio as endangered and PS/GB DPS of canary rockfish and yelloweye rockfish as threatened (75 FR 22276). Based on new genetic data reviewed by the Biological Review Team we determined that the canary rockfish of the PS/GB do not meet the criteria to be considered a DPS and recommended delisting canary rockfish in the 5-year review (NMFS 2016). Based on the new information and recommendation in the 5-year review, NMFS published a proposed rule to remove PS/GB canary rockfish from the Federal List of Threatened and Endangered Species (81 FR 43979; July 6, 2016).

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

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

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

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

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

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

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

The steep reduction in PS/GB bocaccio abundance (and consequent fragmentation) has led to concerns about their viability (Drake et al. 2010). In the 1970’s, size-frequency distributions for bocaccio included a wide range of sizes, with recreationally caught individuals from 25 to 85 cm

(9.8 to 33.5 in.) and a bi-modal distribution (most captured bocaccio were either 30 cm or 70 cm) (Drake et al. 2010). This broad size distribution suggests a spread of ages, with some successful recruitment over many years. In the 1980's, a similar size range was still evident in the catch data, but the distribution was flat across length. By the 2000s, no bocaccio size distribution data were available. The temporal trend in bocaccio size distributions also suggests size truncation of the population, with larger fish becoming less common over time. So as the mature fish density has decreased, productivity may have also been impacted by Allee effects despite the propensity of some individuals to move long distances and potentially reestablish aggregations in formerly occupied habitat (Drake et al. 2010).

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

Canary rockfish life-history includes a larval/pelagic juvenile stage followed by a nearshore juvenile stage, and sub-adult and adult stages. Female canary rockfish produce between 260,000 and 1.9 million eggs per year with larger females producing more eggs. Along the Pacific Coast, the relationship between egg production and female size does not seem to vary a great deal with geography (Gunderson et al. 1980, Love et al. 2002). Fertilization occurs as early as September off central California (Lea et al. 1999) and peaks in December (Phillips 1960, Wyllie-Echeverria 1987), and parturition occurs between January and April and peaks in April (Phillips 1960). In British Columbia, parturition peaks in February for canary rockfish (Hart 1973, Westrheim and Harling 1975).

Canary rockfish larvae have relatively high dispersal potential, with a pelagic larval duration of approximately 116 days (Shanks and Eckert 2005). Larvae are observed under free-floating algae, seagrass, and detached kelp (Shaffer et al. 1995, Love et al. 2002), but are also distributed throughout the water column (Weis 2004) and typically found in the upper 100 m of the water column (Love et al. 2002). Larvae can make small local movements to pursue food immediately after birth (Tagal et al. 2002), but are likely passively distributed with prevailing currents. Canary rockfish larvae are planktivores, feeding primarily on nauplii (crustacean larvae), other invertebrate eggs, and copepods (Moser and Boehlert 1991). Unique oceanographic conditions within Puget Sound proper (sills regulating water exchange from one basin to the next) likely result in most larvae staying within the basin where they are released (e.g., the South Sound) rather than being broadly dispersed (Drake et al. 2010).

When canary rockfish reach sizes of 3 to 9 cm (1 to 3.5 in.) (approximately 3 to 6 months old), juveniles move to tide pools, rocky reefs, kelp beds, low rock and cobble areas (Miller and Geibel 1973, Love et al. 1991, Cailliet et al. 2000, Love et al. 2002). Juveniles may occur in groups near the rock-sand interface in the 15 to 20 m depth range during the day, move into sandy areas at night (Love et al. 2002), and remain in shallower areas for up to three years prior to moving to deeper waters (Boehlert 1980, Methot and Stewart 2005). These habitat features offer a beneficial mix of warmer temperatures, food, and refuge from predators (Love et al. 1991). Areas with floating and submerged kelp species support the highest densities of most juvenile rockfish (Carr 1983, Halderson and Richards 1987, Matthews 1989, Hayden-Spear 2006). Juveniles are zooplanktivores, feeding on crustaceans such as harpacticoids (an order of copepods), barnacle cyprids (final larval stage), and euphasiid eggs and larvae. Juvenile canary rockfish predators include other fishes—especially rockfishes, lingcod, cabezon, and salmon—as well as birds and porpoises.

Adult canary rockfish are primarily orange with a pale grey or white background with three bright orange diagonal stripes across the head (Love et al. 2002). Canary rockfish reach 50 percent maturity at sizes around 40 cm (16 in.) and ages of 7 to 9 years. Sub-adult and adult canary rockfish typically utilize habitats with moderate to extreme steepness, complex bathymetry, and rock and boulder-cobble complexes (Love et al. 2002). Similar to most rockfish species, canary rockfish move deeper as they increase in size (Vetter and Lynn 1997), and adults are found on the rocky shelf and pinnacles (Phillips 1960, Rosenthal et al. 1988, Starr 1998, Cailliet et al. 2000, Johnson et al. 2003, Tissot et al. 2007). Within Puget Sound proper, canary rockfish have been documented in areas of high relief with non-rocky substrates such as sand, mud, and other unconsolidated sediments (Washington et al. 1978, Miller and Borton 1980). Adult canary rockfish mostly inhabit waters 50 to 250 m (160 to 820 ft.) deep (Orr et al. 2000), but may be found in depths up to 425 m (1,400 ft.) (Boehlert 1980). While canary rockfish appear to be generally sedentary, tagging studies have shown that some individuals move up to 700 km (435 miles) over several years (Lea et al. 1999, Love et al. 2002). Canary rockfish have larger home ranges, move long distances, and spend time suspended in the water column (Love et al. 2002). Adult canary rockfish are planktivores/carnivores, consuming euphasiids and other crustaceans and small fishes. Adult canary rockfish predators include yelloweye rockfish, lingcod, salmon, sharks, dolphins, seals, and possibly river otters. Maximum canary rockfish age is at least 84 years (Love et al. 2002), although 60 to 75 years is more common (Caillet et al. 2000). Natural annual mortality ranges from 6 to 9 percent (Methot and Stewart 2005, Stewart 2007).

Prior to contemporary fishery removals, each major basin likely hosted relatively large PS/GB canary rockfish populations (Washington 1977, Washington et al. 1978, Moulton and Miller 1987). This wide distribution allowed canary rockfish to utilize the full suite of available habitats to maximize their abundance and demographic characteristics and, thereby, enhance their resilience (Hamilton 2008). Also, this enabled canary rockfish to potentially exploit ephemerally good habitat conditions or, in turn, receive protection from smaller-scale and negative environmental fluctuations. These fluctuations may change prey abundance for various life stages and/or may change environmental characteristics that influence the annual recruit numbers.

Canary rockfish size and age distributions have been truncated (Drake et al. 2010); and as a result, the reproductive burden may be shifted to younger and smaller fish. In the 1970's, the canary rockfish population exhibited a broad range of sizes and were present in each of the major basins (Moulton and Miller 1987). By the 2000s, there were far fewer size classes represented and no fish greater than 55 cm (21.65 in.) recorded in the recreational data (Drake et al. 2010). Although some of this truncation may be a function of the overall lower sampled fish number, the data suggest fewer older fish remain in the population. This shift could alter the timing and condition of larval release that may be mismatched with habitat conditions within the DPS, potentially reducing the offspring viability (Drake et al. 2010).

The apparent steep reduction in PS/GB canary rockfish abundance leads to concerns about population viability (Drake et al. 2010). Rockfish population resilience is sensitive to changes in connectivity among various fish groups (Hamilton 2008). When localized rockfish depletion occurs, stock resiliency can be reduced, and the natural hydrologic constrictions within Puget Sound may exacerbate that (Levin 1998, Hilborn et al. 2003, Hamilton 2008). In the South Sound, several historically large canary rockfish populations may be severely reduced potentially to previous harvest and low dissolved oxygen (Drake et al. 2010). Also, spatial distribution provides protection from larger scale anthropogenic changes that damage habitat suitability in one basin, such as oil spills or hypoxia, but not necessarily the other basins.

Canary rockfish are more mobile than many other rockfish species, which may help preserve genetic diversity by increasing connectivity among breeding populations. The propensity of some adults and pelagic juveniles to migrate long distances can result in reestablished rockfish aggregations in formerly occupied habitat (Drake et al. 2010). Results from a recent genetic study comparing canary rockfish individuals from within the PS/GB DPS (n=40) to those outside the DPS (n=40) concluded that there was a lack of genetic differentiation among individuals (Tonnes et al. 2016). Further, the 2016 5-year status review (Tonnes et al. 2016) recommended that the PS/GB canary rockfish be declassified as a DPS and, thereby, delisted.

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

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

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

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

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

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

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

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

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

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

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

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

In 2008, WDFW conducted fishery-independent population abundance estimates using spatially and temporally limited research trawls, drop camera surveys, and underwater remotely operated vehicle (ROV) surveys (Pacunski et al. 2013). The trawl surveys were conducted on the bottom to assess marine fish abundance for a variety of species. The drop camera surveys sampled habitats less than 36.6 m (120 ft.), which is potential habitat for bocaccio juveniles. In the San Juan Basin, rocky habitats were mapped and a randomized survey of these areas assessing species assemblages and estimating abundances was conducted. The ROV surveys were conducted exclusively within these rocky habitats and represent the best available abundance estimates because of their survey area, number of transects, and stratification methods. WDFW conducted 200 transects and stratified each rocky habitat survey as either “shallower than” and “deeper than” 36.6 m (120 ft.). The total area surveyed within each stratum was calculated using the average transect width multiplied by the transect length. The mean densities were calculated by dividing the species counts within each stratum by the area surveyed. Population estimates were calculated by multiplying density estimates by the total survey area within each stratum (Pacunski et al. 2013). Additional ROV surveys by WDFW have been conducted in 2010, 2012, and 2013; but results from these surveys have not been published (Tonnes et al. 2016). Further, there are no estimates for juveniles for any of the PS/GB listed rockfish (Tonnes et al. 2016). Below, we provide a description of the abundance and productivity of the three separate rockfish species.

Though bocaccio were never a predominant segment of the multi-species rockfish population within the Puget Sound/Georgia Basin (Drake et al. 2010), their present-day abundance is likely a fraction of their pre-contemporary fishery abundance. These trawls generally sampled over non-rocky substrates where bocaccio are less likely to occur compared to steep-sloped, rocky habitat (Drake et al. 2010). Based on these surveys, the WDFW estimates 4,606 bocaccio are present in the San Juan Islands basin of the DPS (Table 81). This estimate only includes the non-rocky habitats of the San Juan Island basin and, therefore, is likely to be a conservative estimate of the actual PS/GB bocaccio rockfish abundance.

Table 81. WDFW population estimates for bocaccio, canary rockfish, and yelloweye rockfish (Pacunski et al. 2013).

DPS	Survey Method	Population Estimate	
		North Sound	**Puget Sound proper**
PS/GB bocaccio	Bottom Trawl	Not Detected	Not Detected
	Drop Camera	Not Detected	Not Detected
	Remote Operated Camera	4,606 (San Juan Basin)	
	Total Population Estimate	**4,606**	
PS/GB canary rockfish	Bottom Trawl	16,100	Not Detected
	Drop Camera	2,751	Not Detected
	Remove Operated Camera	1,697 (San Juan Basin)	
	Total Population Estimate	**20,548**	
PS/GB yelloweye rockfish	Bottom Trawl	Not Detected	600
	Drop Camera	Not Detected	Not Detected
	Remove Operated Camera	47,407 (San Juan Basin)	
	Total Population Estimate	**47,407** [a]	

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

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

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

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

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

Canary rockfish catches have declined as a proportion to the overall rockfish catch (Palsson et al. 2009, Drake et al. 2010). In the North Sound, canary rockfish occurred in 6.5 percent of the recreational harvests during the 1960s and then declined to 1.4 percent (1980-1989) and further to 0.6 percent (1996-2001) (Palsson et al. 2009, Drake et al. 2010). In the South Sound, canary rockfish were 3.1 percent of the recreational harvests during the 1960s and then declined to 1.1% percent (1980-1989) and further to 0.7 percent (1996-2001) (Palsson et al. 2009, Drake et al. 2010). Combining this frequency decline with the overall rockfish abundance decline throughout Puget Sound, the BRT concluded that the current abundance trend contributes significantly to the DPS's extinction risk.

In 2008, fishery-independent estimate surveys conducted by WDFW estimated 20,548 canary rockfish are present in the San Juan Islands basin (Table 31). This estimate only includes the San Juan Island basin and, therefore, is likely to be smaller than the total PS/GB canary rockfish abundance. The bottom trawl and drop camera surveys did not detect canary rockfish in Puget Sound proper, though they have been historically present there and have been caught in recent recreational fisheries. Factors for the lack of canary rockfish detections in Puget Sound proper include: (1) canary rockfish populations are depleted, (2) the general lack of rocky benthic areas in Puget Sound proper may lead to canary rockfish densities that are naturally less than the San Juan Basin, and (3) the study design or effort may not have been sufficiently powerful to detect canary rockfish.

Productivity measures a population's growth rate through all or a portion of its life-cycle. Canary rockfish life-history traits suggest generally low inherent productivity levels because they are long-lived, mature slowly, and have sporadic episodes of successful reproduction (Tolimieri and Levin 2005, Drake et al. 2010). Further, past commercial and recreational fishing may have depressed the DPS to a threshold beyond which optimal productivity is unattainable (Drake et al. 2010). Also, historic over-fishing may have had dramatic impacts on population size or age structure.

Yelloweye rockfish were 2.4 percent of the rockfish harvest in the North Sound during the 1960s, 2.1 percent of the harvest during the 1980s, and further decreased to an average of one percent from 1996 to 2002 (Palsson et al. 2009). In Puget Sound proper, yelloweye rockfish were 4.4 percent of the rockfish harvest during the 1960s, 0.4 percent during the 1980s, and 1.4

percent from 1996 to 2002 (Palsson et al. 2009). By the 2000s, evidence of fewer older fish in the population prevailed. Since overall fish numbers in the database were also much lower, it is difficult to determine if size truncation occurred.

In 2008, fishery-independent estimate surveys conducted by WDFW estimated that 47,407 yelloweye rockfish are present in the in the San Juan Islands basin (Table 81). Since this estimate only includes the San Juan Island basin, this estimate is considered a conservative estimate of actual PS/GB yelloweye rockfish abundance. Though yelloweye rockfish were detected via bottom trawl surveys in Puget Sound proper, we do not consider the WDFW estimate of 600 fish to be a complete estimate and were not included. Since juvenile yelloweye rockfish are less dependent on rearing in shallow nearshore environments than canary rockfish and bocaccio, the drop camera surveys were not expected to result in any detections.

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

Limiting Factors and Threats: Several factors, both population- and habitat-related, have caused the listed PS/GB rockfish to decline to the point that NMFS has listed them. Their low intrinsic productivity, combined with continuing threats from bycatch in commercial and recreational harvest, non-native species introductions, loss and degradation of habitat, and chemical contamination increase the extinction risk. On August 16, 2016, NMFS released a draft recovery plan for PS/GB rockfish for public comment (81 FR 54556). The Plan provides background on the natural history of yelloweye rockfish and bocaccio, population trends, and the potential threats to their viability. The Plan lays out a recovery strategy to address the potential threats based on the best available science, identifies site-specific actions with time lines and costs, and includes recovery goals and criteria.

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

(Drake et al. 2010). Also, Puget Sound water quality is impacted by sewage, animal waste, and nutrient inputs.

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

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

2.2.3 Southern Green Sturgeon

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

Green sturgeon—like all sturgeon—is a long-lived, slow-growing species. Adult green sturgeon typically migrate into fresh water beginning in late February and spawn from March to July. Green sturgeon females produce 60,000-140,000 eggs. Green sturgeon larvae are different from all other sturgeon because they lack a distinct swim-up or post-hatching stage and are distinguished from white sturgeon by their larger size, light pigmentation, and size and shape of the yolk sac. First feeding occurs 10 days after they hatch, and metamorphosis to juveniles is complete at 45 days. The larvae grow fast, reaching a length of 66 mm and a weight of 1.8 grams in three weeks of exogenous feeding. Larvae hatched in the laboratory are photonegative and exhibit hiding behaviors after the onset of exogenous feeding. The larvae and juveniles are nocturnal. Juveniles appear to spend one to three years in freshwater before they enter the ocean (NMFS 2005c).

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

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

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

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

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

Since 2010, Dual Frequency Identification Sonar (DIDSON) surveys of aggregating sites in the upper Sacramento River for Southern green sturgeon have been conducted. Results from these surveys combined with the observed three to four year spawning cycle for Southern green sturgeon resulted in an estimate of 1,348 adults (Table 82; NMFS 2015b). There are no estimates for juvenile S green sturgeon.

Table 82. Green sturgeon adult spawner numbers from DIDSON surveys in the upper Sacramento River and ESU estimate (NMFS 2015b).

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

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

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

2.2.4 Pacific Eulachon

Description and Geographic Range: On March 16, 2010, NMFS listed the Southern DPS of eulachon (hereafter, "eulachon") as a threatened species (75 FR 13012). This DPS encompasses all populations within the states of Washington, Oregon, and California and extends from the Skeena River in British Columbia south to the Mad River in Northern California (inclusive). In May of 2011, the Committee on the Status for Endangered Wildlife in Canada (COSEWIC) released their assessment and status report for eulachon in Canada. COSEWIC divided the Canadian portion of the US designated Southern DPS into three designatable units (DUs) – Nass/Skeena Rivers population, Central Pacific Coast population, and Fraser River population (COSEWIC 2011a). DUs are discrete evolutionarily significant units, where "significant" means that the unit is important to the evolutionary legacy of the species as a whole and if lost would likely not be replaced through natural dispersion (COSEWIC 2009). Thus, DUs are biologically similar to ESU and DPS designations under the ESA. The Fraser River population (the closest Canadian population to the conterminous U.S.) was assessed as endangered by COSEWIC, and the listing decision for the Species at Risk Act (SARA) registry is currently scheduled for 2014 or later (COSEWIC 2011b).

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

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

Eulachon eggs, averaging 1 mm in size, are commonly found attached to sand or pea-sized gravel, though eggs have been found on a variety of substrates, including silt, gravel-to-cobble sized rock, and organic detritus (Smith and Saalfeld 1955, Langer et al. 1977, Lewis et al. 2002). Eggs found in areas of silt or organic debris reportedly suffer much higher mortality than those found in sand or gravel (Langer et al. 1977). Length of incubation ranges from about 28 days in

4°-5° C waters to 21-25 days in 8° C waters. Upon hatching, stream currents rapidly carry the newly hatched larvae, 4-8 mm in length, to the sea. Young larvae are first found in the estuaries of known spawning rivers and then disperse along the coast. After yolk sac depletion, eulachon larvae acquire characteristics to survive in oceanic conditions and move off into open marine environments as juveniles. Eulachon return to their spawning river at ages ranging from two to five years as a single age class. Prior to entering their spawning rivers, eulachon hold in brackish waters while their bodies undergo physiological changes in preparation for fresh water and to synchronize their runs. Eulachon then enter the rivers, move upstream, spawn, and die to complete their semelparous life cycle (COSEWIC 2011a).

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

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

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

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

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

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

Similar abundance declines have occurred in the Fraser and other coastal British Columbia rivers (Hay and McCarter 2000, Moody 2008). Over a three-generation time of 10 years (1999-2009), the overall Fraser River eulachon population biomass has declined by nearly 97% (Gustafson et al. 2010). In 1999, the biomass estimates were 418 metric tons[4]; and by 2010, had dropped to just 4 metric tons (Table 83). Abundance information is lacking for many coastal British Columbia subpopulations, but Gustafson et al. (2010) found that eulachon runs were universally larger in the past. Furthermore, the BRT was concerned that four out of seven coastal British Columbia subpopulations may be at risk of extirpation as a result of small population concerns such as Allee[5] effects and random genetic and demographic effects (Gustafson et al. 2010).

Table 83. Southern DPS eulachon spawning estimates for the lower Fraser River, British Columbia (data from http://www.pac.dfo-mpo.gc.ca/science/species-especes/pelagic-pelagique/herring-hareng/herspawn/pages/river1-eng.html).

Year	Biomass estimate (metric tons)	Estimated spawner population[a]
2006	29	725,000
2007	41	1,025,000
2008	10	250,000
2009	14	350,000
2010	4	100,000
2011	31	775,000
2012	120	3,000,000
2013	100	2,500,000

[4] The U.S. ton is equivalent to 2,000 pounds and the metric ton is equivalent to 2,204 pounds.
[5] The negative population growth observed at low population densities. Reproduction—finding a mate in particular— for migratory species can be increasingly difficult as the population density decreases.

Year	Biomass estimate (metric tons)	Estimated spawner population[a]
2014	66	1,650,000
2015	317	7,925,000
2011-2015[b]	**95.11**	**2,378,000**

[a] Estimated population numbers are calculated as 25,000 adults/metric ton (eulachon average 40g per adult).
[b] Five-year geometric mean of eulachon biomass estimates (2011-2015).

Under SARA, Canada designated the Fraser River population as endangered in May 2011 due to a 98% decline in spawning stock biomass over the previous 10 years (COSEWIC 2011a). From 2011 through 2015, the Fraser River eulachon spawner population estimate is 2,378,000 adults (Table 28).

The Columbia River and its tributaries support the largest known eulachon run. Although direct estimates of adult spawning stock abundance are limited, commercial fishery landing records begin in 1888 and continue as a nearly uninterrupted data set to 2010 (Gustafson et al. 2010). From about 1915 to 1992, historic commercial catch levels were typically more than 500 metric tons, occasionally exceeding 1,000 metric tons. In 1993, eulachon catch levels began to decline and averaged less than five metric tons from 2005-2008 (Gustafson et al. 2010). Persistent low eulachon returns and landings in the Columbia River from 1993 to 2000 prompted the states of Oregon and Washington to adopt a Joint State Eulachon Management Plan (WDFW and ODFW 2001). From 2011 through 2013, all recreational and commercial fisheries for eulachon were closed in Washington and Oregon; but the fisheries were reopened in 2014. Beginning in 2011, ODFW and Washington Department of Fish and Wildlife (WDFW) began eulachon biomass surveys similar to those conducted on the Fraser River. Five years of surveys have now been completed resulting in an estimate of 79,358,000 eulachon spawning adults for the Columbia River and its tributaries (Table 84).

Table 84. Southern DPS eulachon spawning estimates for the lower Columbia River and tributaries (Gustafson et al. 2016).

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

[a] Estimated spawner population numbers are calculated by estimating an assumed sex ratio of 1:1, a mean relative fecundity of 802.3 eggs per gram female bodyweight, an assumed egg to larval survival of 100%, and a mean fish weight of 40.6 g.
[b] Five-year geometric mean of mean eulachon biomass estimates (2011-2015).

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

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

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

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

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

In the past, commercial and recreational harvests likely contributed to eulachon decline. The best available information for catches comes from the Columbia River, where from 1938 to 1993 landings have averaged almost 2 million pounds per year (approximately 24.6 million fish), and have been as high as 5.7 million pounds in a single year (approximately 70 million fish) (Wydoski and Whitney 2003, Gustafson et al. 2010). Between 1994 and 2010, no catch exceeded one million pounds (approximately 12.3 million fish) annually and the median catch was approximately 43,000 pounds (approximately 529,000 fish), which amounts to a 97.7% reduction in catch (WDFW and ODFW 2001, JCRMS 2011). Catch from recreational eulachon fisheries was also high historically (Wydoski and Whitney 2003); and at its height in popularity, the fishery would draw thousands of participants annually. Currently, commercial and recreational harvest of eulachon is prohibited in both Washington and Oregon.

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

Historically, bycatch of eulachon in the pink shrimp fishery along the U.S. and Canadian coasts has been very high (composing up to 28% of the total catch by weight; Hay and McCarter 2000, DFO 2008). Prior to the mandated use of bycatch-reduction devices (BRDs) in the pink shrimp fishery, 32–61% of the total catch in the pink shrimp fishery consisted of non-shrimp biomass, made up mostly of Pacific hake, various species of smelt including Pacific eulachon, yellowtail rockfish, sablefish, and lingcod (*Ophiodon elongatus*) (Hannah and Jones 2007). Reducing bycatch in this fishery has long been an active field of research (Hannah et al. 2003, Hannah and Jones 2007, Frimodig 2008) and great progress has been made in reducing bycatch. As of 2005, following required implementation of BRDs, the total bycatch by weight had been reduced to about 7.5% of the total catch and osmerid smelt bycatch was reduced to an estimated average of 0.73% of the total catch across all BRD types (Hannah and Jones 2007). Despite this reduction, bycatch of eulachon in these fisheries is still significant. The total estimated bycatch of eulachon in the Oregon and California pink shrimp fisheries ranged from 217,841 fish in 2004 to 1,008,260 fish in 2010 (the most recent year that data is available; Al-Humaidhi et al. 2012).

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

2.2.5 Sea Turtles

2.2.5.1 Green Sea Turtle

Description and Geographic Range: Green turtles are found throughout the world, occurring primarily in tropical, and to a lesser extent, subtropical waters. The species occurs in five major regions: the Pacific Ocean, Atlantic Ocean, Indian Ocean, Caribbean Sea, and Mediterranean Sea. The eastern Pacific population includes turtles that nest on the Pacific coast of Mexico, which have been historically listed under the ESA as endangered. In recent years, NMFS and USFWS established a biological review team to evaluate the status of the populations of green turtles to determine if nesting populations should be divided in to distinct population segments

(similar to the agency's action on loggerhead sea turtles) and whether the listing status of some of the populations should be changed. The 2015 biological status report (Seminoff et al. 2015) can be found at:
http://www.nmfs.noaa.gov/pr/species/Status%20Reviews/green_turtle_sr_2015.pdf
In part as a result of the 2015 status review, on April 6, 2016, NMFS revised the listing of green sea turtles worldwide to 11 DPSs, including listing the East Pacific DPS as threatened (81 FR 20058). As summarized in the 2015 status review, increases in nesting females from the East Pacific DPS have been seen at the Mexican mainland nesting beaches, and the trend appears to be slightly increasing to stable at other major nesting beaches (e.g., Galápagos Islands, Ecuador). NMFS is currently reviewing the three green sea turtle DPSs found in U.S. waters (including the East Pacific DPS) to determine whether critical habitat should be designated.

Molecular genetic techniques have helped researchers gain insight into the distribution and ecology of migrating and nesting green turtles. Throughout the Pacific, nesting assemblages group into two distinct regional areas: 1) western Pacific and South Pacific islands, and 2) eastern Pacific and central Pacific, including the rookery at French Frigate Shoals, Hawaii. In the eastern Pacific, greens forage coastally from southern California in the northern latitudes to Mejillones, Chile in the south. Based on mitochondrial DNA analyses, green sea turtles found on foraging grounds along Chile's coast originate from the Galapagos nesting beaches, while those greens foraging in the Gulf of California originate primarily from the Michoacan nesting stock. Green sea turtles foraging in southern California and along the Pacific coast of Baja California originate primarily from rookeries of the Islas Revillagigedos (Dutton 2003).

Population Status and Trends: NMFS and USFWS (2007d) provided population estimates and trend status for 46 green turtle nesting beaches around the world. Of these, twelve sites had increasing populations (based upon an increase in the number of nests over 20 or more years ago), four sites had decreasing populations, and ten sites were considered stable. For twenty sites there are insufficient data to make a trend determination or the most recently available information is too old (15 years or older). A complete review of the most current information on green sea turtles is available in the 2015 Status Review (Seminoff et al. 2015).

Green sea turtles that may be found within the action area likely nest in the eastern or central Pacific. Green turtles in the eastern Pacific were historically considered one of the most depleted populations of green sea turtles in the world. The primary green sea turtle nesting grounds in the eastern Pacific are located in Michoacán, Mexico, and the Galápagos Islands, Ecuador (NMFS and USFWS 1998). Here, green sea turtles were widespread and abundant prior to commercial exploitation and uncontrolled subsistence harvest of nesters and eggs. Sporadic nesting occurs on the Pacific coast of Costa Rica. Analyses using mitochondrial DNA sequences from three key nesting green sea turtle populations in the eastern Pacific indicates that they may be considered distinct management units: Michoacán, Mexico; Galapagos Islands, Ecuador, and Islas Revillagigedos, Mexico (Dutton 2003). The central Pacific component nests exclusively in the Hawaiian Archipelago, with over 90 percent of nesting at French Frigate Shoals (FFS) in the Northwestern Hawaiian Islands.

Information has been suggesting steady increases in nesting at the primary nesting sites in Michoacán, Mexico, and stable to a slight increase in the Galápagos Islands since the 1990s

(Delgado and Nichols 2005; Senko et al. 2011; Seminoff et al. 2015). Colola beach is the most important green turtle nesting area in the eastern Pacific; it accounts for 75 percent of total nesting in Michoacan and has the longest time series of monitoring data since 1981. Nesting trends at Colola have continued to increase since 2000 with the overall eastern Pacific green sea turtle population also increasing at other nesting beaches in the Galápagos and Costa Rica (Wallace et al. 2010; NMFS and USFWS 2007d). Based on recent nesting beach monitoring efforts, the current adult female nester population for Colola, Michoacán is over 11,000 females, making this the largest nesting aggregation in the East Pacific DPS comprising nearly 60 percent of the estimated total adult female population (Seminoff et al. 2015).

Two foraging populations of green turtles are found in U.S. waters adjacent to the proposed action area. South San Diego Bay serves as important habitat for a resident population of up to about 60 juvenile and adult green turtles in this area (Eguchi et al. 2010). There is also an aggregation of green sea turtles that are persistent in the San Gabriel River and surrounding coastal areas in the vicinity of Long Beach, California (Lawson et al. 2011). Recently, Crear et al. (2016) documented extensive local and seasonal movements throughout the Long Beach area, including the San Gabriel River and Anaheim and Alamitos Bay, and a shallow basin located in nearby Seal Beach, California.

Limiting Factors and Threats: A thorough discussion of threats to green turtles worldwide can be found in the most recent status review (Seminoff et al. 2015). Major threats include: coastal development and loss of nesting and foraging habitat; incidental capture by fisheries; and the harvest of eggs, subadults and adults. Climate change is also emerging as a critical issue. Destruction, alteration, and/or degradation of nesting and near shore foraging habitat is occurring throughout the range of green sea turtles. These problems are particularly acute in areas with substantial or growing coastal development, beach armoring, beachfront lighting, and recreational use of beaches. In addition to damage to the nesting beaches, pollution and impacts to foraging habitat becomes a concern. Pollution run-off can degrade sea grass beds that are the primary forage of green sea turtles. The majority of turtles in coastal areas spend their time at depths less than 5 m below the surface (Schofield et al. 2007; Hazel et al. 2009), and hence are vulnerable to being struck by vessels and collisions with boat traffic are known to cause significant numbers of mortality every year (NMFS and USFWS 2007d; Seminoff et al. 2015). Marine debris is also a source of concern for green sea turtles due to the same reasons described earlier for other sea turtle species.

The bycatch of green sea turtles, especially in coastal fisheries, is a serious problem because in the Pacific, many of the small-scale artisanal gillnet, setnet, and longline coastal fisheries are not well regulated. These are the fisheries that are active in areas with the highest densities of green sea turtles (NMFS and USFWS 2007d). The meat and eggs of green turtles has long been favored throughout much of the world that has interacted with this species. As late as the mid-1970s, upwards of 80,000 eggs were harvested every night during nesting season in Michoacán (Clifton et al. 1982). Even though Mexico has implemented bans on the harvest of all turtle species in its waters and on the beaches, poaching of eggs, females on the beach, and animals in coastal water continues to happen. In some places throughout Mexico and the whole of the eastern Pacific, consumption of green sea turtles remain a part of the cultural fabric and tradition (NMFS and USFWS 2007d).

Like other sea turtle species, increasing temperatures have the potential to skew sex ratios of hatchling and many rookeries are already showing a strong female bias as warmer temperatures in the nest chamber leads to more female hatchlings (Kaska et al. 2006; Chan and Liew 1995). Increased temperatures also lead to higher levels of embryonic mortality (Matsuzawa et al. 2002). An increase in typhoon frequency and severity, a predicted consequence of climate change (Webster el al. 2005), can cause erosion which leads to high nest failure (VanHouten and Bass 2007). Green sea turtles feeding may also be affected by climate change. Seagrasses are a major food source for green sea turtles and may be affected by changing water temperature and salinity (Short and Neckles 1999; Duarte 2002). Climate change could cause shifts in ocean productivity (Hayes et al. 2005), which may affect foraging behavior and reproductive capacity for green sea turtles (Solow et al. 2002) similar to what has been observed during El Niño events in the western Pacific (Chaloupka 2001).

2.2.5.2 Leatherback Sea Turtles

Description and Geographic Range: The leatherback turtle is listed as endangered under the ESA throughout its global range. Increases in the number of nesting females have been noted at some sites in the Atlantic, but there have been substantial declines or collapse of some populations throughout the Pacific, such as in Malaysia, Mexico, and Costa Rica. In the Pacific, leatherback nesting aggregations are found in the eastern and western Pacific. In the eastern Pacific, major nesting sites are located in Mexico, Costa Rica, and to a lesser extent, Nicaragua. Nesting in the western Pacific occurs at numerous beaches in Indonesia, the Solomon Islands, Papua New Guinea, and Vanuatu, with a few nesters reported in Malaysia and only occasional reports of nesting in Thailand and Australia (Eckert et al. 2012).

On January 26, 2012, NMFS revised critical habitat for leatherbacks to include additional areas within the Pacific Ocean (77 FR 4170). The revised designation includes approximately 17,000 square miles stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour and approximately 25,000 miles stretching from Cape Flattery, Washington, to Cape Blanco, Oregon east of the 2,000 meter depth contour. The principal biological feature identified as essential to leatherback conservation was prey, primarily *scyphomedusae*.

Leatherback turtles lead a completely pelagic existence, foraging widely in temperate and tropical waters except during the nesting season, when gravid females return to tropical beaches to lay eggs. Leatherbacks are highly migratory, exploiting convergence zones and upwelling areas for foraging in the open ocean, along continental margins, and in archipelagic waters (Morreale et al. 1994; Eckert 1998, 1999; Benson et al. 2007a, 2011). Recent satellite telemetry studies have documented transoceanic migrations between nesting beaches and foraging areas in the Atlantic and Pacific Ocean basins (Ferraroli et al. 2004; Hays et al. 2004; James et al. 2005; Eckert 2006; Eckert et al. 2006; Benson et al. 2007a; Benson et al. 2011). In the Pacific, leatherbacks nesting in Central America and Mexico migrate thousands of miles into tropical and temperate waters of the South Pacific (Eckert and Sarti 1997; Shillinger et al. 2008). After nesting, females from the Western Pacific nesting beaches make long-distance migrations into a variety of foraging areas including the central and eastern North Pacific, westward to the

Sulawasi and Sulu and South China Seas, or northward to the Sea of Japan (Benson et al. 2007a; Benson et al. 2011).

Population Status and Trends: Leatherbacks are found throughout the world and populations and trends vary in different regions and nesting beaches. In 1980, the leatherback population was estimated at approximately 115,000 (adult females) globally (Pritchard 1982). By 1995, one estimate claimed this global population of adult females had declined to 34,500 (Spotila et al. 1996). A current global population estimate is not available at this time, but details on what is known of populations are provided below.

In the Pacific leatherback populations are declining at all major Pacific basin nesting beaches, particularly in the last two decades (Spotila et al. 1996; Spotila et al. 2000; NMFS and USFWS 2007a). In the eastern Pacific, nesting counts indicate that the population has continued to decline since the mid 1990's leading some researchers to conclude that this leatherback is on the verge of extirpation (Spotila et al. 1996; Spotila et al. 2000). Steep declines have been documented in Mexico and Costa Rica, the two major nesting sites for eastern Pacific leatherbacks. Recent estimates of the number of nesting females/year in Mexico and for Costa Rica is approximately 200 animals or less for each county per year (NMFS and USFWS 2013a). Estimates presented at international conferences show the numbers declining even more in all of the major nesting sites in the eastern Pacific.

The western Pacific leatherback metapopulation that nests in Indonesia, Papua New Guinea, Solomon Islands, and Vanuatu harbors the last remaining nesting aggregation of significant size in the Pacific with approximately 2700–4500 breeding females (Dutton et al. 2007; Hitipeuw et al. 2007). The current overall estimate for Papua Barat (Indonesia), Papua New Guinea, and Solomon Islands is 5,000 to 10,000 nests per year (Nel 2012). Although there is generally insufficient long term data to calculate population trends, in all of these areas, the number of nesting females is substantially lower than historical records (Nel 2012). This metapopulation is made up of small nesting aggregations scattered throughout the region, with a dense focal point on the northwest coast of Papua Barat, Indonesia; this region is also known as the Bird's Head Peninsula where approximately 75 percent of regional nesting occurs (Hitipieuw et al. 2007). Genetic results to date have found that nesting aggregations that comprise the western Pacific population all belong to a single stock (Dutton et al. 2007). The Bird's Head region consists of four main beaches, three that make up the Jamursba-Medi (JM) beach complex, and a fourth which is Wermon beach (Dutton et al. 2007).

The most recently available information on the number of nesting females in northwest Papua reflects a significant decline. Tapilatu et al. (2013) estimated that the annual number of nests at Jamursba-Medi has declined 78.2 percent over the past 27 years (5.5% annual rate of decline), from 14,522 in 1984 to 1,532 in 2011. The beach at Wermon has been consistently monitored since 2002 and has declined 62.8 percent from 2,944 nests in 2002 to 1,292 nests in 2011 (11.6% annual rate of decline). Collectively, Tapilatu et al. (2013) estimated that since 1984, these primary western Pacific beaches have experienced a long-term decline in nesting of 5.9 percent per year. With a mean clutch frequency of 5.5 ±1.6, approximately 489 females nested in 2011.

Migratory routes of leatherback turtles originating from eastern and western Pacific nesting beaches are not entirely known for the entire Pacific population; however, satellite tracking of post-nesting females and foraging males and females, as well as genetic analyses of leatherback turtles caught in U.S. Pacific fisheries or stranded on the West Coast of the U.S. indicate that leatherbacks found off the U.S. West Coast are from the western Pacific nesting populations, specifically boreal summer nesters. Given the relative size of the nesting populations, it is likely that the majority of the the animals originate from the Jamursba-Medi nesting beaches, although some may come from the comparatively small number of summer nesters at Wermon in Papua Barat, Indonesia. As mentioned earlier, one female has been tracked traveling from foraging areas on the U.S. West Coast to the Solomon Islands. The Papua Barat, Jamursba-Medi nesting population generally exhibits site fidelity to the central California foraging area (Benson *et al*. 2011; Seminoff *et al*. 2012).

Limiting Factors and Threats: The primary threats identified for leatherbacks are fishery bycatch and impacts at nesting beaches, including nesting habitat, direct harvest and predation. Leatherback are vulnerable to bycatch in a variety fisheries, including longline, drift gillnet, set gillnet, bottom trawling, dredge, and pot/trap fisheries that are operated on the high seas or in coastal areas throughout the species' range. Off the U.S. west coast, a large time/area closure was implemented in 2001 to protect Pacific leatherbacks by restricting the CA thresher shark/swordfish drift gillnet fishery, which has likely significantly reduced bycatch of leatherbacks in that fishery. On the high seas, bycatch in longline fisheries is considered a major threat to leatherbacks (Lewison et al. 2004). At or adjacent to nesting sites, population declines are primarily the result of a wide variety of human activities, including legal harvests and illegal poaching of adults, immature animals, and eggs; incidental capture in coastal fisheries; and loss and degradation of nesting and foraging habitat as a result of coastal development, including predation by domestic dogs and feral pigs foraging on nesting beaches associated with human settlement and commercial development of coastal areas. In addition to anthropogenic factors, natural threats to nesting beaches and marine habitats such as coastal erosion, seasonal storms, predators, temperature variations, and phenomena such as El Niño also affect the survival and recovery of leatherback populations (Eckert et al. 2012). Marine debris is also a source of mortality to all species of sea turtles because small debris can be ingested and larger debris can entangle animals, leading to death.

2.2.5.3 Loggerhead Sea Turtles, North Pacific DPS

Description and Geographic Range: Loggerheads are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. Major nesting grounds are generally located in temperate and subtropical regions, with scattered nesting in the tropics. On September 22, 2011, the USFWS and NMFS published a final rule listing nine DPS of loggerhead sea turtles (76 FR 58868). The North Pacific Ocean DPS of loggerheads, which is the population of loggerheads likely to be exposed to the proposed actions, was listed as endangered.

Juvenile loggerheads originating from nesting beaches in the western Pacific Ocean appear to use oceanic developmental habitats and move with the predominant ocean gyres for several years before returning to their neritic foraging habitats (Pitman 1990; Bowen et al. 1995; Musick and

Limpus 1997). Adults may also periodically move between neritic and oceanic zones (Harrison and Bjorndal 2006). In the western Pacific, the only major nesting beaches are in the southern part of Japan (Dodd 1988). In Japan, loggerheads nest on beaches across 13 degrees of latitude (24°N to 37°N), from the mainland island of Honshu south to the Yaeyama Islands, which appear to be the southernmost extent of loggerhead nesting in the western North Pacific. Satellite tracking of juvenile loggerheads indicates the Kuroshio Extension Bifurcation Region in the central Pacific to be an important pelagic foraging area for juvenile loggerheads (Polovina et al. 2006; Kobayashi et al. 2008; Howell et al. 2008).

Other important juvenile turtle foraging areas have been identified off the coast of Baja California Sur, Mexico (Peckham and Nichols 2006; Peckham et al. 2007; Conant et al. 2009). After spending years foraging in the central and eastern Pacific, loggerheads return to their natal beaches for reproduction (Resendiz et al.1998; Nichols et al. 2000) and remain in the western Pacific for the remainder of their life cycle (Iwamoto et al. 1985; Kamezaki et al. 1997; Conant et al. 2009; Hatase et al. 2002). Loggerheads that have been documented off the U.S. west coast are primarily found south of Point Conception, California in the Southern California Bight. South of Point Eugenia on the Pacific coast of Baja California, pelagic red crabs (*Pleuroncodes planipes*) have been found in great numbers, attracting top predators such as tunas, whales and sea turtles, particularly loggerheads (Pitman 1990; Wingfield et al. 2011). Pitman (1990) found loggerhead distribution off Baja to be strongly associated with the red crab, which often occurred in such numbers as to "turn the ocean red." Considerable efforts have been spent studying the movements and relationships of juvenile loggerheads in the central Pacific and off Baja and the west coast of the U.S. to understand migrations and/or developmental patterns across the North Pacific (see Nichols et al. 2000; Polovina et al. 2003; Polovina et al. 2004; Polovina et al. 2006; Kobayashi et al. 2008; Howell et al. 2010; Allen et al. 2013), but the ecology of juvenile loggerheads in the eastern Pacific is still not well understood.

Population Status and Trends: The North Pacific loggerhead DPS nests primarily in Japan (Kamezaki et al. 2003), although low level nesting may occur outside of Japan in areas surrounding the South China Sea (Chan et al. 2007; Conant et al. 2009). Nesting beach monitoring in Japan began in the 1950s on some beaches, and grew to encompass all known nesting beaches starting in 1990 (Kamezaki et al. 2003). Along the Japanese coast, nine major nesting beaches (greater than 100 nests per season) and six "submajor" beaches (10–100 nests per season) exist, including Yakushima Island where 40 percent of nesting occurs (Kamezaki et al. 2003). Census data from 12 of these 15 beaches provide composite information on longer term trends in the Japanese nesting assemblage. As a result, Kamezaki et al. (2003) concluded a substantial decline (50–90%) in the size of the annual loggerhead nesting population in Japan since the 1950s.

As discussed in the 2011 final ESA listing determination, current nesting in Japan represents a fraction of historical nesting levels (Conant et al. 2009; 76 FR 58868). Nesting declined steeply from an initial peak of approximately 6,638 nests in 1990–1991, to a low of 2,064 nests in 1997. During the past decade, nesting increased gradually to 5,167 nests in 2005 (Conant et al. 2009), declined and then rose again to a record high of 11,082 nests in 2008, and then 7,495 and 10,121 nests in 2009 and 2010, respectively (STAJ 2008, 2009, 2010). At the November 2011 Sea Turtle Association of Japan annual sea turtle symposium, the 2011 nesting numbers were reported to be slightly lower at 9,011 (NMFS 2012a - Asuka Ishizaki, pers. comm. November 2011). The total number of adult females in the population was estimated at 7,138 for the period 2008-2010 by Van Houtan (2011).

Limiting Factors and Threats: A detailed account of threats of loggerhead sea turtles around the world is provided in recent status reviews (NMFS and USFWS 2007b; Conant et al. 2009). The most significant threats facing loggerheads in the North Pacific include coastal development and bycatch in commercial fisheries. Destruction and alteration of loggerhead nesting habitats are occurring throughout the species' range, especially coastal development, beach armoring, beachfront lighting, and vehicular/ pedestrian traffic. Coastal development includes roads, buildings, seawalls, etc., all of which reduce suitability of nesting beaches for nesting by reducing beach size and restricting beach migration in response to environmental variability. In Japan, many nesting beaches are lined with concrete armoring to reduce or prevent beach erosion, causing turtles to nest below the high tide line where most eggs are washed away unless they are moved to higher ground (Matsuzawa 2006). Coastal development also increases artificial lighting, which may disorient emerging hatchlings, causing them to crawl inland towards the lights instead of seaward. Overall, the Services have concluded that coastal development and coastal armoring on nesting beaches in Japan are significant threats to the persistence of this DPS (76 FR 58868; September 22, 2011).

For both juvenile and adult individuals in the ocean, bycatch in commercial fisheries, both coastal and pelagic fisheries (including longline, drift gillnet, set-net, bottom trawling, dredge, and pound net) throughout the species' range is a major threat (Conant et al. 2009). Specifically in the Pacific, bycatch continues to be reported in gillnet and longline fisheries operating in 'hotspot" areas where loggerheads are known to congregate (Peckham et al. 2007). Interactions and mortality with coastal and artisanal fisheries in Mexico and the Asian region likely represent the most serious threats to North Pacific loggerheads (Peckham et al. 2007; Conant et al. 2009). Additional fishery interactions in domestic and international pelagic fisheries in the North Pacific are also known to exist (Lewison et al. 2004; NMFS 2012a). Marine debris, including debris resulting from the 2011 earthquake and tsunami that took place off Japan, also threatens the North Pacific DPS of loggerheads through ingestion and entanglement.

2.2.5.4 Olive Ridley Sea Turtles

Description and Geographic Range: A 5-year status review of olive ridley sea turtles was completed in 2014 (NMFS and USFWS 2014). Although the olive ridley sea turtle is regarded as the most abundant sea turtle in the world, olive ridley nesting populations on the Pacific coast of Mexico are listed as endangered under the ESA; all other populations are listed as threatened. The status may be revised if and when the Services consider the significance and discreteness of olive ridleys on a global scale in order to determine whether there may be multiple DPSs.

Olive ridley sea turtles occur throughout the world, primarily in tropical and sub-tropical waters. Nesting aggregations in the Pacific Ocean are found in the Marianas Islands, Australia, Indonesia, Malaysia, and Japan (western Pacific), and Mexico, Costa Rica, Guatemala, and South America (eastern Pacific). Like leatherback turtles, most olive ridley sea turtles lead a primarily pelagic existence (Plotkin et al. 1993), migrating throughout the Pacific, from their nesting grounds in Mexico and Central America to the deep waters of the Pacific that are used as foraging areas (Plotkin et al. 1994). While olive ridleys generally have a tropical to subtropical range, with a distribution from Baja California, Mexico to Chile (Silva-Batiz et al. 1996), individuals do occasionally venture north, some as far as the Gulf of Alaska (Hodge and Wing 2000). Olive ridleys live within two distinct oceanic regions including the subtropical gyre and oceanic currents in the Pacific. The gyre contains warm surface waters and a deep thermocline preferred by olive ridleys. The currents bordering the subtropical gyre, the Kuroshio Extension Current, North Equatorial Current and the Equatorial Counter Current, all provide for advantages in movement with zonal currents and location of prey species (Polovina et al. 2004).

Population Status and Trends: Globalyy, olive ridleys are the most abundant sea turtle, but population structure and genetics are poorly understood for this species. It is estimated that there are over 1 million females nesting annually (NMFS and USFWS 2014). Unlike other sea turtle species, most female olive ridleys nest annually. According to the Marine Turtle Specialist Group of the International Union for Conservation of Nature and Natural Resources (IUCN), there has been a 50 percent decline in olive ridleys worldwide since the 1960s, although there have recently been substantial increases at some nesting sites (NMFS and USFWS 2007c). A major nesting population exists in the eastern Pacific on the west coast of Mexico and Central America. Both of these populations use the north Pacific as foraging grounds (Polovina et al. 2004).

Because the proposed action is most likely to occur closer to eastern Pacific nesting and foraging sites, we assume that this population would be more likely (i.e., than the western Pacific population) to be affected by the proposed action. The eastern Pacific population is thought to be increasing, while there is inadequate information to suggest trends for other populations. Eastern Pacific olive ridleys nest primarily in large *arribadas* on the west coasts of Mexico and Costa Rica. Since reduction or cessation of egg and turtle harvest in both countries in the early 1990s, annual nest totals have increased substantially. On the Mexican coast alone, in 2004-2006, the annual total was estimated at 1,021,500 – 1,206,000 nests annually (NMFS and USFWS 2007c). Eguchi et al. (2007) analyzed sightings of olive ridleys at sea, leading to an estimate of 1,150,000 – 1,620,000 turtles in the eastern tropical Pacific in 1998-2006. In contrast, there are no known *arribadas* of any size in the western Pacific, and apparently only a few hundred nests scattered across Indonesia, Thailand, and Australia (Limpus and Miller 2008).

Limiting Factors and Threats: Threats to olive ridleys are described in the most recent five year status review (NMFS and USFWS 2014). Direct harvest and fishery bycatch are considered the two biggest threats. There has been historical and current direct harvest of olive ridleys. In the 1950’s through the 1970’s, it is estimated that millions of olive ridleys were killed for meat and leather and millions of eggs were collected at nesting beaches in Mexico, Costa Rica, and other locations in Central and South America. Harvest has been reduced in the 1980’s and 1990’s, although eggs are still harvested in parts of Costa Rica and there is an illegal harvest of eggs in parts of Central America and India (NMFS and UWFWS 2014).

Olive ridleys have been observed caught in a variety of fishing gear including longline, drift gillnet, set gillnet, bottom trawl, dredge and trap net. Fisheries operating in coastal waters near *arribadas* can kill tens of thousands of adults. This is evident on the east coast of India where thousands of carcasses wash ashore after drowning in coastal trawl and drift gillnets fishing near the huge *arribada (*NMFS and USFWS 2007c*)*. Based upon available information, it is likely that olive ridley sea turtles are being affected by climate change. Similar to other sea turtle species, olive ridleys are likely to be affected by rising temperatures that may affect nesting success and skew sex ratios, and rising sea surface temperatures may affect available nesting beach areas as well as ocean productivity. Marine debris, including debris resulting from the 2011 earthquake and tsunami that took place off Japan, also threatens olive ridleys through ingestion and entanglement.

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).

The action area for the proposed action includes the three geographic regions the NWFSC conducts research surveys: the Puget Sound Research Area (PSRA; Figure 4), the Lower Columbia River Research Area (LCRRA; Figure 5), and the California Current Research Area (CCRA; Figure 6), which also includes waters off southeast Alaska (not shown in the figure). For the purposes of analyzing potential impacts to ESA-listed species and designated critical habitats, we assume the fisheries survey research activities will occur anywhere throughout these three regions.

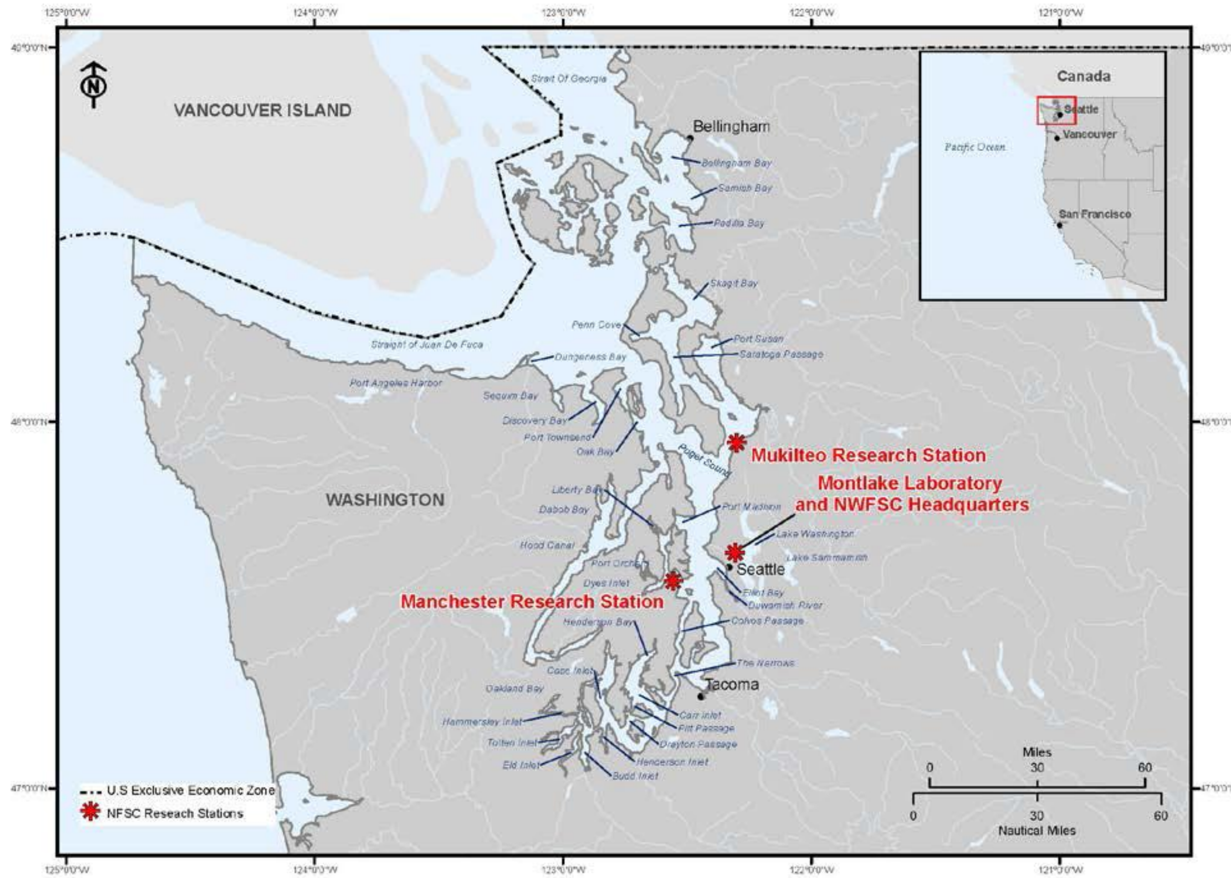

Figure 4. Puget Sound Research Area (PSRA).

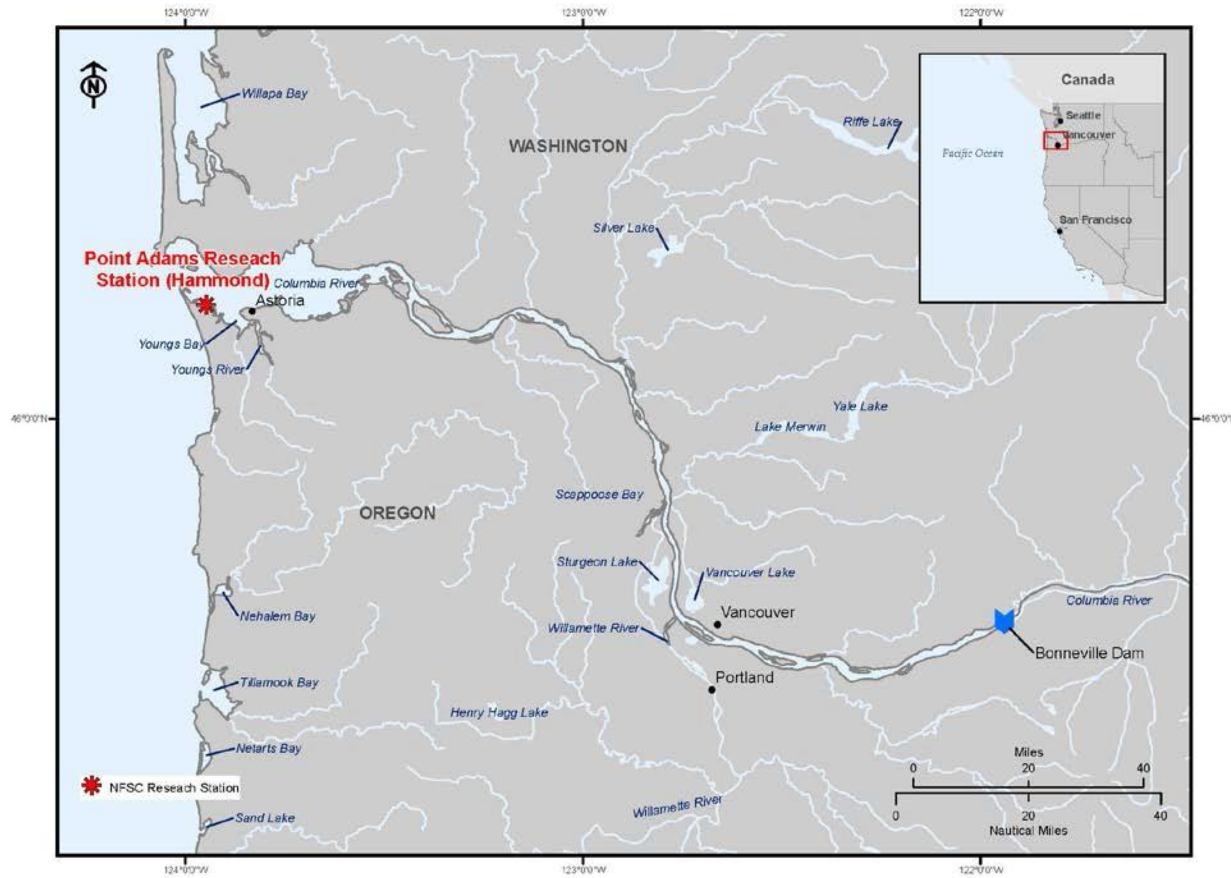

Figure 5. Lower Columbia River Research Area (LCRRA).

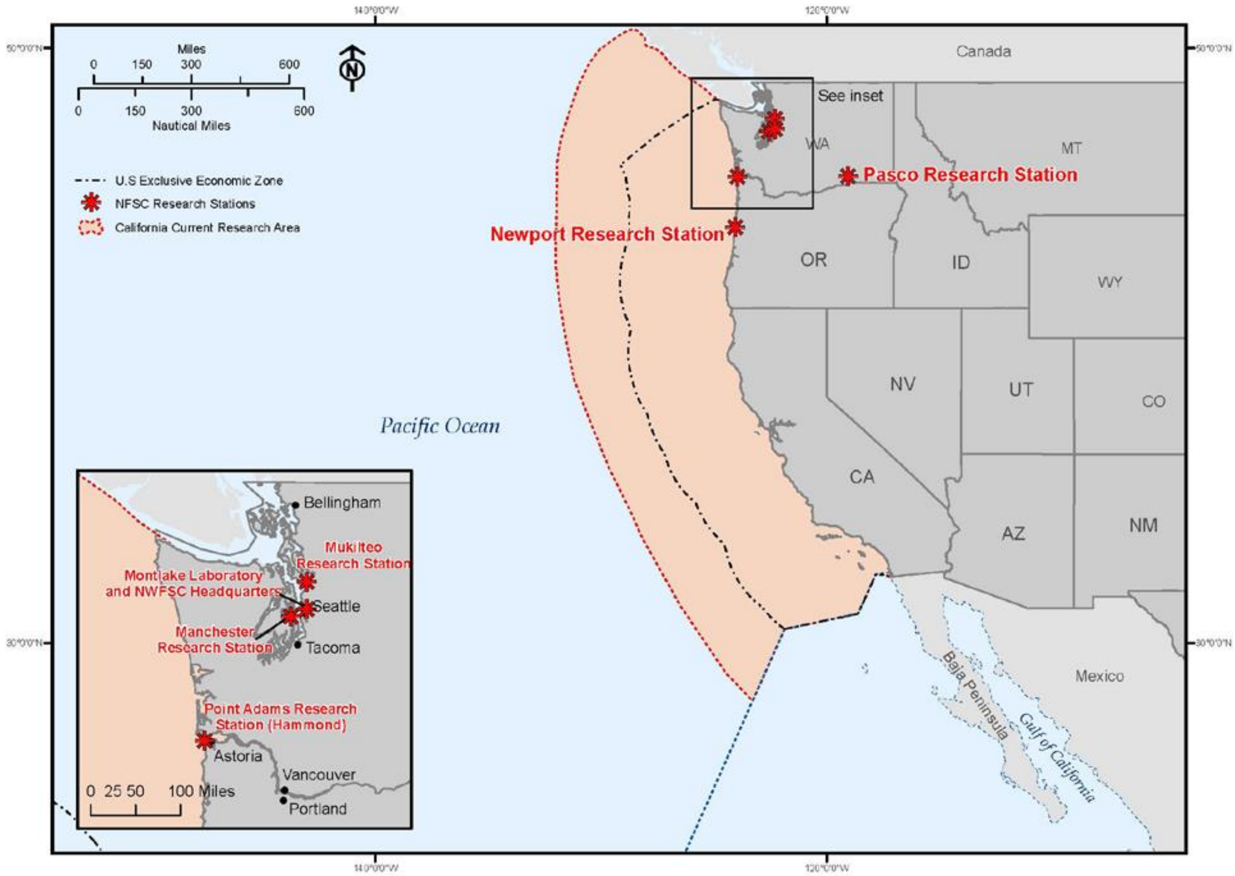

Figure 6. California Current Research Area (CCRA).

2.4 Environmental Baseline

The "environmental baseline" includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

2.4.1 Marine Fish

The best scientific information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of west coast salmonids. NMFS' status reviews, Technical Recovery Team publications, and recovery plans for the listed species considered in this opinion identify several factors that have caused them to decline, as well as those that prevent them from recovering (many of which are the same). Very generally, these include habitat degradation and curtailment caused by human development and harvest and hatchery practices. NMFS' decision to list them identified a variety of factors that were limiting their recovery. None of these documents identifies scientific research as either a cause for decline or a factor preventing their recovery. See Table 85 for a summary of the major factors limiting recovery of the listed species considered in this opinion; more details can also be found in the individual discussions of the species below and in the species status sections.

Table 85. Major factors limiting recovery.

	CC Chinook salmon	PS Chinook salmon	HCS chum salmon	SONCC coho salmon	NC steelhead	PS steelhead	OL sockeye salmon	S eulachon	S green sturgeon	PS/GB bocaccio	PS/GB canary rockfish	PS/GB yelloweye rockfish
Degraded floodplain and in-river channel structure	•	•		•	•	•	•					
Riparian area degradation and loss of in-river large woody debris	•	•	•	•	•	•	•					
Degraded tributaries/river habitat conditions			•	•	•							
Reduced access to spawning/rearing habitat	•			•	•	•		•				
Degraded estuarine conditions and loss of estuarine habitat	•	•	•	•	•	•	•					
Excessive sediment in spawning gravels	•	•	•	•	•	•	•					
Degraded water quality		•		•	•	•	•	•		•	•	•
High water temperature		•		•		•						
Reduced streamflow in migration areas	•			•	•		•					
Predation on adults and juveniles			•	•	•		•	•				
Chemical pollutants								•		•	•	•
Bycatch								•	•	•	•	•
Degradation of nearshore habitats		•		•						•	•	•
Climate change	•	•	•	•	•	•	•	•	•	•	•	•

2.4.1.1 Salmonids

Status in the Marine Environment: Despite the importance of the marine phase of their life-cycle, there has been some information available on the status of the salmon ESUs while in the marine waters. Once salmon leave their natal rivers, they are difficult the track. Chinook salmon generally migrate out of their natal rivers within six months to a year of emergence and will spend one to seven years at sea. Coho will spend about 18 months in fresh water and approximately 6 or 18 months in the marine environment. Very little is known about steelhead in the ocean as they are rarely encountered or recovered in ocean salmon fisheries. Information on salmon abundance and distribution once they leave fresh water is based upon the recovery of salmon with coded wire tags (CWTs) in ocean fisheries. For over 30 years, the marine distribution and relative abundance of specific stocks, including ESA-listed ESUs, has been done using a representative hatchery stock (or stocks) to serve as proxies for the wild and hatchery fish within the ESUs. This assumes that hatchery and wild stocks have similarities in life histories and migrations in marine waters. The validity of using a hatchery stock as a proxy for a wild stock has been brought up as a serious issue in ocean salmon fisheries management. Differences in the performance, survival, behavior, and physical condition between natural and hatchery-origin salmonids have been identified innumerous studies (see Chittenden et al. 2009 for a review of some references). However, studies have focused on features associated with relative fitness with regard to early-life dynamics. Once in the marine environment, there is little evidence of exactly how these differences influence movement or exposure to harvest in fisheries. After examining nearly 2 million CWT recovery locations, Weitkamp and Neely (2002) found consistency between natural and hatchery coho CWT recovery patterns on the North American west coast, and concluded the use of hatchery populations as a proxy for marine distribution for coho was reasonable.

Catch and Bycatch in Commercial Fisheries: Since 1977, salmon fisheries in the exclusive economic zone (EEZ) (three to 200 miles offshore) off Washington, Oregon, and California have been managed under the salmon FMP. The take of ESA-listed salmon ESUs in the ocean and in-river salmon fisheries has been analyzed by the NMFS in a number of biological opinions and in each of these, NMFS found that salmon directed fisheries would not jeopardize the continued existence of ESA-listed salmon or NMFS has provided reasonable and prudent alternatives to avoid jeopardy. The salmon fisheries, both ocean harvest and in-river harvest, are managed to avoid jeopardy by meeting escapement objectives to protect ESA-listed and non-ESA-listed populations.

Large numbers of salmon are caught incidentally in large commercial fisheries off the U.S. west coast, including: the bottom trawl and whiting components of the groundfish fishery off the coasts of Washington, Oregon, and California; and purse seine fisheries that target coastal pelagic species (CPS) such as sardines and squid. A number of section 7 consultations have been conducted to determine effects of the fishery on ESA-listed salmon. In each of the consultations, NMFS has determined that the incidental take of salmon in the fishery would not likely jeopardize the continued existence of the ESUs (mostly Chinook) under consideration (NMFS 1999; NMFS 2006a).

Other Factors Affecting Salmonids: Beyond the impacts of fisheries described above, at-sea survival of salmon can be affected by a number of manmade and natural factors once they reach the marine environment. Juvenile salmon are prey for marine seabirds, marine mammals, and larger fish. Adult salmon are prey to pinnipeds such as sea lions, harbor seals (NMFS 1997b) and killer whales in the Pacific Northwest (see section 2.2.1.1.4.1; Osborne 1999 and NMFS 2009). In certain areas where salmon and predators are in close proximity in relatively high concentrations, predation has been identified as a significantly limiting factor for certain ESUs (e.g., sea lions at Bonneville Dam (NMFS 2008a)**.**

The environmental conditions at the time of ocean entry and near the point of ocean entry are likely to be especially important in determining the survival of juvenile Chinook (Lindley et al. 2009). If ocean productivity and feeding conditions are good, growth will be high and starvation or the effects of size-dependent predation may be lower. Recent studies have provided evidence that growth and survival rates of salmon in the California Current off the Pacific Northwest can be linked to fluctuations in ocean conditions (Peterson et al. 2006; Wells et al. 2008). The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and local scale, provides an indication of the role they play in salmon survival in the ocean.

There is evidence to suggest that salmon abundance is linked to variation in climate effects on the marine environment. It is widely understood that variations in marine survival of salmon correspond with periods of cold and warm ocean conditions, with cold regimes being generally favorable for salmon survival and warm ones unfavorable (Behrenfeld et al. 2006; Wells et al. 2006). Both short term El Nino Southern Oscillation (ENSO) and longer term climate variability, (Pacific Decadal Oscillation), appear to play a part in salmon survival and abundance.

Research Effects: Although they have never been identified as a factor for decline or a threat preventing recovery, scientific research and monitoring activities have the potential to affect the species' survival and recovery by killing listed salmonids. For the year 2015, NMFS issued several section 10(a)(1)(A) and section 4(d) scientific research permits and authorizations allowing lethal and non-lethal take of listed salmon and steelhead. Actual take levels associated with these activities are almost certain to be a good deal lower than the authorized levels. There are two reasons for this. First, most researchers do not handle or kill the full number of juveniles (or adults) they are allowed. Our research tracking system reveals that for the past five years researchers, on average, ended up taking approximately only 33 percent of the number of juvenile salmonids and 31 percent of the adults they requested and the actual mortality was only 9 percent of requested for juveniles and 2 percent for adults. Second, the estimates of mortality for each proposed study are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer fish - especially juveniles - would be killed during any given research project than the researchers are allotted, in some cases many fewer.

In 2015, NMFS consulted on the effects of fisheries research conducted and funded by the SWFSC, the issuance of a LOA under the MMPA for the incidental take of marine mammals pursuant to those research activities, and the issuance of a scientific research permit under the ESA for directed take of ESA-listed salmonids (NMFS 2015a; 2015-2455). NMFS determined that the SWFSC fisheries research was not likely to jeopardize the continued existence of Sacramento River winter Chinook; Central Valley spring Chinook; California coastal Chinook; Snake River fall Chinook; Snake River spring/summer Chinook; Lower Columbia River Chinook; Upper Willamette River Chinook; Upper Columbia River spring Chinook; Puget Sound Chinook; Hood Canal summer run Chum; Columbia River Chum; Central California coastal coho; S. Oregon/N. California coastal coho; Oregon Coast coho; and Lower Columbia River coho; Snake River sockeye; Ozette Lake sockeye; Southern California steelhead; South-Central California steelhead; Central California Coast steelhead; California Central Valley steelhead; Northern California steelhead; Upper Columbia River steelhead; Snake River Basin steelhead; Lower Columbia River steelhead; Upper Willamette River steelhead; Middle Columbia River steelhead; or Puget Sound steelhead. For salmonids, NMFS expected that a total of 53 Chinook, 5 chum, 51 coho, 4 sockeye, and 4 steelhead, would be incidentally captured and killed in SWFSC survey trawls in the CCRA.

2.4.1.2 Rockfish

Benthic habitats within Puget Sound have been influenced by a number of factors. The degradation of some rocky habitat, loss of eelgrass and kelp, introduction of non-natural-origin species that modify habitat, and degradation of water quality are threats to marine habitat in Puget Sound (Drake et al. 2010b; Palsson et al. 2009). Some benthic habitats have been impacted by derelict fishing gear that include lost fishing nets, and shrimp and crab pots (Good et al. 2010). Derelict fishing gear can continue “ghost” fishing and is known to kill rockfish, salmon, and marine mammals as well as degrade rocky habitat by altering bottom composition and killing numerous species of marine fish and invertebrates that are eaten by rockfish (Good et al. 2010). Thousands of nets have been documented within Puget Sound and most have been found in the San Juan Basin and the Main Basin. The Northwest Straits Initiative has operated a program to remove derelict gear throughout the Puget Sound region. In addition, WDFW and the Lummi, Stillaguamish, Tulalip, Nisqually, and Nooksack Tribes and others have supported or conducted derelict gear prevention and removal efforts. Net removal has mostly concentrated in waters less than 100 feet (33 m) deep where most lost nets are found (Good et al. 2010).The removal of over 4,600 nets and over 3,000 derelict pots have restored over 650 acres of benthic habitat (Northwest Straights Initiative 2014), though many derelict nets and crab and shrimp pots remain in the marine environment. Several hundred derelict nets have been documented in waters deeper than 100 feet deep (NRC 2014). Over 200 rockfish have been documented within recovered derelict gear, including one canary rockfish (within a net) (NRC 2010). Because habitats deeper than 100 feet (30.5 m) are most readily used by adult yelloweye rockfish, canary rockfish, and bocaccio, there is an unknown but potentially significant impact from deepwater derelict gear on rockfish habitats within Puget Sound.

We discuss fisheries management pertinent to rockfish that is part of the environmental baseline in the Puget Sound area as a context for the fisheries take authorized within previous section 7 consultations. In addition, we briefly summarize fisheries management in Canadian waters of the DPSs, as it is relevant to ESA-listed rockfish that use waters in Canada and the San Juan area. In 2010, the Washington State Fish and Wildlife Commission formally adopted regulations that ended the retention of rockfish by recreational anglers in Puget Sound and closed fishing for bottom fish in all waters deeper than 120 feet. On July 28, 2010, WDFW enacted the following package of regulations by emergency rule for the following non-tribal commercial fisheries in Puget Sound in order to protect dwindling rockfish populations:

1) Closure of the set net fishery,
2) Closure of the set line fishery,
3) Closure of the bottom trawl fishery,
4) Closure of the inactive pelagic trawl fishery,
5) Closure of the inactive bottom fish pot fishery.

As a precautionary measure, WDFW closed the above commercial fisheries westward of the ESA-listed rockfish DPSs’ boundary to Cape Flattery. The WDFW extended the closure west of the rockfish DPSs’ boundary to prevent commercial fishermen from concentrating gear in that area. The commercial fisheries closures listed above were enacted on a temporary basis (up to 240 days), and WDFW permanently closed them in February 2011. The pelagic trawl fishery was closed by permanent rule on the same date.

Recreational fishers targeting bottom fish and the shrimp trawl fishery in Puget Sound can incidentally catch listed rockfish. In 2012 we issued an incidental take permit to the WDFW for listed rockfish caught in these two fisheries. The permit will be in effect for 5 years and authorizes the total incidental take of up to 152 yelloweye rockfish, 138 canary rockfish, and 43 bocaccio annually (all of these fish would be released). Some released fish are expected to survive; thus, of the total takes, we authorized a subset of lethal take of up to 75 yelloweye rockfish, 79 canary rockfish, and 25 bocaccio annually (consultation number F/NWR/2012/1984). Recreational and commercial halibut fishermen can incidentally catch listed rockfish. In 2014 we assessed the bycatch associated with the halibut fishery in Puget Sound. We estimated that up to 265 yelloweye rockfish, 31 canary rockfish, and 10 bocaccio would be caught annually in the 2014, 2015, and 2016 fishing seasons. Of these, it is anticipated that all caught listed rockfish would be killed (consultation number 2014/F/WCR/403). After the 2014 fishery, it was reported that 7 yelloweye rockfish and one canary rockfish were incidentally caught in the commercial halibut fishery (James 2015a) though there is uncertainty if all bycatch is being identified. In 2015 we permitted various researchers a total lethal take of 26 yelloweye rockfish, 38 canary rockfish and 26 bocaccio.

Fisheries management in British Columbia, Canada (also partially overlapping with the DPSs' boundary) has been altered to better conserve rockfish populations. In response to declining rockfish stocks, the government of Canada initiated comprehensive changes to fishery policies beginning in the 1990s (Yamanaka and Logan 2010). Conservation efforts were focused on four management steps: (1) accounting for all catch, (2) decreasing total fishing mortality, (3) establishing areas closed to fishing, and (4) improving stock assessment and monitoring (Yamanaka and Lacko 2001). The Department of Fisheries and Oceans (DFO) adopted a policy of ensuring that inshore rockfish are subjected to fisheries mortality equal to or less than half of natural mortality.

These efforts led to the 2007 designation of a network of Rockfish Conservation Areas (RCAs) that encompasses 30% of rockfish habitat of the inside waters of Vancouver Island (Yamanaka and Logan 2010). The DFO defined and mapped "rockfish habitat" from commercial fisheries log CPUE density data as well as change in slope bathymetry analysis (Yamanaka and Logan 2010). These reserves do not allow directed commercial or recreational harvest for any species of rockfish, or the harvest of other marine species if that harvest may incidentally catch rockfish.[6] Since the RCAs are relatively new, it is uncertain how effective they have been in protecting rockfish populations (Haggarty 2013) but one analysis found that sampled RCAs in Canada had 1.6 times the number of rockfish compared to unprotected areas (Cloutier 2011). There are anecdotal reports that compliance with the RCAs may be poor and that some may comprise less than optimum areas of rockfish habitat (Haggarty 2013). Systematic monitoring of the RCAs may be lacking as well (Haggarty 2013). Outside the RCAs, recreational fishers generally may

[6] Recreational fishing allowed in RCAs: invertebrates by hand picking or dive, crab by trap, shrimp/prawn by trap, smelt by gillnet. Commercial fishing allowed in RCAs: invertebrates by hand picking or dive, crab and prawn by trap, scallops by trawl, salmon by seine or gillnet, herring by gillnet, seine and spawn-on-kelp sardine by gillnet, seine, and trap, smelt by gillnet, euphausiid (krill) by mid-water trawl, opal squid by seine groundfish by mid-water trawl. (http://www.pac.dfo-mpo.gc.ca/fm-gp/maps-cartes/rca-acs/permitted-permis-eng.htm)

keep one rockfish per day from May 1 to September 30. Commercial rockfish catches in area 4(b) are managed by a quota system (DFO 2011).

2.4.1.3 Southern Green Sturgeon

Green sturgeon occur throughout the action area. Marine waters off Washington, Oregon, and California within the action area encompass designated critical habitat for green sturgeon (marine waters within the 60-fathom (110 m) contour from Monterey Bay to the Strait of Juan de Fuca) and represent a major portion of the marine migratory habitat of the Southern DPS. Impacts to this portion of the action area are described below and include disturbance of benthic habitats and communities, reductions in water quality (contaminants, increased sedimentation, and turbidity), and increased levels of underwater noise. Southern DPS green sturgeon also occur in Puget Sound.

Fisheries Bycatch: The operation of the Federal groundfish fishery and the state-managed California halibut bottom trawl fishery has resulted in past and present impacts on green sturgeon incidentally caught in these fisheries. Although retention of green sturgeon is prohibited, some portion of the green sturgeon incidentally caught dies immediately or after being released back into the water. Because Southern DPS green sturgeon are not morphologically distinguishable from Northern DPS green sturgeon, the effects of these fisheries described below are not specific to Southern DPS green sturgeon. To estimate the effects of these fisheries on Southern DPS green sturgeon, we used stock composition information from genetic and tagging studies to estimate the proportion of the green sturgeon incidentally caught that may belong to the Southern DPS.

The LE groundfish bottom trawl sector and the at-sea Pacific hake/whiting sector (at-sea hake sector) of the Pacific Coast Groundfish Fishery (PCGF) have incidentally caught green sturgeon in the past (Al-Humaidhi et al. 2012). Incidental catch of green sturgeon in these fisheries has varied over the years. The LE groundfish bottom trawl sector encountered an estimated 0 to 43 green sturgeon per year from 2002 through 2010 (Al-Humaidhi et al. 2012). Based on the location of the encounters (WCGOP and NWFSC 2011) and data on green sturgeon stock composition in marine and coastal estuarine waters (Israel et al. 2009; Israel 2010), we estimate that the majority of the green sturgeon encountered likely belonged to the Southern DPS, with a range of 0 to 39 Southern DPS green sturgeon encounters per year from 2002 through 2010. Almost all the fish were released alive. In the at-sea hake sector, only three green sturgeon were encountered and observed in the period from 1991 through 2011 and all had died because of the encounter (Al-Humaidhi et al. 2012; Vanessa Tuttle, pers. comm., A-SHOP, July 23, 2012). Data are not available to determine if the fish belonged to the Southern DPS or Northern DPS. A-SHOP data include two additional records of unidentified sturgeon encountered and observed during the 1990s (Vanessa Tuttle, pers. comm., A-SHOP, August 17, 2012).

Green sturgeon are encountered in the state-regulated California halibut bottom trawl fishery conducted in coastal marine waters. From 2002 through 2010, an estimated 104 to 786 green sturgeon encounters occurred per year in the fishery (Al-Humaidhi et al. 2012). It is possible that individual green sturgeon are encountered by the fishery more than once per year, but recapture rates are not known. The majority of the green sturgeon encountered likely belonged to the

Southern DPS, based on the location of the encounters (primarily in coastal marine waters adjacent to San Francisco Bay) (Al-Humaidhi et al. 2012) and data on green sturgeon stock composition in marine waters and coastal estuaries of California (Israel et al. 2009; Israel 2010). We estimate that from 2002 through 2010, the fishery had 86 to 786 encounters with Southern DPS green sturgeon per year. Changes in state fishing regulations were implemented in 2006 to reduce access to the California halibut fishery (California Fish and Game Code Section 8494) and appear to have decreased total California halibut landings and the number of encounters with green sturgeon per year. The estimated encounters with Southern DPS green sturgeon ranged from 86 to 289 per year from 2007 through 2010, compared to 152 to 786 per year from 2002 through 2006 (Al-Humaidhi et al. 2012). Thus, the level of encounters has been reduced compared to historical levels. Based on the 2007 through 2010 bycatch data, we estimate that the California halibut bottom trawl fishery encounters 86 to 289 Southern DPS green sturgeon per year. Applying a bycatch mortality rate of 5.2 percent, we estimate that encounters in the California halibut bottom trawl fishery kills 5 to 15 Southern DPS green sturgeon per year.

Other Human Sources of Injury: Several ocean dredged material disposal sites have been designated within the action area. NMFS consults with the EPA on the proposed designation of these sites, as well as on the issuance of permits by the EPA for disposal activities at these sites. For example, in recent years, NMFS has consulted with the EPA on the proposed designation of several sites off the Oregon coast (off the mouth of the Rogue River, Umpqua River, and Yaquina River) (NMFS 2009, and 2012b). In 2012, NMFS also consulted on the use of four ocean disposal sites off the Columbia River as part of the Columbia River Channel Operations and Maintenance Program (NMFS 2012c). NMFS concluded that the proposed actions were likely to adversely affect but not likely to jeopardize the continued existence of the Southern DPS green sturgeon. The disposal of dredged materials at these disposal sites has the potential to entrain and bury small (i.e., ≤ 2 feet in length) subadult green sturgeon that, unlike adults and larger subadults, may not be able to move quickly enough to avoid descending sediments. This may result in injury to small subadult green sturgeon, but the number affected was expected to be low given the location of the disposal sites and the migratory patterns of green sturgeon in marine waters (e.g., green sturgeon are likely to spend limited time in one area as they move from estuary to estuary).

Underwater noise generated from in-water construction activities has the potential to cause injury to fish species such as green sturgeon; however, there is limited information available to assess these effects. In 2011, NMFS consulted on the proposed Columbia River Jetty System Rehabilitation Project at the mouth of the Columbia River (NMFS 2011b). NMFS concluded that the proposed action was likely to adversely affect but not likely to jeopardize the continued existence of the Southern DPS green sturgeon. Although pile driving and removal activities associated with the project could result in underwater noise effects on green sturgeon, the sound levels generated by the project were expected to be below estimated threshold levels that would result in injury to fish. NMFS expected that few, if any, green sturgeon would be in close proximity to the jetties and concluded that the activities were not likely to result in behavioral responses of green sturgeon that may be in the area. To minimize effects, NMFS recommended limiting activities to a few days or a single event annually.

Renewable ocean energy installations may also affect green sturgeon behavior and migration in marine waters because of potential impacts from anthropogenic noise and electromagnetic fields, as well as the addition of structures to the water column and seafloor. NMFS consulted on the effects of renewable ocean energy installations off the Oregon coast (off Reedsport and off Newport) and concluded that the proposed actions were likely to adversely affect but not likely to jeopardize the continued existence of the Southern DPS green sturgeon (NMFS 2012d and 2012e. Electromagnetic fields generated by the installations may either attract or deter green sturgeon in the area. In addition, the installation structures themselves could pose a migration barrier for green sturgeon. For both projects, the degree of exposure and responses of green sturgeon to the potential effects was uncertain, but expected to most likely be small. The proposed installations would cover a small area and would not create a continuous physical barrier to passage, based on plans allowing for a minimum spacing of 150 to 200 feet between structures. Additionally, NMFS estimated that one adult and one subadult green sturgeon may be captured during biological monitoring activities, but those fish would likely be released alive. The consultations included measures to implement study plans and adaptive management frameworks to identify unanticipated negative effects of the installations on green sturgeon and the development of appropriate actions to avoid and minimize those effects in the future. Proposed studies included studies to examine electromagnetic fields and their effects, project effects on fish and invertebrate habitat, and project effects on wave, current, and sediment transport.

Prey Availability: Several activities occur within the action area that may affect prey resources for Southern DPS green sturgeon. The feeding habits and diet of green sturgeon in the ocean is poorly known, but they may prey upon demersal fish (sand lance are a known diet item) captured in bottom trawl fisheries. Disturbance of benthic habitats by bottom trawl fisheries may also affect prey species and alter the abundance, distribution, and composition of benthic communities. How these changes may affect Southern DPS green sturgeon and designated critical habitat is unclear, however, because some of these benthic communities are in high energy environments characterized by frequent disturbance and rapid recolonization. In addition, it is unclear whether disturbance of benthic habitats by bottom trawls may reduce or enhance feeding opportunities for green sturgeon. Also, green sturgeon feeding while in marine waters and the prey resources they may feed on have not yet been confirmed or identified. Thus, effects of fishing activities on prey availability in designated green sturgeon critical habitat and feeding opportunities for green sturgeon are difficult to evaluate until more definitive information is known about the marine habitat use and diets of green sturgeon.

Dredging activities, disposal of dredged material at ocean disposal sites, and the management and operation of renewable ocean energy installations may also affect prey availability for green sturgeon in marine waters. In recent years, NMFS has conducted consultations on the designation and use of ocean disposal sites as well as proposed renewable ocean energy installations off the Oregon coast (identified in the sections above). In each consultation, NMFS concluded that the proposed actions were likely to adversely affect but not likely to jeopardize the continued existence of, or destroy or adversely modify designated critical habitat for, the Southern DPS green sturgeon. These actions may reduce the availability of prey resources for green sturgeon because of the disturbance of benthic habitats and the injury or burial of prey resources during the disposal of dredged materials. However, the reductions were expected to be highly localized and insignificant relative to the abundance of prey available to green sturgeon. The proposed actions were expected to affect a small area compared to the available surrounding habitat for prey species. In addition, prey abundance is determined by larger scale physical and biological factors beyond the scope of the proposed action.

Another concern is the potential introduction of contaminants into the environment through the disposal of dredged materials or through spills or leaks at the installations. NMFS concluded that effects on prey resources were expected to be small. As described above, levels of compounds in dredged materials for disposal were not expected to exceed concentrations harmful to organisms at the disposal sites, because dredged materials must be tested prior to disposal to ensure they meet current statutes and regulations for "clean" dredged material that is suitable for ocean disposal. In addition, the risk of spills and leaks at the installations was minimized with the adoption of spill prevention, management, and response plans.

Finally, climate change may alter conditions in coastal marine waters and result in shifts in the distribution of prey resources for green sturgeon in coastal marine areas. We are limited in our ability to assess the effects of climate change on green sturgeon critical habitat, however, because of the limited information available regarding green sturgeon habitat use in coastal marine waters. In addition, variation in the effects of climate change on the marine environment adds to the uncertainty. For example, the effects of climate change may cause some species to increase in abundance and expand in distribution, whereas other species may decline in abundance and become more restricted in distribution.

2.4.1.4 Eulachon, Southern DPS

The Eulachon of the southern DPS range from the Skeena River in British Columbia south to the Mad River in Northern California. Impacts to the action area are described below and include research fisheries and fisheries bycatch.

Research Fisheries: 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 eulachon. NMFS issues numerous section 10(a)(1)(A) scientific research permits allowing lethal and non-lethal take of listed species. We also authorized state scientific research programs under ESA section 4(d). Although eulachon take is not prohibited, the permit applicants are required to consult with NMFS on their take of the species. In 2012 NMFS estimated the lethal and nonlethal take from the research being permitted was about 2,500 fish and 1,000 fish, respectively, and much of this is occurring in coastal marine waters (NMFS 2012b).

Shrimp Fisheries Bycatch: Eulachon are taken as bycatch in shrimp trawl fisheries off the coasts of Washington, Oregon, and California in the CCRA (NWFSC 2010). Offshore trawl fisheries for ocean shrimp (*Pandalus jordani*) extend from the west coast of Vancouver Island to the U.S. West Coast off Cape Mendocino, California (Hannah et al. 2003). Al-Humaidhi et al. (2012) provide estimates of the number of individual eulachon caught in the Oregon and California ocean shrimp trawl fishery as bycatch from 2004 to 2010 (except for 2006 when these fisheries were not observed). The total estimated bycatch of eulachon in the Oregon and California ocean shrimp fisheries ranged from 217,841 fish in 2004 to a high of 1,008,259 fish in 2010 (Al-Humaidhi et al. 2012). For all years observed, fleet-wide eulachon bycatch estimates in the

Oregon ocean shrimp fishery were much higher than in the California fishery. In 2010, estimated eulachon bycatch in the Washington ocean shrimp fishery was 66,820 fish; and the total 2010 estimated eulachon bycatch for all three states combined was 1,075,081 (Al-Humaidhi et al. 2012). Eulachon encountered as bycatch in these fisheries come from a wide range of age classes but are all assumed to be part of the southern DPS.

2.4.2 Sea Turtles

As described above in the status section, loggerhead, green, leatherback and olive ridley sea turtles have been and continue to be affected by numerous activities within the proposed action area. The proposed action area encompasses a vast portion of the ocean stretching including the coastal and offshore waters of the CCRA in the north Pacific. Because impacts on all four species are similar, we look at the environmental baseline for all species together, calling out differences among species as appropriate.

Fisheries Interactions: Along the west coast of the U.S. in the CCRA, all four sea turtle species considered in this opinion are occasionally reported and observed interacting with fishing gear, including pot/trap gear, gillnets, and hook and line recreational gear, with leatherbacks showing to be the more common species interacting with gear (Figures 7 and 8). Recent known interactions include a leatherback found entangled in sablefish trap gear fishing offshore of Fort Bragg in 2008, as well as live leatherback entanglements with the drift gillnet fishery off central California in 2009 and 2012. All four species of sea turtles considered in this opinion have been observed caught in the California drift gillnet fishery historically, although sea turtle interactions are considered rare events in this fishery (NMFS 2012c). When considering the impact of U.S. west coast Federal fisheries on ESA-listed species of turtles, recent biological opinions have found no jeopardy to any of these species (NMFS 2012d, 2012c). There are two state gillnet fisheries in California that may interact with sea turtles: the set gillnet fishery targeting halibut and white seabass; and the small mesh drift gillnet fishery targeting yellowtail, barracuda, and white seabass. No sea turtle interactions have been documented historically or recently, given the sporadic observer coverage of those fisheries.

Pelagic longline fisheries for swordfish and tuna based in Hawaii, which can range into areas of the ocean that may border or are within the CCRA are also known to be susceptible to sea turtle bycatch. The shallow-set fishery for swordfish has traditionally interacted with more turtles than the deep-set fishery for tuna, although mortality rates of turtles in shallow-set gear is lower than in deep-set gear. The reason for the lower mortality rates in the shallow-set fishery is due to the gear being set at shallower depths, which allows turtles to reach the surface to breathe. Loggerheads are particularly susceptible to shallow-set gear and in the 1990s the Hawaii-based shallow-set fishery interacted with several hundred loggerheads annually (NMFS 2012a). However, the shallow-set fishery was closed in 2001 and only re-opened in 2004 after instituting measures for reducing turtle interactions. This reformation of the Hawaii-based shallow-set fishery, including gear modifications and reduced effort, has resulted in an approximately 97 percent reduction in the average number of loggerhead interactions in this fishery since the 1990s (McCracken 2000; NMFS 2012a). Since 2005, the combined Hawaii-based longline fisheries have reduced their estimated loggerhead mortality to four annually (NMFS 2014b). For leatherbacks, the Hawaii-based longline fisheries combined have reduced their estimated mortality to seven annually since 2005 (NMFS 2014b). A small number of olive ridley and green turtle takes have also been documented in those fisheries. These fisheries have also both been recently determined not to be jeopardizing any ESA-listed sea turtles (NMFS 2012a; NMFS 2014b).

Estimating the total number of sea turtle interactions in other Pacific fisheries, many of which occur in part within or near the CCRA interact with the same sea turtle populations as U.S. fisheries, is difficult because of low observer coverage and inconsistent reporting from international fleets. However several attempts have been made for certain fisheries known to have significant sea turtle bycatch issues such as pelagic longlining. Lewison et al. (2004) estimated 1,000 – 3,200 leatherback mortalities and 2,600 – 6,000 loggerhead mortalities from pelagic longlining in the Pacific in 2000. Beverly and Chapman (2007) more recently estimated loggerhead and leatherback longline bycatch in the Pacific to be approximately 20 percent of that estimated by Lewison et al. (2004). Chan and Pan (2012) estimated that there were approximately 1,866 total sea turtle interactions of all species in 2009 in the central and North Pacific by comparing swordfish production and turtle bycatch rates from fleets fishing in the central and North Pacific area. Given that recent developments to reduce sea turtle bycatch in fisheries have been working their way into some international fisheries and the incomplete data sets and reporting that exist, the exact level of current sea turtle bycatch internationally is not clear. However, given the information that is available, we believe that international bycatch of sea turtles in fisheries throughout the Pacific Ocean, including areas that border or within the CCE, continues to occur at significant rates several orders of magnitude greater than what is being documented or anticipated in U.S. Pacific ocean fisheries.

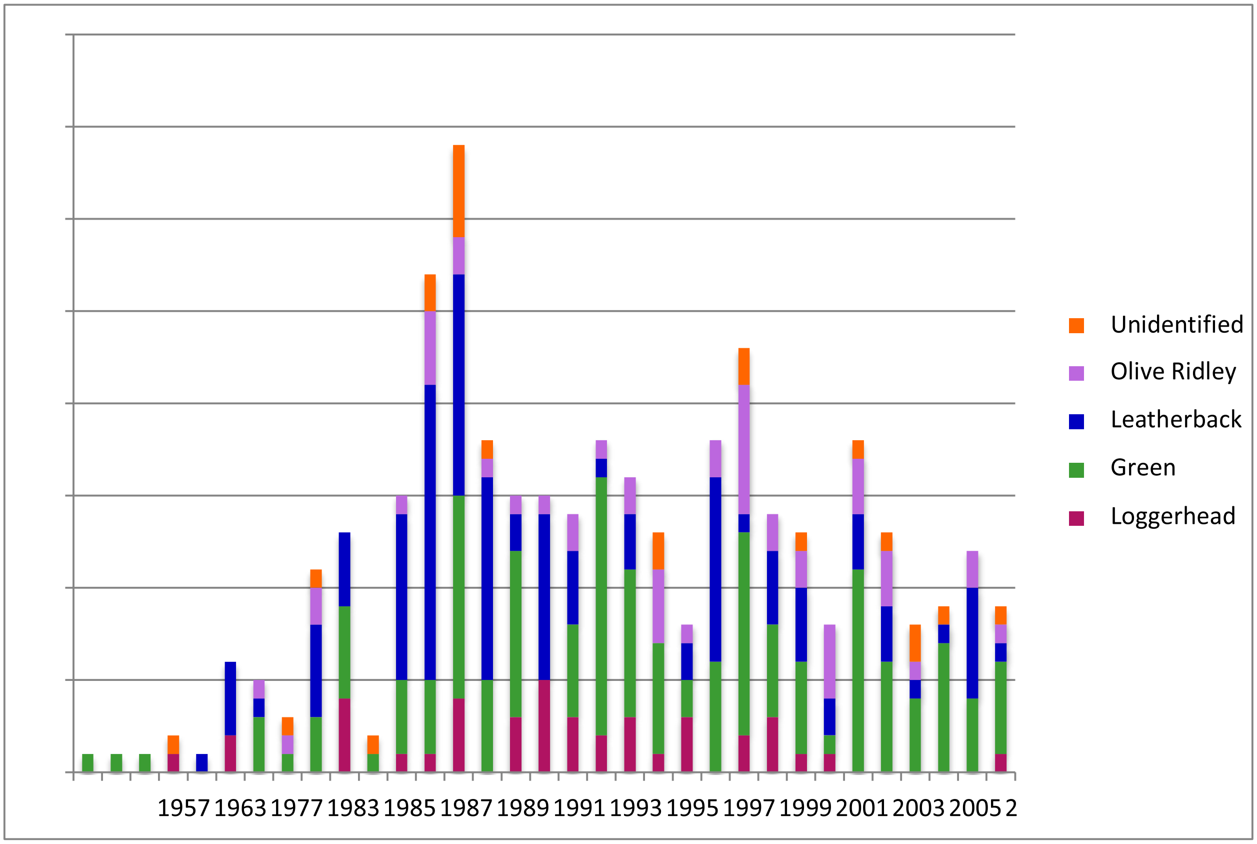

Figure 7. Sea turtle strandings documented off the U.S. west coast, 1957-2009.

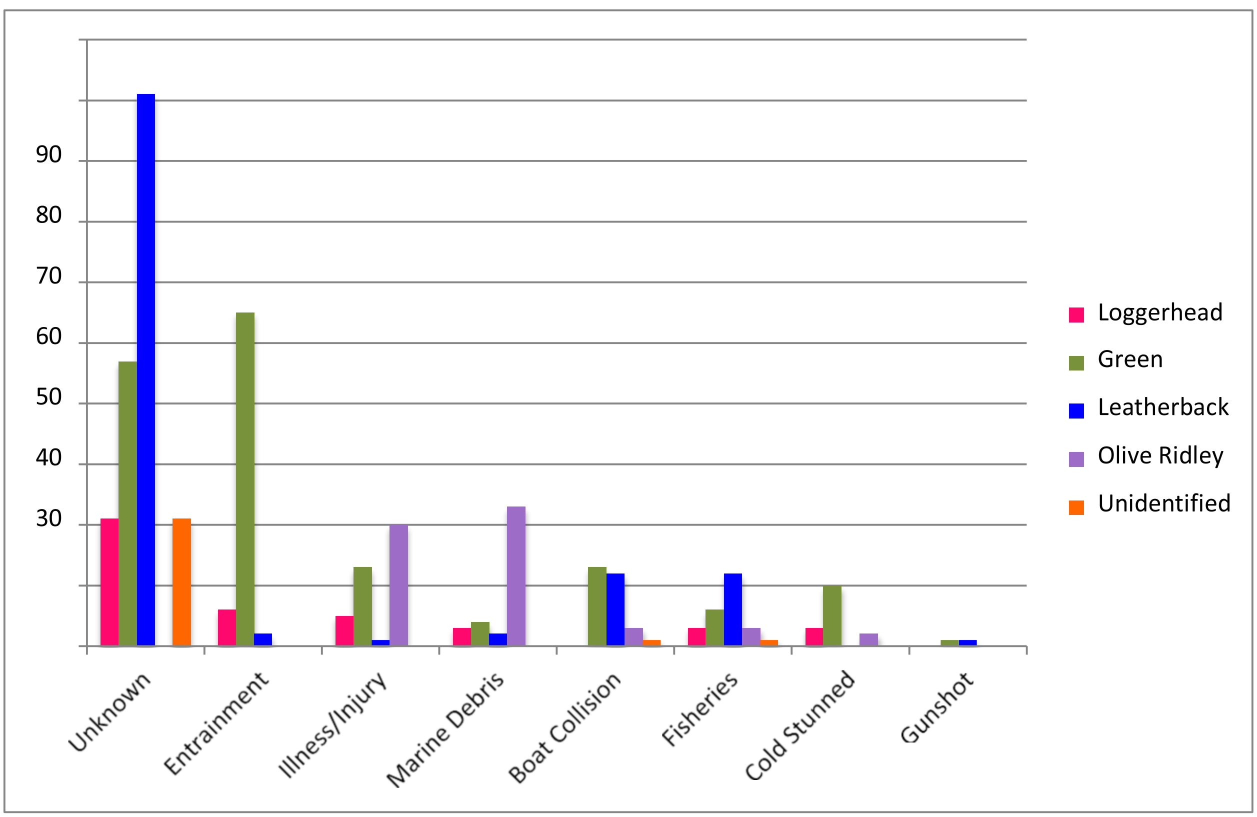

Figure 8. Known causes of sea turtle strandings off the U.S. west coast, 1957-2009.

Vessel Collisions: Vessel collisions are occasionally a source of injury and mortality to sea turtles along the west coast. A review of the strandings database for the U.S. west coast maintained by NMFS indicates that green and leatherbacks are reported most often as stranded due to the impact by vessels strikes, with olive ridleys rarely struck, likely because they are so rare off the California coast. Green turtles are particularly vulnerable to collisions when in coastal foraging areas in San Diego and Long Beach, California, while leatherbacks have been reported struck off central California, likely when they are foraging in or near the approach to the Ports of San Francisco and Oakland. The United States Coast Guard (USCG) is responsible for safe waterways under the Port and Waterways Safety Act (PWSA) and establishes shipping lanes. The USCG recently completed Port Access Route Studies for the Santa Barbara Channel and the approaches to San Francisco made recommended to the International Maritime Organization (IMO) that the traffic separation schemes be modified, in part, to reduce the co-occurrence of large ships and whales. NMFS does not know how these changes may affect sea turtles. The IMO gave final endorsement by the IMO in November 2012. The USCG is currently working on domestic rule making under the PWSA to codify these IMO approved changes. Lane changes went into effect June 1, 2013.

Other Threats: Strandings of sea turtles in the CCRA along the U.S. west coast reflect in part the nature of interactions between sea turtles and human activities, as many stranding are associated with human causes. All four of these sea turtles species considered in this opinion have been observed entrained at power plants off coastal California, either alive, injured, or determined to be previously dead. A review of the stranding records indicates that green turtles are the most commonly reported species entrained at power plants. Since green turtles have been documented foraging in the warm water effluent near power plants, particularly in the San Diego and Long Beach California areas, we assume that they would be most affected. Sea turtles (particularly olive ridleys) have been documented stranded off California through their encounters with marine debris, either through ingesting debris or becoming entangled in the debris. Other documented threats include illness, gunshot wounds and cold-stunning. Issues with coastal development, including dredging and beach renourishment (e.g., depositing sediment in important coastal habitats), are believed to pose a threat as well. Because not all dead stranded sea turtles are necropsied, the stranding database does not provide full documentation of the source of many threats to sea turtles, and the causes of a majority of strandings are unknown.

NMFS issues scientific research permits to allow research actions that involve take of sea turtles within the CCE. Currently there are 6 permits that allow directed research on sea turtles, typically involving either targeted capture or sampling of individuals that may have stranded or incidentally taken in some other manner. These permits allow a suite of activities that include tagging, tracking, and collection of biological data and samples. These activities are intended to be non-injurious, with only minimal short term affects. But the risks of a sea turtle incurring an injury or mortality cannot be discounted as a result of directed research.

2.5 Effects of the Action

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

2.5.1 Marine Fishes

An effect of the research analyzed below that cannot be quantified is the conservation benefit to the species resulting from the research. The Permit 1586-4R would benefit the listed species by helping managers develop protection and restoration strategies and monitor the effects of recovery actions by determining if nearshore populations are increasing or decreasing and by establishing baseline abundance/composition metrics and genetic structure of nearshore populations throughout Puget Sound.

While the following research is not intended to take ESA-listed marine fish, some may die as an inadvertent result of the activities. The Groundfish Bottom Trawl Survey, the Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey, the Investigations of Hake Ecology, Survey Methods, the California Current Ecosystem study, and the Bycatch Reduction Research in West Coast Trawl Fisheries are expected to incidentally take ESA-listed marine fish in the course of this research. The indirect effects of these studies that may incidentally take ESA-listed marine fish are herein evaluated in combination with the anticipated direct effects of permit 1586-4R.

The NWFSC research surveys that primarily use trawl gear could result in the capture of many species of fish and invertebrates that are sources of prey for ESA-listed marine fishes. Eulachon consume phytoplankton, zooplankton, crustaceans and other small species at various stages of their lives (NMFS 2011e). Such small items are only caught with plankton nets during NWFSC surveys in the LCRRA, and only minimal amounts when they are. Additionally, eulachon are primarily in the LCRRA as juveniles and during spawning events (during which time they do not feed), further minimizing the potential effect of prey removal as a result of NWFSC surveys. All life stages of ESA-listed rockfish are found in the PSRA. Their food habits are generally similar and include numerous zooplankton, copepod and phytoplankton species for juveniles, and larger crustaceans, urchins, and numerous fish species for adults. (NMFS 2014g). Such species are commonly caught during NWFSC surveys in the PSRA, but only in small amounts relative to biomass estimates or catch rates in commercial fisheries (refer to Section 4.2.3 Target Fish and Section 4.2.7 Invertebrates *In* the DPEA) and research removals are unlikely to effect the availability of prey to ESA-listed rockfish in the Puget Sound.

In addition to the relative low levels of prey removals from NWFSC research, the nature of NWFSC research typically moving from station to station spreads out small prey removals across large areas of the project area over extended periods of time as opposed to concentrating them in certain areas/times where localized prey depletions that could potentially lead to adverse effects on foraging efficiency or nutritional deficiencies for individuals. Information on the relative effects of varying prey densities, foraging efficiency, and nutritional needs at an individual or population level for ESA-listed marine fish species is currently unknown. However, we do not expect that small prey removals spread out across large areas in space and time is likely to significantly affect the fitness or survival of any ESA-listed marine fish species considered in this opinion.

In previous sections, we estimated the annual abundance of adult and juvenile listed salmonids, eulachon, rockfish, and green sturgeon. We do not anticipate any measurable habitat effects (refer to section 2.12 for the analysis of critical habitat that are not likely to be adversely affected. Therefore, the analysis will consist primarily of examining directly measurable impacts on abundance. Abundance effects stand on their own and can be tied directly to productivity effects and less directly to structure and diversity effects. Examining the magnitude of these effects at the individual and, where possible, population levels is the best way to determine effect at the species level. Table 86 displays the estimated annual abundance of the listed species.

Table 86. Estimated annual abundance of ESA-listed fish.

Species	Origin	Abundance	
		Adult	Juvenile
CC Chinook	Natural	5,599	447,920
CVS Chinook	LHAC	2,683	2,120,000
	Natural	5,251	1,092,518
LCR Chinook	LHAC	38,594	35,298,675
	Natural	29,469	12,866,892
PS Chinook	LHAC	13,223[a]	35,792,500
	LHIA		6,017,150
	Natural	19,258	2,598,480
SacR winter-run Chinook	LHAC	215	400,000
	Natural	3,708	771,449
SnkR fall-run Chinook	LHAC	26,558[a]	2,291,544
	Natural	11,254	605,921
SnkR spr/sum-run Chinook	LHAC	5,696[a]	4,164,942
	Natural	11,347	1,428,881
UCR spring-run Chinook	LHAC	2,967[a]	516,020
	Natural	1,475	484,538
UWR spring-run Chinook	LHAC	34,454[a]	1,299,323
	Natural	11,443	5,792,774
CR Chum	Natural	10,644	3,462,120
HCS Chum	LHIA	2,179	150,000
	Natural	20,855	3,368,592
CCC Coho	LHAC/LHIA	1,912[b]	250,000
	Natural		133,840
LCR Coho	LHAC	23,082[a]	8,446,649
	Natural	32,986	729,256
OC Coho	LHAC	2,046[a]	60,000
	Natural	234,203	16,394,210
SONCC Coho	LHAC	10,934[a]	200,000
	Natural	9,056	1,101,382
OL Sockeye	LHAC	178[a]	45,750

Species	Origin	Abundance: Adult	Abundance: Juvenile
	Natural	2,143	353,282
SR Sockeye	LHAC	1,373[b]	136,489
	Natural		15,960
CCV Steelhead	LHAC	3,822	1,600,653
	Natural	1,482	169,033
CCC Steelhead	LHAC	3,866	600,000
	Natural	2,187	248,771
LCR Steelhead	LHAC	22,297[a]	1,079,744
	Natural	12,920	393,641
MCR Steelhead	LHAC	1,842[a]	324,253
	Natural	23,872	479,860
NC Steelhead	Natural	5,929	674,424
PS Steelhead	LHAC	13,422[b]	165,897
	LHIA		79,000
	Natural		1,526,753
SCCC Steelhead	Natural	695	79,057
SR Steelhead	LHAC	300,060[a]	3,289,351
	Natural	33,340	1,142,126
UCR Steelhead	LHAC	6,579[a]	642,033
	Natural	2,846	280,338
UWR Steelhead	Natural	5,971	207,853
S Green Sturgeon	Natural	1,348	**
Eulachon	Natural	81,736,000	**
PS/GB Bocaccio	Natural	4,606	**
PS/GB Canary Rockfish	Natural	20,548	**
PS/GB Yelloweye Rockfish	Natural	47,407	**

[a] Listed Hatchery origin salmon adults are a combined estimate of LHAC and LHIA adults.
[b] Adult abundance is a total of all origins
** Abundance is unknown for this lifestage

In conducting the following analyses, we were unable to tie the effects of each proposed action to its impacts to individual populations (or population groups) due to the broad geographic range of each action, and because individual populations are no longer separate within the geographic range of the action area. Therefore, each action will only be analyzed at the ESU/DPS level; and the effect of the action is measured in terms of its impact on the relevant species' total abundance by origin (Natural), production [Listed Hatchery Adipose Clip (LHAC) and Listed Hatchery Intact Adipose (LHIA)], and lifestage (juvenile and adult). Five actions [one Section 10(a)(1)(A) permit and four activities will be analyzed.

2.5.1.1 Permit 1586-4R

As noted in section 1.3.3, issuing Section 10(a)(1)(A) permit 1586-4R would renew the NWFSC's existing permit that authorizes take of listed juvenile HCS chum salmon, PS steelhead, PS/GB bocaccio, PS/GB canary rockfish, and PS/GB yelloweye rockfish take; juvenile and adult PS Chinook salmon; and adult S eulachon. Using beach seines, Nordic surface trawls, lampara nets, purse seines, and hook and line, the researchers would collect, handle, and release fish. For this renewal, based on the research methods and past mortality levels, up to five natural-origin adult and 150 natural-origin juvenile PS Chinook, four natural-origin juvenile HCS chum, two natural-origin juvenile PS steelhead, 14 adult S eulachon, one juvenile PS/GB bocaccio, one juvenile PS/GB canary rockfish, and one juvenile PS/GB yelloweye rockfish may die as a result of the research. Table 87 provides the total requested take, which includes take in the form of capture/handle/release (C/H/R), capture/mark, tag, sample tissue/release live (C/M,T,S/R), and direct mortality, and also combines take of natural-origin and hatchery-origin.

Table 87. Proposed Take Under Permit 1586-4R.

ESU/DPS	Life Stage	Origin	Take Action[a]	Requested Take	Requested Mortality
PS Chinook	Adult	LHAC	C/H/R	250	0/250
			C/M,T,S/R	275	0/275
			IM	25	25/25
PS Chinook	Adult	LHIA	C/H/R	250	0/250
			C/M,T,S/R	375	5/375
PS Chinook	Adult	Natural	C/H/R	225	4/225
			C/M,T,S/R	75	1/75
PS Chinook	Juvenile	LHAC	C/H/R	3,500	25/3,500
			C/M,T,S/R	750	20/750
			IM	750	750/750
PS Chinook	Juvenile	LHIA	C/H/R	3,500	25/3,500
			C/M,T,S/R	1,500	20/3,500
			IM	200	200/200
PS Chinook	Juvenile	Natural	C/H/R	5,050	31/5,050
			C/M,T,S/R	2,700	19/2,700
			IM	100	100/100
HCS Chum	Juvenile	LHIA	C/H/R	80	2/80
HCS Chum	Juvenile	Natural	C/H/R	200	4/200
PS Steelhead	Juvenile	LHAC	C/H/R	50	2/50
PS Steelhead	Juvenile	LHIA	C/H/R	50	2/50
PS Steelhead	Juvenile	Natural	C/H/R	75	2/75
S Eulachon	Adult	Natural	C/H/R	110	14/110
PS/GB Bocaccio	Juvenile	Natural	C/H/R	5	1/5
PS/GB Canary Rockfish	Juvenile	Natural	C/H/R	10	1/10
PS/GB Yelloweye Rockfish	Juvenile	Natural	C/H/R	9	1/9

[a] C/H/R – Capture/Handle/Release; C/M,T,S/R – Capture, Mark, Tag, Sample Tissue/Release Live Animal; IM – Intentional (Directed) 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 (see Table 87) to the total abundance numbers expected for the population and species (see Table 86). This research may kill the following percentages (calculated by using the mortality take numbers in Table 87 and dividing them by the corresponding total abundance numbers given in Table 86) of listed salmonid, rockfish, and eulachon abundances (Table 88).

Table 88. Comparison of Possible Lethal Take (see Table 87) to Annual Abundance (see Table 86) at the ESU/DPS Scale for Permit 1586-4R.

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
PS Chinook	Adult	LHAC/LHIA	0.2269%
PS Chinook	Adult	Natural	0.0260%
PS Chinook	Juvenile	LHAC	0.0022%
PS Chinook	Juvenile	LHIA	0.0041%
PS Chinook	Juvenile	Natural	0.0058%
HCS Chum	Juvenile	LHIA	0.0013%
HCS Chum	Juvenile	Natural	0.0001%
PS Steelhead	Juvenile	LHAC	0.0012%
PS Steelhead	Juvenile	LHIA	0.0025%
PS Steelhead	Juvenile	Natural	0.0001%
S Eulachon	Adult	Natural	<0.0001%
PS/GB Bocaccio	Juvenile	Natural	*
PS/GB Canary Rockfish	Juvenile	Natural	*
PS/GB Yelloweye Rockfish	Juvenile	Natural	*

* Abundances of juvenile ESA-listed PS/GB rockfish are unknown.

Since take activities would occur throughout Puget Sound where all populations could be present, the effect of that take cannot be examined at the population level. At the ESU/DPS level, the permitted activities may kill at most 0.0260% of the PS Chinook’s and 0.0001% of the HCS chum and PS steelhead’s natural components (as shown in Table 88). Only PS Chinook salmon lethal take is intentional, and it is to obtain coded-wire tags for hatchery release information, otoliths for saltwater entry information, scales for genetic analysis, tissue samples for chemistry analysis, and stomach contents for diet analysis. These analyses allow examination of contaminant exposure and its relation to adjacent land use, and source population information for examining population distribution and timing. Indirect mortalities will be used in lieu of directed mortalities whenever possible. For juvenile listed PS/GB rockfish, their abundances are unknown; but their abundances are estimated to be at least a magnitude larger than that of the adult abundances. Fecundity for these three listed rockfish species range from tens of thousands of eggs to millions of eggs, and the request for mortality is no more than one for any of the listed rockfish juveniles. Therefore, impact upon these listed rockfish species are considered discountable. And it is possible that the impacts could be even smaller than those laid out above. During research activities for this project from 2008 through 2015, only 15.3% of the requested take and 11.4% of the requested mortalities were used.

2.5.1.2 Groundfish Bottom Trawl Survey

As noted previously in section 1.3.4.1, the Groundfish Bottom Trawl Survey was previously authorized through Section 10(a)(1)(A) permit 16333-2M to take listed sub-adult CC, CVS, LCR, PS, SacR winter-run, SnkR fall-run, SnkR sum/spr-run, UCR spring-run, and UWR spring-run Chinook salmon; CR and HCS chum salmon; CCC, LCR, OC, and SONCC coho salmon; OL and SR sockeye salmon; and CCC, CV, LCR, MCR, NC, PS, SCCC, SR, UCR, and UWR steelhead and adult eulachon and green sturgeon. Since the purpose of these surveys are to quantify the abundance and distribution of groundfish, all ESA-listed salmonid, eulachon, and green sturgeon take is considered incidental. For this study, the researchers would collect, handle, sample, and release salmonids and eulachon. Fin clip, scale, and/or other samples would be collected from salmonids and eulachon for DNA or other analyses. Green sturgeon will be captured, handled, and released. The NWFSC would conduct a series of bottom trawls along the West Coast, from the U.S.-Mexico border to the U.S.-Canada border, which could intercept individual members of every salmonid, eulachon, and green sturgeon species covered in this opinion. The nature of the research methodology is such that, though the listed species are not being targeted, any fish that are intercepted would probably be killed. The intercepted fish would generally be considered to be "subadults." That is, they would represent a life stage that is less numerous than the smolt life stage, but more numerous than the adult life stage. No abundance estimates exist for this life stage. Because of this, and to be conservative in our evaluation of effects, we will simply treat all the salmonid take as if it were adult take. Eulachon may be retained and archived for future analysis. For each west coast salmonid species, at least one sub-adult/adult may die as an unintended result of the research. The requested take is laid out in Table 89.

Table 89. Proposed incidental take for the Groundfish Bottom Trawl Survey.

ESU/DPS	Life Stage	Origin	Take Action[a]	Requested Take	Requested Mortality
CC Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
CVS Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
CVS Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
LCR Chinook	Subadult	LHAC	C/M,T,S/R	2	2/2
LCR Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
PS Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
PS Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
SacR winter-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
SnkR fall-run Chinook	Subadult	LHAC	C/M,T,S/R	2	2/2
SnkR fall-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
SnkR sum/spr-run Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
SnkR sum/spr-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
UCR spring-run Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
UCR spring-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
UWR spring-run Chinook	Subadult	LHAC	C/M,T,S/R	2	2/2
UWR spring-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
CR chum	Subadult	Natural	C/M,T,S/R	1	1/1
HCS chum	Subadult	Natural	C/M,T,S/R	1	1/1

ESU/DPS	Life Stage	Origin	Take Action[a]	Requested Take	Requested Mortality
CCC coho	Subadult	Natural	C/M,T,S/R	1	1/1
LCR coho	Subadult	LHAC	C/M,T,S/R	8	8/8
LCR coho	Subadult	Natural	C/M,T,S/R	1	1/1
OC coho	Subadult	LHAC	C/M,T,S/R	1	1/1
OC coho	Subadult	Natural	C/M,T,S/R	4	4/4
SONCC coho	Subadult	LHAC	C/M,T,S/R	1	1/1
SONCC coho	Subadult	Natural	C/M,T,S/R	1	1/1
OL sockeye	Subadult	Natural	C/M,T,S/R	1	1/1
SR sockeye	Subadult	Natural	C/M,T,S/R	1	1/1
CCC steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
CCC steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
CCV steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
CCV steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
LCR steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
LCR steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
MCR steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
MCR steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
NC steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
PS steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
PS steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
SCCC steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
SR steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
SR steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
UCR steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
UCR steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
UWR steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
Green sturgeon	Adult	Natural	C/H/R	5	0/5
Eulachon	Adult	Natural	C/M,T,S/R	20,000	20,000/20,000

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

The fish mortality rate is expected to be high due to the use of a bottom trawl as the method of capture. Salmonids, and especially eulachon, are susceptible to descaling, crushing, and trawl net-related injuries and are expected to die at a high percentage from these injuries. Even though a 100% mortality rate is requested for this permit that is neither the goal nor the expected result of this research. Green sturgeon are expected to be impacted minimally, and they are expected to be released to the ocean alive. Using the possible lethal take (provided in Table 89) and dividing by the annual abundance (provided in Table 86) for each ESU, life stage and origin, we estimated that the research may kill the following percentages of the adult abundances (Table 90).

Table 90. Comparison of possible lethal take (Table 89) to annual abundance (Table 86) at the ESU/DPS scale for the Groundfish Bottom Trawl Survey.

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
CC Chinook	Subadult	Natural	0.0179%
CVS Chinook	Subadult	LHAC	0.0373%
CVS Chinook	Subadult	Natural	0.0190%
LCR Chinook	Subadult	LHAC	0.0052%
LCR Chinook	Subadult	Natural	0.0034%
PS Chinook	Subadult	LHAC	0.0076%
PS Chinook	Subadult	Natural	0.0052%
SacR winter-run Chinook	Subadult	Natural	0.0270%
SnkR fall-run Chinook	Subadult	LHAC	0.0075%
SnkR fall-run Chinook	Subadult	Natural	0.0089%
SnkR sum/spr-run Chinook	Subadult	LHAC	0.0176%
SnkR sum/spr-run Chinook	Subadult	Natural	0.0088%
UCR spring-run Chinook	Subadult	LHAC	0.0338%
UCR spring-run Chinook	Subadult	Natural	0.0678%
UWR spring-run Chinook	Subadult	LHAC	0.0058%
UWR spring-run Chinook	Subadult	Natural	0.0087%
CR chum	Subadult	Natural	0.0094%
HCS chum	Subadult	Natural	0.0048%
CCC coho	Subadult	Natural	0.0523%
LCR coho	Subadult	LHAC	0.0347%
LCR coho	Subadult	Natural	0.0030%
OC coho	Subadult	LHAC	0.0489%
OC coho	Subadult	Natural	0.0017%
SONCC coho	Subadult	LHAC	0.0091%
SONCC coho	Subadult	Natural	0.0110%
OL sockeye	Subadult	Natural	0.0467%
SR sockeye	Subadult	Natural	0.0728%
CCC steelhead	Subadult	LHAC	0.0259%
CCC steelhead	Subadult	Natural	0.0457%
CCV steelhead	Subadult	LHAC	0.0262%
CCV steelhead	Subadult	Natural	0.0675%
LCR steelhead	Subadult	LHAC	0.0045%
LCR steelhead	Subadult	Natural	0.0077%
MCR steelhead	Subadult	LHAC	0.0543%
MCR steelhead	Subadult	Natural	0.0042%
NC steelhead	Subadult	Natural	0.0169%
PS steelhead	Subadult	LHAC/Natural	0.0149%
SCCC steelhead	Subadult	Natural	0.1439%
SR steelhead	Subadult	LHAC	0.0003%

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
SR steelhead	Subadult	Natural	0.0030%
UCR steelhead	Subadult	LHAC	0.0152%
UCR steelhead	Subadult	Natural	0.0351%
UWR steelhead	Subadult	Natural	0.0167%
Eulachon	Adult	Natural	0.0245%

Since the research would take place along the whole U.S. Pacific coast from Mexico to Canada, the effects of that take cannot be examined at the population level. Further, no individual population is likely to experience a disproportionate amount of these losses. At the ESU/DPS level, the permitted activities may kill at most 0.1439% of any natural-origin salmonid component (SCCC steelhead, Table 90). Other marine fish impacted include eulachon (0.0245%, Table 90). For salmonid spcies, the effects displayed above are actually inflated quite a bit by the fact that most of the take would be in the form of subadults—a life stage that may have 25-50% more individuals than would the adult life stage for each species. Therefore, while the research may have a very small effect on the species' abundance and productivity, it would in all probability not affect structure or diversity at all. And it is possible that the impacts could be even smaller than those laid out above. During research activities for this project from 2011 through 2015, only 53.2% of the requested take and mortalities were used.

2.5.1.3 Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey

As noted previously in section 1.3.4.2, the Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey was previously authorized through Section 10(a)(1)(A) permit 16335-2M to take listed sub-adult CC, CVS, LCR, PS, SacR winter-run, SnkR fall-run, SnkR sum/spr-run, UCR spring-run, and UWR spring-run Chinook salmon; CR and HCS chum salmon; CCC, LCR, OC, and SONCC coho salmon; and OL and SR sockeye salmon and adult eulachon. Since the purpose of these surveys are to assess the distribution, abundance, and biology of Pacific hake, all ESA-listed salmonid and eulachon take is considered incidental. For this study, the researchers would collect, handle, sample, and release listed fish. Fin clip, scale, and/or other samples would be collected from salmonids and eulachon for DNA or other analyses. The NWFSC would conduct a series of mid-water trawls along the West Coast, from the U.S./Mexico border to the Dixon Entrance, Alaska/British Columbia, which could intercept individual members of every salmon and eulachon species covered in this opinion. The nature of the research methodology is such that, though the listed species are not being targeted, any fish that are intercepted would probably be killed. The intercepted fish would generally be considered to be "subadults." That is, they would represent a life stage that is less numerous than the smolt life stage, but more numerous than the adult life stage. No abundance estimates exist for this life stage. Because of this, and to be conservative in our evaluation of effects, we will simply treat all the take as if it were adult take. Eulachon may be retained and archived for future analysis. For each west coast salmon ESU, at least one sub-adult/adult may die as an unintended result of the research. The requested take is laid out in Table 91.

Table 91. Proposed incidental take under the Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

ESU/DPS	Life Stage	Origin	Take Action[a]	Requested Take	Requested Mortality
CC Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
CVS Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
CVS Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
LCR Chinook	Subadult	LHAC	C/M,T,S/R	2	2/2
LCR Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
PS Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
PS Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
SacR winter-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
SnkR fall-run Chinook	Subadult	LHAC	C/M,T,S/R	2	2/2
SnkR fall-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
SnkR sum/spr-run Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
SnkR sum/spr-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
UCR spring-run Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
UCR spring-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
UWR spring-run Chinook	Subadult	LHAC	C/M,T,S/R	2	2/2
UWR spring-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
CR chum	Subadult	Natural	C/M,T,S/R	1	1/1
HCS chum	Subadult	Natural	C/M,T,S/R	1	1/1
CCC coho	Subadult	Natural	C/M,T,S/R	1	1/1
LCR coho	Subadult	LHAC	C/M,T,S/R	8	8/8
LCR coho	Subadult	Natural	C/M,T,S/R	1	1/1
OC coho	Subadult	LHAC	C/M,T,S/R	1	1/1
OC coho	Subadult	Natural	C/M,T,S/R	4	4/4
SONCC coho	Subadult	LHAC	C/M,T,S/R	1	1/1
SONCC coho	Subadult	Natural	C/M,T,S/R	1	1/1
OL sockeye	Subadult	Natural	C/M,T,S/R	1	1/1
SR sockeye	Subadult	Natural	C/M,T,S/R	1	1/1
Eulachon	Adult	Natural	C/M,T,S/R	5,000	5,000/5,000

[a] C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release

The fish mortality rate is expected to be high due to the use of a mid-water trawl as the method of capture. Salmon, and especially eulachon, are susceptible to descaling, crushing, and trawl net-related injuries and are expected to die at a high percentage from these injuries. Even though a 100% mortality rate is requested for this permit that is neither the goal nor the expected result of this research. This research may kill the following percentages of the adult abundances (Table 92).

Table 92. Comparison of possible lethal take to annual abundance at the ESU and DPS scale for the Integrated Ecosystem and Pacific Hake Acoustic-Trawl Survey.

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
CC Chinook	Subadult	Natural	0.0179%
CVS Chinook	Subadult	LHAC	0.0373%
CVS Chinook	Subadult	Natural	0.0190%
LCR Chinook	Subadult	LHAC	0.0052%
LCR Chinook	Subadult	Natural	0.0034%
PS Chinook	Subadult	LHAC	0.0076%
PS Chinook	Subadult	Natural	0.0052%
SacR winter-run Chinook	Subadult	Natural	0.0270%
SnkR fall-run Chinook	Subadult	LHAC	0.0075%
SnkR fall-run Chinook	Subadult	Natural	0.0089%
SnkR sum/spr-run Chinook	Subadult	LHAC	0.0176%
SnkR sum/spr-run Chinook	Subadult	Natural	0.0088%
UCR spring-run Chinook	Subadult	LHAC	0.0338%
UCR spring-run Chinook	Subadult	Natural	0.0678%
UWR spring-run Chinook	Subadult	LHAC	0.0058%
UWR spring-run Chinook	Subadult	Natural	0.0087%
CR chum	Subadult	Natural	0.0094%
HCS chum	Subadult	Natural	0.0048%
CCC coho	Subadult	Natural	0.0523%
LCR coho	Subadult	LHAC	0.0347%
LCR coho	Subadult	Natural	0.0030%
OC coho	Subadult	LHAC	0.0489%
OC coho	Subadult	Natural	0.0017%
SONCC coho	Subadult	LHAC	0.0091%
SONCC coho	Subadult	Natural	0.0110%
OL sockeye	Subadult	Natural	0.0467%
SR sockeye	Subadult	Natural	0.0728%
Eulachon	Adult	Natural	0.0061%

Since the research would take place along the whole U.S. Pacific coast from Mexico to Alaska, and the effects of that take cannot be examined at the population level. Further, no individual population is likely to experience a disproportionate amount of these losses. At the ESU/DPS level, the permitted activities may kill at most 0.0728% of any natural-origin salmonid component (SR sockeye salmon). Other marine fish impacted include eulachon (0.0061%). For salmonid species, the effects displayed above are actually inflated quite a bit by the fact that most of the take would be in the form of subadults—a life stage that may have 25-50% more individuals than would the adult life stage for each species. Therefore, while the research may have a very small effect on the species' abundance and productivity, it would in all probability not affect structure or diversity at all. And it is possible that the impacts could be even smaller than those laid out above. During research activities for this project from 2012 through 2015, only 33.5% of the requested take and mortalities were used.

2.5.1.4 Investigations of Hake Ecology, Survey Methods, and the California Current Ecosystem

As noted previously in section 1.3.4.3, the Investigations of Hake Ecology, Survey Methods, and the California Current Ecosystem was previously authorized through Section 10(a)(1)(A) permit 16337-2M to take listed sub-adult CC, CVS, LCR, PS, SacR winter-run, SnkR fall-run, SnkR sum/spr-run, UCR spring-run, and UWR spring-run Chinook salmon; CR and HCS chum salmon; CCC, LCR, OC, and SONCC coho salmon; and OL and SR sockeye salmon and adult eulachon. Since the purpose of these surveys are (1) to test new field methodology for improving hake biomass estimates and (2) to investigate the winter distribution, abundance, and biology of Pacific hake, all ESA-listed salmonid and eulachon take is considered incidental. For this study, the researchers would collect, handle, sample, and release listed fish. Fin clip, scale, and/or other samples would be collected from salmonids and eulachon for DNA or other analyses. The NWFSC would conduct a series of mid-water and bottom trawls along the West Coast, from the U.S./Mexico border to the Dixon Entrance, Alaska/British Columbia, which could intercept individual members of every salmon and eulachon species covered in this opinion. The nature of the research methodology is such that, though the listed species are not being targeted, any fish that are intercepted would probably be killed. The intercepted fish would generally be considered to be “subadults.” That is, they would represent a life stage that is less numerous than the smolt life stage, but more numerous than the adult life stage. No abundance estimates exist for this lifestage. Because of this, and to be conservative in our evaluation of effects, we will simply treat all the take as if it were adult take. Eulachon may be retained and archived for future analysis. For each west coast salmon ESU, at least one sub-adult/adult may die as an unintended result of the research. The requested take is laid out in Table 93.

Table 93. Proposed incidental take under the Investigations of Hake Ecology, Survey Methods, and the California Current Ecosystem.

ESU/DPS	Life Stage	Origin	Take Action[a]	Requested Take	Requested Mortality
CC Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
CVS Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
CVS Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
LCR Chinook	Subadult	LHAC	C/M,T,S/R	2	2/2
LCR Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
PS Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
PS Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
SacR winter-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
SnkR fall-run Chinook	Subadult	LHAC	C/M,T,S/R	2	2/2
SnkR fall-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
SnkR sum/spr-run Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
SnkR sum/spr-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
UCR spring-run Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
UCR spring-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1

ESU/DPS	Life Stage	Origin	Take Action[a]	Requested Take	Requested Mortality
UWR spring-run Chinook	Subadult	LHAC	C/M,T,S/R	2	2/2
UWR spring-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
CR chum	Subadult	Natural	C/M,T,S/R	1	1/1
HCS chum	Subadult	Natural	C/M,T,S/R	1	1/1
CCC coho	Subadult	Natural	C/M,T,S/R	1	1/1
LCR coho	Subadult	LHAC	C/M,T,S/R	8	8/8
LCR coho	Subadult	Natural	C/M,T,S/R	1	1/1
OC coho	Subadult	LHAC	C/M,T,S/R	1	1/1
OC coho	Subadult	Natural	C/M,T,S/R	4	4/4
SONCC coho	Subadult	LHAC	C/M,T,S/R	1	1/1
SONCC coho	Subadult	Natural	C/M,T,S/R	1	1/1
OL sockeye	Subadult	Natural	C/M,T,S/R	1	1/1
SR sockeye	Subadult	Natural	C/M,T,S/R	1	1/1
Eulachon	Adult	Natural	C/M,T,S/R	5,000	5,000/5,000

[a] C/M,T,S/R – Capture/Mark, Tag, Sample Tissue/Release

The fish mortality rate is expected to be high due to the use of a mid-water and bottom trawl as the method of capture. Salmon, and especially eulachon, are susceptible to descaling, crushing, and trawl net-related injuries and are expected to die at a high percentage from these injuries. Even though a 100% mortality rate is requested for this permit that is neither the goal nor the expected result of this research. This research may kill the following percentages of the adult abundances (Table 94).

Table 94. Comparison of possible lethal take to annual abundance at the ESU and DPS scale for the Investigations of Hake Ecology, Survey Methods, and the California Current Ecosystem.

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
CC Chinook	Subadult	Natural	0.0179%
CVS Chinook	Subadult	LHAC	0.0373%
CVS Chinook	Subadult	Natural	0.0190%
LCR Chinook	Subadult	LHAC	0.0052%
LCR Chinook	Subadult	Natural	0.0034%
PS Chinook	Subadult	LHAC	0.0076%
PS Chinook	Subadult	Natural	0.0052%
SacR winter-run Chinook	Subadult	Natural	0.0270%
SnkR fall-run Chinook	Subadult	LHAC	0.0075%
SnkR fall-run Chinook	Subadult	Natural	0.0089%
SnkR sum/spr-run Chinook	Subadult	LHAC	0.0176%
SnkR sum/spr-run Chinook	Subadult	Natural	0.0088%
UCR spring-run Chinook	Subadult	LHAC	0.0338%
UCR spring-run Chinook	Subadult	Natural	0.0678%
UWR spring-run Chinook	Subadult	LHAC	0.0058%

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
UWR spring-run Chinook	Subadult	Natural	0.0087%
CR chum	Subadult	Natural	0.0094%
HCS chum	Subadult	Natural	0.0048%
CCC coho	Subadult	Natural	0.0523%
LCR coho	Subadult	LHAC	0.0347%
LCR coho	Subadult	Natural	0.0030%
OC coho	Subadult	LHAC	0.0489%
OC coho	Subadult	Natural	0.0017%
SONCC coho	Subadult	LHAC	0.0091%
SONCC coho	Subadult	Natural	0.0110%
OL sockeye	Subadult	Natural	0.0467%
SR sockeye	Subadult	Natural	0.0728%
Eulachon	Adult	Natural	0.0061%

Since the research would take place along the whole U.S. Pacific coast from Mexico to Alaska, and the effects of that take cannot be examined at the population level. Further, no individual population is likely to experience a disproportionate amount of these losses. At the ESU/DPS level, the permitted activities may kill at most 0.0728% of any natural-origin salmonid component (SR sockeye salmon). Other marine fish impacted include S eulachon (0.0061%). For salmonid species, the effects displayed above are actually inflated quite a bit by the fact that most of the take would be in the form of subadults—a life stage that may have 25-50% more individuals than would the adult life stage for each species. Therefore, while the research may have a very small effect on the species' abundance and productivity, it would in all probability not affect structure or diversity at all. And it is possible that the impacts could be even smaller than those laid out above. During research activities for this project from 2012 through 2015, less than 0.1% of the requested take and mortalities (only one take and one mortality) were used.

2.5.1.5 Bycatch Reduction Research in West Coast Trawl Fisheries

As noted previously in section 1.3.4.4, the Bycatch Reduction Research in West Coast Trawl Fisheries was previously authorized through Section 10(a)(1)(A) permit 16338-2M to take listed sub-adult CC, CVS, LCR, PS, SacR winter-run, SnkR fall-run, SnkR sum/spr-run, UCR spring-run, and UWR spring-run Chinook salmon; CR and HCS chum salmon; CCC, LCR, OC, and SONCC coho salmon; OL and SR sockeye salmon; and CCC, CV, LCR, MCR, NC, PS, SCCC, SR, UCR, and UWR steelhead and adult eulachon and green sturgeon. Since the purpose of these surveys are to test and evaluate bycatch reduction devices (BRDs) and trawl gear modifications (i.e. headrope/footrope modifications), all ESA-listed salmonid, eulachon, and green sturgeon take is considered incidental. For this study, the researchers would collect, handle, sample, and release salmonids and eulachon. Fin clip, scale, and/or other samples would be collected from salmonids and eulachon for DNA or other analyses. Green sturgeon will be captured, handled, and released. The NWFSC would conduct a series of mid-water and bottom trawls along the West Coast, from Northern California to the U.S.-Canada border, which could intercept individual members of every salmonid, eulachon, and green sturgeon covered in this opinion. The nature of the research methodology is such that, though the listed species are not being targeted, any fish that are intercepted would probably be killed. The intercepted fish would generally be considered to be “subadults.” That is, they would represent a life stage that is less numerous than the smolt life stage, but more numerous than the adult life stage. No abundance estimates exist for this life stage. Because of this, and to be conservative in our evaluation of effects, we will simply treat all the take as if it were adult take. Eulachon may be retained and archived for future analysis. For each west coast salmonid species, one subadult/adult may die as an unintended result of the research. The requested take is laid out in Table 95.

Table 95. Proposed take under the Bycatch Reduction Research in West Coast Trawl Fisheries.

ESU/DPS	Life Stage	Origin	Take Action[a]	Requested Take	Requested Mortality
CC Chinook	Subadult	Natural	C/M,T,S/R	2	1/2
CVS Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
CVS Chinook	Subadult	Natural	C/M,T,S/R	3	1/3
LCR Chinook	Subadult	LHAC	C/M,T,S/R	17	5/17
LCR Chinook	Subadult	Natural	C/M,T,S/R	11	3/11
PS Chinook	Subadult	LHAC	C/M,T,S/R	6	2/6
PS Chinook	Subadult	Natural	C/M,T,S/R	7	2/7
SacR winter-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
SnkR fall-run Chinook	Subadult	LHAC	C/M,T,S/R	12	3/12
SnkR fall-run Chinook	Subadult	Natural	C/M,T,S/R	4	1/4
SnkR sum/spr-run Chinook	Subadult	LHAC	C/M,T,S/R	2	1/2
SnkR sum/spr-run Chinook	Subadult	Natural	C/M,T,S/R	4	1/4
UCR spring-run Chinook	Subadult	LHAC	C/M,T,S/R	1	1/1
UCR spring-run Chinook	Subadult	Natural	C/M,T,S/R	1	1/1
UWR spring-run Chinook	Subadult	LHAC	C/M,T,S/R	15	4/15
UWR spring-run Chinook	Subadult	Natural	C/M,T,S/R	4	1/4
CR chum	Subadult	Natural	C/M,T,S/R	1	1/1
HCS chum	Subadult	Natural	C/M,T,S/R	1	1/1
CCC coho	Subadult	Natural	C/M,T,S/R	1	1/1
LCR coho	Subadult	LHAC	C/M,T,S/R	8	8/8
LCR coho	Subadult	Natural	C/M,T,S/R	1	1/1
OC coho	Subadult	LHAC	C/M,T,S/R	1	1/1
OC coho	Subadult	Natural	C/M,T,S/R	4	4/4
SONCC coho	Subadult	LHAC	C/M,T,S/R	1	1/1
SONCC coho	Subadult	Natural	C/M,T,S/R	1	1/1
OL sockeye	Subadult	Natural	C/M,T,S/R	1	1/1
SR sockeye	Subadult	Natural	C/M,T,S/R	1	1/1
CCC steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
CCC steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
CCV steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
CCV steelhead	Subadult	Natural	C/M,T,S/R	1	1/1

ESU/DPS	Life Stage	Origin	Take Action[a]	Requested Take	Requested Mortality
LCR steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
LCR steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
MCR steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
MCR steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
NC steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
PS steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
PS steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
SCCC steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
SR steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
SR steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
UCR steelhead	Subadult	LHAC	C/M,T,S/R	1	1/1
UCR steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
UWR steelhead	Subadult	Natural	C/M,T,S/R	1	1/1
Green sturgeon	Adult	Natural	C/H/R	5	0/5
Eulachon	Adult	Natural	C/M,T,S/R	100	100/100

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

Since this research will be testing bycatch reduction devices (BRDs), the majority of the salmonids captured in the trawl nets are expected to escape through the BRDs while in the water. For the salmonids that do not escape through the BRDs, the mortality rate is expected to be high due to the use of a mid-water and bottom trawl as the method of capture. Salmon, and especially eulachon, are susceptible to descaling, crushing, and trawl net-related injuries and are expected to die at a high percentage from these injuries. Green sturgeon are expected to be impacted minimally, and they are expected to be released to the ocean alive. This research may kill the following percentages of the listed salmonid and eulachon abundances (Table 96).

Table 96. Comparison of possible lethal take to annual abundance at the ESU/DPS scale for the Bycatch Reduction Research in West Coast Trawl Fisheries.

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
CC Chinook	Subadult	Natural	0.0179%
CVS Chinook	Subadult	LHAC	0.0373%
CVS Chinook	Subadult	Natural	0.0190%
LCR Chinook	Subadult	LHAC	0.0130%
LCR Chinook	Subadult	Natural	0.0102%
PS Chinook	Subadult	LHAC	0.0151%
PS Chinook	Subadult	Natural	0.0104%
SacR winter-run Chinook	Subadult	Natural	0.0270%
SnkR fall-run Chinook	Subadult	LHAC	0.0113%
SnkR fall-run Chinook	Subadult	Natural	0.0089%
SnkR sum/spr-run Chinook	Subadult	LHAC	0.0176%

ESU/DPS	Life Stage	Origin	Percent of ESU/DPS
SnkR sum/spr-run Chinook	Subadult	Natural	0.0088%
UCR spring-run Chinook	Subadult	LHAC	0.0337%
UCR spring-run Chinook	Subadult	Natural	0.0678%
UWR spring-run Chinook	Subadult	LHAC	0.0116%
UWR spring-run Chinook	Subadult	Natural	0.0087%
CR chum	Subadult	Natural	0.0094%
HCS chum	Subadult	Natural	0.0048%
CCC coho	Subadult	Natural	0.0523%
LCR coho	Subadult	LHAC	0.0347%
LCR coho	Subadult	Natural	0.0030%
OC coho	Subadult	LHAC	0.0489%
OC coho	Subadult	Natural	0.0017%
SONCC coho	Subadult	LHAC	0.0091%
SONCC coho	Subadult	Natural	0.0110%
OL sockeye	Subadult	Natural	0.0467%
SR sockeye	Subadult	Natural	0.0728%
CCC steelhead	Subadult	LHAC	0.0259%
CCC steelhead	Subadult	Natural	0.0457%
CCV steelhead	Subadult	LHAC	0.0262%
CCV steelhead	Subadult	Natural	0.0675%
LCR steelhead	Subadult	LHAC	0.0045%
LCR steelhead	Subadult	Natural	0.0077%
MCR steelhead	Subadult	LHAC	0.0543%
MCR steelhead	Subadult	Natural	0.0042%
NC steelhead	Subadult	Natural	0.0169%
PS steelhead	Subadult	LHAC/Natural	0.0149%
SCCC steelhead	Subadult	Natural	0.1439%
SR steelhead	Subadult	LHAC	0.0003%
SR steelhead	Subadult	Natural	0.0030%
UCR steelhead	Subadult	LHAC	0.0152%
UCR steelhead	Subadult	Natural	0.0351%
UWR steelhead	Subadult	Natural	0.0167%
Eulachon	Adult	Natural	0.0001%

Since the research would take place along the U.S. Pacific coast from northern California to Canada, and the effects of that take cannot be examined at the population level. Further, no individual population is likely to experience a disproportionate amount of these losses. At the ESU/DPS level, the permitted activities may kill at most 0.1439% of any natural-origin salmonid component (SCCC steelhead). Other marine fish impacted include S eulachon (0.0001%). For salmonid species, the effects displayed above are actually inflated quite a bit by the fact that most of the take would be in the form of subadults—a life stage that may have 25-50% more individuals than would the adult life stage for each species. Therefore, while the research may have a very small effect on the species' abundance and productivity, it would in all probability not affect structure or diversity at all. And it is possible that the impacts could be even smaller than those laid out above. During research activities for this project from 2011 through 2015, only 11.7% of the requested take and 11.8% of the requested mortalities were used.

<u>2.5.2 Sea Turtles</u>

Here we describe our analysis on the effects from the first proposed action (as briefly described in section 1.3.1 and in more detail in the DPEA) on ESA-listed sea turtles.

While ESA-listed sea turtles have the potential to occur in the LCRRA and PSRA, their occurrence is infrequent and the potential for effects in these areas from the proposed action are unlikely. Because hard shelled species of sea turtles are generally more densely populated in warmer ocean waters, much of the proposed action area where NWFSC surveys occur in the northern portion of the CCRA north of Point Conception is also outside of areas where high densities of any hard shelled turtles may be expected. However, given the broad scope of NWFSC research activities occurring throughout the CCRA, there is general overlap between NWFSC research and leatherbacks, greens, olive ridleys, and loggerhead sea turtles. Sea turtle stranding records indicate that loggerhead, green, and olive ridley turtles do periodically occur in coastal waters all along the U.S. west coast (NMFS stranding data), and it is possible that sea turtles could be incidentally captured or entangled in NWFSC surveys in the CCRA at any time, especially during summer/fall when water temperatures would be expected to be warmest throughout the U.S. west coast.

As described in the proposed action in section 1.3.1 and in the DPEA (see Appendix B), the distribution of NWFSC research using active capture survey gear in the CCRA would range across a wide swath of the U.S. EEZ with varying intensity throughout the year. For example, in the spring and summer, midwater trawling for northern juvenile rockfish would occur in the coastal waters of WA, OR, and northern CA. Similarly, midwater bottom trawling for the Hake Acoustic survey would occur off coastal waters (including southern CA) and surface trawling would occur off coastal waters of WA and OR. In contrast, groundfish bottom trawling and ocean fishery sampling of Chinook using hook and line gear would be spread throughout the entire EEZ across the entire coast. In the fall, pelagic and bottom trawling would occur off the coastal waters of WA, OR, and CA, as well as additional hook and line fishing off southern CA. Bottom trawling and ocean fishery sampling of Chinook across the entire EEZ would continue to occur in the fall. In the winter, a limited amount of midwater trawling would occur from WA to CA.

Entanglement/Gear Interaction- Although the NWFSC has no history of interactions with sea turtles in their research gear, the Southwest Fisheries Science Center (SWFSC) has had one incidental capture/entanglement of a leatherback sea turtle during their 2011 Juvenile Salmon Survey (as described fully in NMFS 2015a). The sea turtle was incidentally caught in a Nordic 264 surface trawl fishing due west of Pigeon Point, San Mateo County, California. Once the crew extracted the turtle out of the net, the turtle showed no signs of severe injuries, and was released alive. The turtle was subsequently observed swimming and breathing normally at the surface behind the vessel. Although the only survey where a sea turtle has been taken was during the SWFSC Juvenile Salmon Survey, other NWFSC trawl surveys are also conducted in the CCRA in areas where any of these sea turtle species considered in this opinion may occur. In the spring, NWFSC conducts midwater and surface trawling in the CCRA using the same trawling net, the Nordic 264 surface trawl net, as well as other bottom, midwater, and surface trawling nets. Therefore, we conclude this one event reflects the general risk of capture for sea turtles in all survey trawls in the CCRA, which is to say a rare event is possible at any time.

Even though there is overlap between sea turtles and NWFSC research in the CCRA, the interaction rate between sea turtles and NWFSC trawl survey gear in the CCRA is expected to be very small based on the historical performance of NWFSC research. Given the known overlap and generally accepted vulnerability of sea turtles to trawl gear, it is likely that the gear configuration and survey protocols that have been used for deployment have been effective to some degree at reducing the exposure of sea turtles to NWFSC research gear to a point where capture or entanglement in trawl gear can be classified as simply a very rare event but that cannot be completely discounted.

Turtles are air breathers and do require time at the surface, but also spend time diving in the water column searching for prey. While more attention has been placed on the significance of turtle bycatch in bottom trawl fisheries that occurs in nearshore coastal waters, pelagic trawls are not exempt from sea turtle bycatch potential. Under the proposed action, pelagic trawls involving the Nordic 264 would use a marine mammal excluder device that could potentially reduce the likelihood of adverse impacts to sea turtles. Similar in concept to turtle excluder devices (TEDs) that have been used for decades to reduce turtle bycatch of many species in trawl fisheries around the world, this device may well be effective at minimizing the chance of a sea turtle being captured and trapped in the codend as well.

Bridge crew on NWFSC research cruises routinely watch for floating obstacles while underway and would take measures to avoid collisions with sea turtles if they could. However, given the one documented interaction with a sea turtle (a leatherback), we assume it is still possible that a sea turtle could encounter NWFSC survey trawls in the CCRA, despite the efforts to avoid interaction and move away after observing any turtles present. NMFS also assumes that while excluder devices are likely very effective at preventing turtles from being captured in survey trawls, they are not 100% effective as entanglement in the netting with a flipper or in the excluder deice grid/opening is possible. In addition, some survey trawls are executed without excluder devices. While activity that occurs in certain areas such as off the mouth of the Columbia River, or central California in the summer and fall, may be more likely to encounter leatherback sea turtles, other activities in southern California are more likely to encounter green, loggerheads, or olive ridley sea turtles. Effectively, any of these four species may be captured/entangled in trawl gear, and there isn’t enough information to distinguish relative risk among these species from only one historical incident. Although multiple interactions of sea turtles over any period of time are possible, the historical record does not support this as a likely outcome within a survey year. As a result, we expect that up to one sea turtle may be captured in the NWFSC survey trawl gear during the course of any year anywhere the NWFSC conducts survey trawls as described in the proposed action. That one turtle could come from any of the four ESA-listed species that have been discussed in this opinion.

Any sea turtle that is subject to forced submergence in a trawl net is at risk of drowning and death. The protocols for NWFSC survey trawls using the Nordic 264 surface trawl gear typically employ a short tow time (30 minutes) which is expected to minimize the risk of drowning. In shrimp fisheries in the Atlantic, restriction of tow times to 55 minutes or less is considered a mitigation measure that reduces the risks of drowning for sea turtles captured in that fishery to an extent where turtle excluder device use is not required, because of the known ability of sea turtles to normally hold their breath for this period of time, even under duress of capture in fishing gear (50 CFR 22.3.206(d)(3)(i)). While it is not impossible for a sea turtle to drown forcibly submerged for 30 minutes or less, we infer it is unlikely. As a result, we expect that the single sea turtle that may be captured each year in a NWFSC survey trawl net will survive.

In summary, we expect that: (1) up to one sea turtle from any of these species may be captured or entangled in NWFSC research during any year; (2) this turtle will be released alive and are expected to survive; and (3) this turtle may be from any of the four species discussed in this opinion.

Collisions- Collisions of ships and marine animals can cause major wounds, which may lead to the death of the animal. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007).

Collisions between NWFSC research vessels and sea turtles are possible since turtles must come to the surface to breathe, and may spend time resting or foraging near the surface. Along the U.S west coast, strandings believed to be associated with vessel strikes are one of the most common sources of sea turtle strandings (LeRoux et al. 2011). Whether these strikes are associated more commonly with larger vessels more similar to NWFSC research vessels or smaller vessels used for recreation or other purposes is unknown. To date, the NWFSC has not reported any incidents of sea turtle vessel strikes during their research cruises, although it is possible that vessel strikes with sea turtles could occur undetected. As described in the DPEA, during all research cruises, the NWFSC maintains constant watch and would take measures to avoid collisions with sea turtles if possible. Transit speeds on NWFSC research cruises vary from 6-14 knots, but average 10 knots. The vessel's speed during active sampling is slower, typically 2-4 knots, which would likely further minimized the risk of collision with sea turtles.

Given the lack of any historical information suggesting NWFSC research vessels present any particular risk of sea turtle strikes, the efforts to avoid turtles while conducting research or in transit, and the relatively slow transit speeds of the vessels during the surveys, the risks of vessel collisions for sea turtles during NWFSC research activities are considered remote.

Exposure to Noise- Noise is generally thought of as any sound that is undesirable because it interferes with communication, is intense enough to damage hearing, diminishes the quality of the environment, or is otherwise annoying. As one of the potential stressors to marine species, noise and acoustic influences may seriously disrupt communication, navigational ability, and social patterns. Many marine animals use sound to communicate, navigate, locate prey, and sense their environment. Estimating sound exposures potentially leading to behavioral and physical effects as a result of intermittent high frequency sounds from active acoustic devices used in fisheries research is challenging for a variety of reasons. Among these is the wide variety of operating characteristics of these devices, variability in sound propagation conditions throughout the typically large areas in which they are operated, uneven (and often poorly understood) distribution of marine species, differential (and often poorly understood) hearing capabilities in marine species, and the uncertainty in the potential for effects from different acoustic systems on different species.

Little is known about hearing in sea turtles, but the available data does suggest that sea turtles have better hearing at low frequencies (≤ 1000 Hz) (Ridgeway et al. 1969; Lenhardt 1994; Bartol and Ketten 2003; Martin et al. 2012; Dow-Piniak et al. 2012; Piniak et al. 2016), which is well below the frequencies of acoustic instruments used in fisheries research. As a result, active acoustic sources used by the NWFSC during research activity are not expected to be detectable by any species of sea turtles, and no effects from high frequency sound use are anticipated. Given the relative low frequencies of vessel noise, it is likely that sea turtles can detect the presence of passing vessels, which produce low frequency sounds. However, given the small number of NWFSC research vessels and their dispersal over the action area and the short duration exposure to a vessel in transit or temporarily located in an area for only a matter of hours at most, we do not anticipate any significant effects on sea turtles from exposure to vessel noise.

Prey reductions- The NWFSC research surveys that primarily use trawl gear could result in the capture of many species of fish and invertebrates that are sources of prey for ESA-listed species. The specific diets of sea turtles do vary by species and life stage, although jellyfish and other invertebrates may be significant sources of food during pelagic life stages, especially for leatherbacks (Graham 2009, Eckhert et al. 2012). Two common jellyfish species, *Chrysaora fuscescens* and *Aurelia labiate*, are frequently caught as a result of NWFSC surveys in the CCRA. However, data suggests *Chrysaora fuscescens* is more frequently consumed in the study area than other scyphozoan species (Graham 2009).

From 2008-2012, the average annual research catch of *Chrysaora fuscescens* from NWFSC surveys was approximately 1,987 kg. The average annual estimated catch of *Aurelia* species was 1,265 kg. The Groundfish Bottom Trawl Survey catches the most jellyfish from other NWFSC surveys. Based on acoustic backscatter survey data, the mean areal density of jellyfish species in the central California foraging area of leatherback sea turtles is 251,522 ± 57,504 jellyfish per square nautical mile (Graham 2009). Thus, the amount of jellyfish removed as a result of NWFSC surveys is considered insignificant to the total prey available.

In addition to the relative low levels of prey removals from NWFSC research, the nature of NWFSC research typically moving from station to station spreads out small prey removals across large areas of the project area over extended periods of time as opposed to concentrating them in certain areas/times where localized prey depletions that could potentially lead to adverse effects on foraging efficiency or nutritional deficiencies for individuals. Information on the relative effects of varying prey densities, foraging efficiency, and nutritional needs at an individual or population level for ESA-listed sea turtles is currently unknown. However, we do not expect that small prey removals spread out across large areas in space and time is likely to significantly affect the fitness or survival of any ESA-listed sea turtle species considered in this opinion.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

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

This consultation incorporates a vast project action area encompassing the coastal waters off of WA, OR, and CA, the Columbia River, and Puget Sound. During this consultation, NMFS searched for information on future State, tribal, local, or private actions that were reasonably certain to occur in the action area within the general timeframe of this proposed action, which is 5 years. Activities that may occur in this area will likely consist of state, Federal, or foreign government actions related to ocean use policy and management of public resources, such as fishing, oil exploration, or energy development projects. Changes in ocean use policies as a result of government action, are highly uncertain and may be subject to sudden changes as political and financial situations develop. Examples of actions that may occur include development of aquaculture projects; changes to state, Federal, foreign, and international fisheries which may alter fishing patterns or influence the bycatch of ESA-listed species; installation of hydrokinetic projects near areas where marine species are known to migrate or congregate; designation or modification of marine protected areas that include habitat or resources that are known to affect marine species; changes to vessel traffic, and coastal development which may also alter patterns of vessel traffic. The activities external to NWFSC fisheries research affecting ESA-listed fish will likely continue into the foreseeable future (see Table 5.1-1 *In* the DPEA). The level of impact will depend on the application and efficacy of current and proposed mitigation measures and the level of direct or indirect effects associated with most of these types of actions appear speculative at this point. Current and continuing non-Federal actions that may continue to occur in the action area and may be affecting ESA-listed marine mammals are addressed in the *Environmental Baseline* section. As a result, we are not aware of any cumulative effects other than those already described in the *Environmental Baseline* section.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminishes the value of designated or proposed critical habitat for the conservation of the species.

2.7.1 Marine Fishes

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 addition to the steps outlined above, the final analyses are also made in consideration of the other scientific research and monitoring that has been authorized through 4(d) and Section 10(a)(1)(A) research permits and may affect the various listed species. The reasons we integrate the proposed take in the one permit and four previous permits that are now covered by the ITS in this opinion with the take from other research authorizations are that they are similar in nature, and we have good information on what the effects are. Thus, it is possible to determine the overall effect of all research in the region on the species considered here. The following three tables, therefore, (a) combine the proposed take for the permit and four projects considered in this opinion for all components of each fish species (Table 97), (b) add the take proposed by the researchers in this opinion to the take that has already been authorized in the region (Table 98), and then (c) compare those totals to the estimated annual abundance of each species under consideration (Table 99).

Table 97. Total annual requested take and percentages of the ESA-listed fish species for the permit (described in section 1.3.3) and four projects (described in section 1.3.4) covered in this Biological Opinion.

CC Chinook salmon	Adult	Natural	5	0.08930%	4	0.07144%
CVS Chinook salmon	Adult	LHAC	4	0.14909%	4	0.14909%
		Natural	6	0.11426%	4	0.07618%
LCR Chinook salmon	Adult	LHAC	23	0.05959%	11	0.02850%
		Natural	14	0.04751%	6	0.02036%
PS Chinook salmon[b]	Adult	LHAC	559	8.95410%	30	0.26469%
		LHIA	625		5	
		Natural	310	1.60972%	10	0.05193%
	Juvenile	LHAC	5000	0.01397%	795	0.00222%
		LHIA	5,200	0.08642%	245	0.00407%
		Natural	7,850	0.30210%	150	0.00577%
SacR winter-run Chinook salmon	Adult	Natural	4	0.10787%	4	0.10787%
SnkR fall-run Chinook salmon	Adult	LHAC	18	0.06778%	9	0.03389%
		Natural	7	0.06220%	4	0.03554%
SnkR spring/summer-run Chinook salmon	Adult	LHAC	5	0.08778%	4	0.07022%
		Natural	7	0.06169%	4	0.03525%
UCR spring-run Chinook salmon	Adult	LHAC	4	0.13482%	4	0.13482%
		Natural	4	0.27119%	4	0.27119%

Species	Life					
UWR spring-run Chinook salmon	Adult	LHAC	21	0.06095%	10	0.02902%
		Natural	7	0.06117%	4	0.03496%
CR chum salmon		Natural	4	0.03758%	4	0.03758%
HCS chum salmon	Adult	LHIA	0	0.00000%	0	0.00000%
		Natural	4	0.01918%	4	0.01918%
	Juvenile	LHIA	80	0.05333%	2	0.00133%
		Natural	200	0.00594%	4	0.00012%
CCC coho salmon	Adult	Natural	4	0.20921%	4	0.20921%
LCR coho salmon	Adult	LHAC	32	0.13864%	32	0.13864%
		Natural	4	0.01213%	4	0.01213%
OC coho salmon	Adult	LHAC	4	0.19550%	4	0.19550%
		Natural	16	0.00683%	16	0.00683%
SONCC coho salmon	Adult	LHAC	4	0.03658%	4	0.03658%
		Natural	4	0.04417%	4	0.04417%
OL sockeye salmon	Adult	Natural	4	0.18665%	4	0.18665%
SR sockeye salmon	Adult	Natural	4	0.29133%	4	0.29133%
CCC steelhead	Adult	LHAC	2	0.05173%	2	0.05173%
		Natural	2	0.09145%	2	0.09145%
CCV steelhead	Adult	LHAC	2	0.05233%	2	0.05233%
		Natural	2	0.13495%	2	0.13495%
LCR steelhead	Adult	LHAC	2	0.00897%	2	0.00897%
		Natural	2	0.01548%	2	0.01548%
MCR steelhead	Adult	LHAC	2	0.10858%	2	0.10858%
		Natural	2	0.00838%	2	0.00838%
NC steelhead	Adult	Natural	2	0.03373%	2	0.03373%
PS steelhead[c]	Adult	LHAC	2	0.02980%	2	0.02980%
		LHIA	0		0	
		Natural	2		2	
	Juvenile	LHAC	50	0.03014%	2	0.00121%
		LHIA	50	0.06329%	2	0.00253%
		Natural	75	0.00491%	2	0.00013%
SCCC steelhead	Adult	Natural	2	0.28777%	2	0.28777%
SR steelhead	Adult	LHAC	2	0.00067%	2	0.00067%
		Natural	2	0.00600%	2	0.00600%
UCR steelhead	Adult	LHAC	2	0.03040%	2	0.03040%
		Natural	2	0.07027%	2	0.07027%
UWR steelhead	Adult	Natural	2	0.03350%	2	0.03350%
S green sturgeon	Adult	Natural	7	0.51929%	0	0.00000%
S eulachon	Adult	Natural	30,210	0.03696%	30,114	0.03684%
PS/GB bocaccio	Juvenile	Natural	5	**	1	**
PS/GB canary rockfish	Juvenile	Natural	10	**	1	**
PS/GB yelloweye rockfish	Juvenile	Natural	9	**	1	**

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

Table 98. Total expected take of the ESA-listed species for scientific research and monitoring already approved for 2016.

Species	Life Stage	Origin[a]	Total Take	Percent of Abundance	Lethal Take	Percent of ESU/DPS killed
CC Chinook salmon	Adult	Natural	4,885	87.2477%	6	0.1072%
CVS Chinook salmon	Adult	LHAC	25,226	940.2164%	244	9.0943%%
		Natural	2,948	56.1417%	65	1.2379%
LCR Chinook salmon	Adult	LHAC	937	2.42784%	21	0.05441%
		Natural	1,093	3.70898%	13	0.04411%
PS Chinook salmon[b]	Adult	LHAC	2,802	22.46086%	86	0.72601%
		LHIA	168		10	
		Natural	908	4.71492%	32	0.16616%
	Juvenile	LHAC	96,555	0.26976%	10,128	0.02830%
		LHIA	153,763	2.55541%	5,517	0.09169%
		Natural	401,099	15.43591%	8,529	0.32823%
SacR winter-run Chinook salmon	Adult	Natural	158	4.2611%	6	0.1618%
SnkR fall-run Chinook salmon	Adult	LHAC	235	0.88486%	3	0.01130%
		Natural	421	3.74089%	6	0.05331%
SnkR spring/summer-run Chinook salmon	Adult	LHAC	1,605	28.17767%	10	0.17556%
		Natural	7,744	68.24711%	51	0.44946%
UCR spring-run Chinook salmon	Adult	LHAC	266	8.96528%	7	0.23593%
		Natural	587	39.79661%	15	1.01695%
UWR spring-run Chinook salmon	Adult	LHAC	257	0.74592%	6	0.01741%
		Natural	270	2.35952%	3	0.02622%
CR chum salmon		Natural	60	0.56370%	1	0.00939%
HCS chum salmon	Adult	LHIA	0	0.00000%	0	0.00000%
		Natural	1,787	8.56869%	26	0.12467%
	Juvenile	LHIA	225	0.15000%	6	0.00400%
		Natural	714,787	21.21916%	4,881	0.14490%
CCC coho salmon	Adult	Natural	1,696	88.7029%	22	1.1506%
LCR coho salmon	Adult	LHAC	3,017	13.07079%	67	0.29027%
		Natural	3,547	10.75305%	36	0.10914%
OC coho salmon	Adult	LHAC	24	1.17302%	1	0.04888%
		Natural	15,733	6.71768%	157	0.06704%
SONCC coho salmon	Adult	LHAC	593	5.42345%	9	0.08231%
		Natural	1,498	16.54152%	23	0.25398%
OL sockeye salmon	Adult	Natural	14	0.65329%	0	0.00000%
SR sockeye salmon	Adult	Natural	164	11.94465%	5	0.36417%
CCC steelhead	Adult	LHAC	0	0.0000%	0	0.0000%
		Natural	1,438	65.7522%	25	1.1431%
CCV steelhead	Adult	LHAC	6,112	159.9163%	272	7.1167%
		Natural	3,461	233.5358%	97	6.5452%
LCR steelhead	Adult	LHAC	172	0.77140%	4	0.01794%
		Natural	3,836	29.69040%	38	0.29412%
MCR steelhead	Adult	LHAC	946	51.35722%	10	0.54289%
		Natural	3,920	16.42091%	38	0.15918%
NC steelhead	Adult	Natural	3,230	54.4780%	7	0.1181%
PS steelhead[c]	Adult	LHAC	34	11.16823%	4	0.25332%
		LHIA	11		0	
		Natural	1,454		30	
	Juvenile	LHAC	4,850	2.92350%	113	0.06811%
		LHIA	2,780	3.51899%	28	0.03544%

Species	Life					
		Natural	64,771	4.24240%	1,374	0.08999%
SCCC steelhead	Adult	Natural	224	32.2302%	5	0.7194%
SR steelhead	Adult	LHAC	10,705	3.56762%	129	0.04299%
		Natural	14,915	44.73605%	160	0.47990%
UCR steelhead	Adult	LHAC	564	8.57273%	17	0.25840%
		Natural	624	21.92551%	10	0.35137%
UWR steelhead	Adult	Natural	288	4.82331%	2	0.03350%
S green sturgeon	Adult	Natural	139	10.31157%	4	0.29674%
S eulachon	Adult	Natural	6,021	0.00737%	3,005	0.00368%
PS/GB bocaccio	Juvenile	Natural	37	**	5	**
PS/GB canary rockfish	Juvenile	Natural	79	**	19	**
PS/GB yelloweye rockfish	Juvenile	Natural	51	**	11	**

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

Table 99. Total annual expected take of the ESA-listed species for scientific research and monitoring already approved for 2016 plus the permits covered in this Biological Opinion.

CC Chinook salmon	Adult	Natural	4,890	87.3370%	10	0.1786%
CVS Chinook salmon	Adult	LHAC	25,230	940.3653%	248	9.2434%
		Natural	2,954	56.2560%	69	1.3140%
LCR Chinook salmon	Adult	LHAC	960	2.48743%	32	0.08291%
		Natural	1,107	3.75649%	19	0.06447%
PS Chinook salmon[b]	Adult	LHAC	3,361	31.41496%	116	0.99070%
		LHIA	793		15	
		Natural	1,218	6.32464%	42	0.21809%
	Juvenile	LHAC	101,555	0.28373%	10,923	0.03052%
		LHIA	158,963	2.64183%	5,762	0.09576%
		Natural	408,949	15.73801%	8,679	0.33400%
SacR winter-run Chinook salmon	Adult	Natural	162	4.3689%	10	0.2697%
SnkR fall-run Chinook salmon	Adult	LHAC	253	0.95263%	12	0.04518%
		Natural	428	3.80309%	10	0.08886%
SnkR spring/summer-run Chinook salmon	Adult	LHAC	1,610	28.26545%	14	0.24579%
		Natural	7,751	68.30880%	55	0.48471%
UCR spring-run Chinook salmon	Adult	LHAC	270	9.10010%	11	0.37074%
		Natural	591	40.06780%	19	1.28814%
UWR spring-run Chinook salmon	Adult	LHAC	278	0.80687%	16	0.04644%
		Natural	277	2.42069%	7	0.06117%
CR chum salmon		Natural	64	0.60128%	5	0.04697%
HCS chum salmon	Adult	LHIA	0	0.00000%	0	0.00000%
		Natural	1,791	8.58787%	30	0.14385%
	Juvenile	LHIA	305	0.20333%	8	0.00533%
		Natural	714,987	21.22510%	4,885	0.14502%
CCC coho salmon	Adult	Natural	1,700	88.9121%	26	1.3598%
LCR coho salmon	Adult	LHAC	3,049	13.20943%	99	0.42891%
		Natural	3,551	10.76517%	40	0.12126%

Species	Life					
OC coho salmon	Adult	LHAC	28	1.36852%	5	0.24438%
		Natural	15,749	6.72451%	173	0.07387%
SONCC coho salmon	Adult	LHAC	597	5.46003%	13	0.11890%
		Natural	1,502	16.58569%	27	0.29814%
OL sockeye salmon	Adult	Natural	18	0.83994%	4	0.18665%
SR sockeye salmon	Adult	Natural	168	12.23598%	9	0.65550%
CCC steelhead	Adult	LHAC	2	0.0517%	2	0.0517%
		Natural	1,440	65.8436%	27	1.2346%
CCV steelhead	Adult	LHAC	6,114	159.9686%	274	7.1690%
		Natural	3,463	233.6707%	99	6.6802%
LCR steelhead	Adult	LHAC	174	0.78037%	6	0.02691%
		Natural	3,838	29.70588%	40	0.30960%
MCR steelhead	Adult	LHAC	948	51.46580%	12	0.65147%
		Natural	3,922	16.42929%	40	0.16756%
NC steelhead	Adult	Natural	3,232	54.5117%	9	0.1518%
PS steelhead[c]	Adult	LHAC	36	11.19803%	6	0.28312%
		LHIA	11		0	
		Natural	1,456		32	
	Juvenile	LHAC	4,900	2.95364%	115	0.06932%
		LHIA	2,830	3.58228%	30	0.03797%
		Natural	64,846	4.24731%	1,376	0.09013%
SCCC steelhead	Adult	Natural	226	32.5180%	7	1.0072%
SR steelhead	Adult	LHAC	10,707	3.56829%	131	0.04366%
		Natural	14,917	44.74205%	162	0.48590%
UCR steelhead	Adult	LHAC	566	8.60313%	19	0.28880%
		Natural	626	21.99578%	12	0.42164%
UWR steelhead	Adult	Natural	290	4.85681%	4	0.06699%
S green sturgeon	Adult	Natural	146	10.83086%	4	0.29674%
S eulachon	Adult	Natural	36,231	0.04433%	33,119	0.04052%
PS/GB bocaccio	Juvenile	Natural	42	**	6	**
PS/GB canary rockfish	Juvenile	Natural	89	**	20	**
PS/GB yelloweye rockfish	Juvenile	Natural	60	**	12	**

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

2.7.1.1 Salmonids

For juvenile salmonids, the total amount of estimated natural origin, lethal take for the proposed research would be 150 PS Chinook salmon, 4 HCS chum salmon, and 2 PS steelhead (refer to Table 97). This is the maximum amount of lethal take contemplated in this biological opinion; if the various permit and incidental takes are granted and exercised, a lesser amount of take is expected to actually occur. Overall, these numbers represent very small fractions of the expected natural origin abundances and may kill at most 0.00577% of any natural listed component (PS Chinook salmon) (Table 97).

For adult salmonids, the total amount of estimated natural origin, lethal take for the proposed research would be 44 Chinook salmon, 8 chum salmon, 28 coho salmon, 8 sockeye salmon, and

20 steelhead. This is the maximum amount of lethal take contemplated in this biological opinion; if the various permit and incidental takes are granted and exercised, a lesser amount of take is expected to actually occur. Further, this lethal take is distributed across all listed ESUs/DPSs based upon the proportion of what each ESU/DPS comprises of each salmonid species. Therefore, ESUs/DPSs with greater abundances were authorized greater amounts of lethal take. Overall, these numbers represent very small fractions of the expected natural origin abundances and may kill at most 0.29133% of any natural listed component (SR sockeye salmon) (Table 97).

When combined with scientific research and monitoring permits already approved (Section 10 (a)(1)(A) research, state 4(d), and tribal 4(d) permits) (Table 98), the total take and mortalities are generally low (Table 99). For example, approximately 15.74% of juvenile natural origin, PS Chinook salmon would be taken. However, and as noted previously, the majority of salmonids handled subsequently recover shortly after handling with no long-term ill effects. For natural-origin PS Chinook salmon juvenile take, only 2.12% of the requested take is authorized as lethal take; thus we estimate that a maximum of 0.334% of natural-origin PS Chinook salmon juvenile take would be killed. Unlike the majority of salmon ESUs/DPSs, the CV Chinook salmon total take and mortality already approved is relatively high (Table 98). However, the 9.0943 percent potential mortality is for adult Listed Hatchery Adipose Clipped origin CV Chinook, for which take prohibitions to do not apply in any case. The potential mortality for natural origin CV Chinook salmon would be 1.2379 percent of estimated species abundance. Thus the projected total lethal take for all research and monitoring activities represents a small percent of the species' total abundance. Further, the activities contemplated in this opinion represent only fractions of those already small numbers. Just 0.07618 percent of the adult natural origin CV Chinook salmon mortality (Table 97), would result from activities contemplated in this opinion. And 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 (12.35% of requested take and 11.07% of requested mortalities were used in ID, OR, and WA Section 10a1A permits from 2008 to 2014). Thus, the activities contemplated in this opinion would add only very small fractions to those already approved numbers.

Thus, as Tables 97-99 demonstrate, all the mortalities, taken together, represent very small fractions of the various species' abundances. Nonetheless, and for a number of reasons, the actual mortalities are likely much smaller than the displayed percentages in the Tables. First, the juvenile abundance estimates are deliberately designed to generate a conservative picture of abundance. Second, it is important to remember that estimates of lethal take for most of the proposed studies are purposefully inflated to account for potential accidental deaths and it is therefore very likely that fewer listed species would be killed by the research than stated. Third, for salmonids, many of the fish that were analyzed as "adults" were actually sub-adults. This "sub-adult" life stage is represented by multiple spawning years and many more individuals than those that reach the adult stage. Therefore, the already small percentages were derived by (a) conservatively estimating the actual number of juveniles, (b) overestimating the number of fish likely to be killed, and (c) treating each dead fish as part of the same year class. Thus, the actual numbers of salmonids the research is likely to kill are undoubtedly smaller than the stated figures—probably something on the order of one quarter of the values given in the tables.

2.7.1.2 Rockfish, Eulachon, and Green Sturgeon

For listed eulachon, rockfish, and green sturgeon, all the mortalities, even taken together, represent very small fractions of the various species' abundances. Since no directed mortality is requested for any of these permits within this opinion, it is important to remember that lethal take estimates exist only to account for potential accidental deaths, or incidental take.

For the listed S eulachon, the total amount of estimated lethal take for the proposed research would be 30,114 eulachon. This is the maximum amount of lethal take contemplated in this biological opinion; if the various permits are granted and exercised, a lesser amount of take is expected to actually occur. Overall, these numbers represent very small fractions of the abundances for eulachon (0.03684%) (Table 97). For the vast majority of scientific research permits, history has shown that researchers generally take fewer eulachon than the allotted number of eulachon every year (29.94% of requested take and 42.46% of requested mortalities were used in OR and WA Section 10a1A permits from 2009 to 2014).

For the listed PS/GB rockfish species, the total amount of estimated lethal take for the proposed research would be three juvenile rockfish (one bocaccio, one canary rockfish, and one yelloweye rockfish). This is the maximum amount of lethal take contemplated in this biological opinion; if the various permits are granted and exercised, a lesser amount of take is expected to actually occur. For these juvenile listed PS/GB rockfish, their abundances are unknown; but their abundances are estimated to be at least a magnitude larger than that of the adult abundances. Fecundity for these three listed rockfish species range from tens of thousands of eggs to millions of eggs, and the request for mortality is no more than seven for any of the listed rockfish juveniles.

For the listed S green sturgeon, there is no request for, nor do we anticipate, any direct or indirect mortality in this biological opinion.

For all of these species, it is very likely that fewer fish would be killed by the research than stated. In fact, for the vast majority of scientific research permits, history has shown that researchers generally take far fewer than the allotted number of fish every year. As a result, the detrimental effect of the research activities contemplated in this opinion—even when they are added to the effects already contemplated in the region—are expected to be minimal. Because these effects are so small, the actions would have only a slight negative effect on the species' abundance and productivity. And because that slight impact is in most cases distributed throughout the entire listing units, it would be so attenuated as to have no appreciable effect on spatial structure or diversity.

2.7.1.3 Summary

As noted in the sections on species status, no listed species currently has all its biological requirements being met. Their status is such that there must be a substantial improvement in the environmental conditions of their habitat and other factors affecting their survival if they are to begin to approach recovery. While the proposed research activities would in fact have some negative effect on each of the species' abundance, in all cases, this effect would be miniscule relative to their current total abundance numbers, the activity has not been identified as a threat. In addition, while the future impacts of cumulative effects are uncertain at this time, 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 by warming water temperatures and causing ocean acidification. However, given the proposed actions' short time frames, limited areas where the surveys would occur, and small number of fish potentially taken, those negative effects, while somewhat unpredictable, are small. Moreover, the actions would in no way contribute to climate change (even locally), and in any case the proposed actions would actually help monitor the effects of climate change by noting stream temperatures, flows, marine conditions, etc. So while we can expect both cumulative effects and climate change to continue their negative trends, it is unlikely that any of the proposed actions would have any additive impact to the pathways by which those effects are realized (e.g., a slight reduction in salmonid abundance would have no effect on increasing stream temperatures or continuing land development).

However, those abundance and productivity reductions are so small as to have no more than a negligible effect on the species' survival and recovery. In all cases, even the worst possible effect on abundance would be small fractions of one percent, the activity has never been identified as a threat, and the research is designed to benefit the species' survival in the long term.

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

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

2.7.2 Sea Turtles

Based on the analysis of potential effects from the NWFSC research activities considered in this opinion, we determined that adverse effects from incidental capture or entanglement in research gears including survey trawls for ESA-listed sea turtles in the CCRA are likely. We have considered potential disturbance from active acoustic and vessels, the potential for vessel strikes, and potential impacts from reduction of prey impacts as well, and determined that adverse effects from these factors are unlikely. We have considered that up to 1 individual sea turtle could be incidentally captured or entangled in trawl gear any given year throughout the full range of where the NWFSC conducts these activities, and these turtles could be of any age or sex in these respective populations. Based on the nature of NWFSC research operations, we conclude the most likely outcome from any incidental captures or entanglements is that individual turtles will survive these encounters. As a result, we have concluded that that the proposed activities are not likely to have a detectable impact on any ESA-listed sea turtle populations in terms of their current abundance or future reproductive output potential, or population structure and diversity. When the effect of this proposed action is added to the status, environmental baseline, and cumulative effects of other activities, and the anticipated effects of climate change over the foreseeable future, there is no increase in the risks of extinction or impediments to recovery for any of these ESA-listed sea turtles species. Ultimately, because no measurable impacts to these species is anticipated, we conclude that the proposed action will not reduce the likelihood of survival and recovery of the following sea turtle species considered in this opinion: leatherback sea turtle; North Pacific loggerhead sea turtle; olive ridley sea turtle; and green sea turtle.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed actions are not likely to jeopardize the continued existence of CC, CVS, LCR, PS, SacR winter-run, SnkR fall-run, SnkR summer/spring-run, UCR spring-run, and UWR spring-run Chinook salmon; CR and HCS chum salmon; CCC, LCR, OC, and SONCC coho salmon; OL and SR sockeye salmon; CCC, CV, LCR, MCR, NC, PS, SCCC, SR, UCR, and UWR steelhead; S eulachon; S green sturgeon; PS/GB bocaccio; PS/GB canary rockfish; PS/GB yelloweye rockfish, leatherback sea turtle, loggerhead sea turtle, olive ridley sea turtle, or green sea turtle.

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.

2.9.1 Amount or Extent of Take

For the section 10(a)(1)(A) research permit (1586-4R), there is no incidental take at all. The only anticipated take associated with this permit is direct take that is the purpose of, and is specifically authorized by the permit. However, in connection with the other activities that comprise the proposed action, in the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

Table 100. Description of total annual incidental take for the next five years of ESA-listed marine fishes and the annual take of sea turtles expected through capture or entanglement in NWFSC research surveys. For sea turtles, the take could come from any of the ESA-listed sea turtles species referenced.

Species	Life Stage	Origin[a]	Total Take	Lethal Take
CC Chinook salmon	Adult	Natural	5	4
CVS Chinook salmon	Adult	LHAC	4	4
		Natural	6	4
LCR Chinook salmon	Adult	LHAC	23	11
		Natural	14	6
PS Chinook salmon	Adult	LHAC	9	5
		Natural	10	5
SacR winter-run Chinook salmon	Adult	Natural	4	4
SnkR fall-run Chinook salmon	Adult	LHAC	18	9
		Natural	7	4
SnkR spring/summer-run Chinook salmon	Adult	LHAC	5	4
		Natural	7	4
UCR spring-run Chinook salmon	Adult	LHAC	4	4
		Natural	4	4
UWR spring-run Chinook salmon	Adult	LHAC	21	10
		Natural	7	4
CR chum salmon	Adult	Natural	4	4
HCS chum salmon	Adult	Natural	4	4
CCC coho salmon	Adult	Natural	4	4
LCR coho salmon	Adult	LHAC	32	32
		Natural	4	4
OC coho salmon	Adult	LHAC	4	4
		Natural	16	16
SONCC coho salmon	Adult	LHAC	4	4
		Natural	4	4
OL sockeye salmon	Adult	Natural	4	4
SR sockeye salmon	Adult	Natural	4	4
CCC steelhead	Adult	LHAC	2	2
		Natural	2	2
CCV steelhead	Adult	LHAC	2	2
		Natural	2	2
LCR steelhead	Adult	LHAC	2	2
		Natural	2	2
MCR steelhead	Adult	LHAC	2	2

Species	Life Stage	Origin[a]	Total Take	Lethal Take
		Natural	2	2
NC steelhead	Adult	Natural	2	2
PS steelhead	Adult	LHAC	2	2
		Natural	2	2
SCCC steelhead	Adult	Natural	2	2
SR steelhead	Adult	LHAC	2	2
		Natural	2	2
UCR steelhead	Adult	LHAC	2	2
		Natural	2	2
UWR steelhead	Adult	Natural	2	2
S green sturgeon	Adult	Natural	7	0
S eulachon	Adult	Natural	30,100	30,100
Sea turtles (leatherback, North Pacific loggerhead, olive ridley, green)	Juvenile/Adult	-	1	0

Incidental take of ESA-listed fishes are expected from the four projects described in section 1.3.4 (Table 100). For these projects, salmonids can be identified to species and origin; but they cannot be identified to ESU/DPS in the field due to capture location (i.e., open ocean, locations ranging along the U.S. West Coast). While some salmonids would be handled and tissue samples are authorized to be taken (but not mandatory), these samples are neither timely, completely accurate, nor a complete sample of take (some take will be identified by camera and other take will be returned to the ocean quickly to increase survivorship). So to estimate take and mortalities, abundance by ESU/DPS (listed and unlisted) for each salmon species has been estimated; and the proportion from these estimates will be extrapolated from the actual take and mortality numbers to estimate take and mortality by ESU/DPS for each project. These extrapolations will be used to determine if there is an exceedance of take or mortality that has been analyzed and approved in this biological opinion. However, incidental take can be measured and quantified for green sturgeon, eulachon, and sea turtles. For green sturgeon, all take will be conservatively counted as being from the threatened southern DPS. For eulachon, all take and mortality will be counted to the individual with larger catches estimated. For sea turtles, we expect that one sea turtle may be incidentally captured in NWFSC trawl research in the CCRA each year. This take could occur with any of the four species listed above. We expect that sea turtles will be released alive and survive. If the totals in Table 100 are exceeded, then take will have occurred in excess of what has been considered in this opinion.

MMPA Letter of Authorization for NWFSC research and acoustic harassment

As part of the proposed action covered in this opinion (described in section 1.3.2), NMFS OPR is proposing MMPA Level A authorization of serious injury and mortality of non ESA-listed marine mammals as a result of incidental capture or entanglement with the NWFSC survey gear, as well as MMPA Level B acoustic harassment of some ESA-listed and some non ESA-listed marine mammals resulting from NWFSC research activities and the use of active acoustic equipment aboard ship-based surveys (81 FR 38516). We have considered the impact of the proposed actions described in sections 1.3.1 and 1.3.2 and concluded that all effects to ESA-listed marine mammals are insignificant or discountable and that ESA incidental take of such marine mammals is not reasonably certain to occur. Refer to section 2.12 for the marine mammal analysis.

<u>2.9.2 Effect of the Take</u>

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

<u>2.9.3 Reasonable and Prudent Measures</u>

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

1. The NWFSC shall minimize the amount of injury and or mortality among ESA-listed animals that are incidentally taken in any research survey.

2. The NWFSC shall monitor, document, and report all incidental take of listed species resulting from their surveys.

<u>2.9.4 Terms and Conditions</u>

The terms and conditions described below are non-discretionary, and the NWFSC or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). The NWFSC or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

1. The following terms and conditions implement reasonable and prudent measure 1:

1a. The researcher must ensure that listed fish species are taken only at the levels, by the means, in the areas and for the purposes stated in the application, and according to the conditions in this biological opinion.

1b. The researcher must not intentionally kill or cause to be killed any listed fish species unless this biological opinion specifically allows intentional lethal take.

1c. The researcher 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 researcher must process listed fish first to minimize handling stress.

1d. Each researcher must stop capturing and handling listed fish if the instantaneous water temperature exceeds 70 degrees Fahrenheit at the capture site. Under these conditions, listed fish may only be identified and counted. Additionally, electrofishing is not permitted if the instantaneous water temperatures exceed 64 degrees Fahrenheit.

1e. If the researcher 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.

1f. The researcher must use a sterilized needle for each individual injection when passive integrated transponder tags (PIT-tags) are inserted into listed fish.

1g. If the researcher 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.

1h. The researcher 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 just determining fish presence.

1i. The researcher using backpack electrofishing equipment must comply with NMFS' Backpack Electrofishing Guidelines (June 2000) available at http://www.westcoast.fisheries.noaa.gov/publications/reference_documents/esa_refs/section4d/electro2000.pdf.

1j. The researcher must obtain approval from NMFS before changing sampling locations or research protocols.

1k. The researcher is responsible for any biological samples collected from listed species as long as they are used for research purposes. The researcher may not transfer biological samples to anyone not listed in the application without prior written approval from NMFS.

1l. The researcher must obtain all other Federal, state, and local permits/authorizations needed for the research activities.

1m. The NWFSC shall implement mitigation and avoidance measures described in section 1.3.1 of this opinion to avoid interactions with listed species, including those required in conjunction with the MMPA LOA authorization[7].

1n. The NWFSC shall implement measures to minimize the handling time and improve the survivability of all ESA-listed species incidentally captured or entangled in NWFSC research survey gear, allowing for biological sampling as appropriate.

[7] As noted above, we have concluded that incidental take of listed marine mammals is not reasonably certain to occur. The references to marine mammals in the Terms and Conditions are intended to only function as a conservative check on that conclusion, and information about incidental take of a marine mammal would trigger reinitiation.

1o. Chief Scientists and all staff responsible for overseeing implementation of minimization and avoidance measures for ESA-listed species and marine mammals, as well as safe handling of and scientific sample collection from these species, shall receive training on procedures and protocols, updated as deemed necessary by the NWFSC in consultation with WCR.

2. The following terms and conditions implement reasonable and prudent measure 2:

2a. The researcher 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 researcher must submit a written report detailing why the authorized take level was exceeded or is likely to be exceeded.

2b. On or before January 31st of every year, the researcher 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(s), the number of fish intentionally killed and unintentionally killed, the date(s) when the take(s) occurred, and a brief summary of the research results. The report must be submitted electronically on our NOAA APPS website, and the forms can be found at https://apps.nmfs.noaa.gov/. Falsifying annual reports or records is a violation of this biological opinion.

2c. The researcher must allow any NMFS employee or representative to accompany field personnel while they conduct the research activities.

2d. The researcher must allow any NMFS employee or representative to inspect any records or facilities related to researcher activities.

2e.The NWFSC shall monitor and record the incidental capture or entanglement of all ESA-listed species and marine mammals. If monitoring indicates that any of the incidental take limits are exceeded- or shows any incidental take of marine mammals- then the NWFSC needs to contact NMFS WCR immediately. An annual report summarizing the take of all ESA-listed species and marine mammals during the previous research season shall be provided by April 1st each year to the following address:

Chris Yates
NMFS West Coast Region Protected Resources Division
501 W. Ocean Blvd, Suite 4200
Long Beach, CA 90802

Information included in the reports provided to the WCR PRD must include: species name, number(s), size/weight/age class/gender (if applicable), and any available information on the date, location (latitude and longitude), and release condition associated with each take of all ESA-listed species, as well as pertinent details on the monitoring and mitigation measures in use at the time when takes occurred. The NWFSC may elect to use the annual report and reporting format required under the proposed MMPA LOA for marine mammals, augmented as necessary to fulfill the reporting requirement for ESA-listed species.

2f. Any takes of ESA-listed marine mammals or sea turtles in California, must be reported to the NMFS West Coast Region Stranding Coordinator, Justine Viezbicke, at 562-980-3230 or Justin.Viezbicke@noaa.gov, as soon as practicable. If takes occurs of ESA-listed marine mammals or sea turtles in Oregon or Washington, report to the NMFS Regional Stranding Coordinator, Kristin Wilkinson, at 206-526-4749. Under the proposed MMPA LOA, the NWFSC is required to report any take of all marine mammals and sea turtles to NMFS within 48 hours of returning to port through the Protected Species Incidental Take (PSIT) database. The NWFSC and OPR shall take steps necessary to ensure the WCR Marine Mammal and Sea Turtle Stranding Program is notified coincidentally with these reports, and that data and/or stranding forms are submitted to the WCR Stranding Coordinator in a timely fashion upon return to port.

2g. The NWFSC and OPR shall coordinate with the WCR PRD annually, or upon request as necessary, to review any new information regarding impacts to ESA-listed species from NWFSC research, any new science or commercial data related to ESA-listed species, any new or revised ESA-listing decisions, or any other relevant developments which have occurred in the last year that may be applicable to this proposed action. The proposed MMPA LOA requires OPR and the NWFSC to meet annually to discuss the monitoring reports, current science, and whether mitigation or monitoring modifications under the LOA are appropriate. The presence of the WCR PRD in that meeting can be used to satisfy this condition.

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. Because so little is known about the marine distribution of many ESA-listed species throughout the proposed action area, the NWFSC should document all sightings and encounters of ESA-listed species that may contribute to the body of knowledge regarding their distribution in marine waters.

2. The NWFSC, in conjunction with the WCR and OPR, should evaluate development and implementation of additional mitigation and avoidance measures for ESA-listed species and other marine mammals, as well as potential modification of current measures, to minimize interactions with protected resources while maximizing the efficiency and performance of NWFSC research activities.

3. The NWFSC, in conjunction with WCR, should continue exploring and developing new approaches to improve the understanding of how ecosystem and climatic variables may affect the presence, abundance, and distribution of ESA-listed species and other protected resources.

2.11 Reinitiation of Consultation

This concludes formal consultation for Fisheries Research Conducted and Funded by the

Northwest Fisheries Science Center; Issuance of a Letter of Authorization under the Marine Mammal Protection Act for the Incidental Take of Marine Mammals Pursuant to those Research Activities; and Issuance of a Scientific Research Permit under the Endangered Species Act for Directed Take of ESA-listed Marine Fishes.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

In the context of this opinion, there is no incidental take anticipated as a result of permit 1586-4R and therefore the reinitiation trigger set out in (1) is not applicable to this permit approval action. However, if any of the direct take amounts specified in this opinion's effects analysis (section 2.5.1.1) 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.

2.12 "Not Likely to Adversely Affect Determinations"

The proposed action is not likely to adversely affect the blue whale (*Balaenoptera musculus*), fin whale (*B. physalus*), humpback whale (*Megaptera novaeangliae*), North Pacific right whale (*Eubalaena japonica*), sei whale (*B. borealis*), Southern Resident killer whale (*Orcinus orca*), sperm whale (*Physeter macrocephalus*), Western North Pacific gray whale (*Eschrichtius robustus*), Guadalupe fur seal (*Arctocephalus townsendi*), hawksbill sea turtle (*Eretmochelys imbricate*), black abalone (*Haliotis cracherodii*), white abalone (*Haliotis crachersorenseni*), or Southern California steelhead (*Oncorhynchus mykiss*). NMFS also believes the proposed action is not likely to destroy or adversely modify critical habitat for Southern Resident killer whales, green sturgeon, or leatherback sea turtles.

2.12.1 Marine Mammals

Below, we first discuss the status and likelihood of occurrence for ESA-listed marine mammals in the proposed action area, and second discuss the potential effects of the proposed actions described in sections 1.3.1 and 1.3.2.

2.12.1.1 Marine Mammal Status and Occurrence

Blue whales

We listed blue whales as endangered under the Endangered Species Conservation Act (ESCA) in June 1970 (35 FR 18319). The ESA replaced the ESCA in 1973 and continued to list blue whales as endangered. We issued the final recovery plan for fin blue whales in July 1998 (NMFS 1998).

The blue whale has a worldwide distribution in circumpolar and temperate waters. Seasonal migrations of blue whales are driven by food requirements. Pole-ward movements in spring allow the whales to take advantage of high zooplankton production in summer, while movement toward the subtropics in the fall allows blue whales to reduce their energy expenditure while fasting and to avoid ice entrapment. The Eastern North Pacific Stock of blue whales ranges from the northern Gulf of Alaska to the eastern tropical Pacific (Carretta et al. 2016). Nine biologically important areas for blue whale feeding are identified off the California coast (Calambokidis et al. 2015). Most of this stock is believed to migrate south to spend the winter and spring in high productivity areas off Baja California, in the Gulf of California, and on the Costa Rica Dome. Blue whales occur primarily in offshore deep waters (but sometimes near shore, e.g. the deep waters in Monterey Canyon, CA) and feed almost exclusively on euphausiids.

The best estimate of blue whale abundance in the U.S. West Coast feeding stock component of the Eastern North Pacific stock is 1,647 for 2008 to 2011 (Calambokidis and Barlow 2013, Carretta et al. 2016). Barlow and Forney (2007) estimated the density of blue whales off California, Oregon, and Washington at 1.36 whales/1000 km2. The minimum population size is approximately 1,551 blue whales with a calculated potential biological removal (PBR, which is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while wallowing that stock to reach or maintain its optimum sustainable population) allocation for U.S. waters of 2.3 whales per year (Carretta et al. 2016). The average annual incidental mortality and serious injury rate from ship strikes in California waters (0.9/year for 2009-2013) is less than the calculated potential biological removal (PBR) for this stock. This rate, however, does not include unidentified large whales struck by ships, so the actual number may exceed PBR if any of the unidentified large whales are blue whales. There have been no reported blue whale mortalities associated with commercial fisheries and the total fishery mortality and serious injury rate is approaching zero (Carretta et al. 2016).

Fin whales

We listed fin whales as endangered under the Endangered Species Conservation Act (ESCA) in June 1970 (35 FR 18319). The ESA replaced the ESCA in 1973 and continued to list fin whales as endangered. We issued the final recovery plan for fin whales in July 2010 (NMFS 2010a).

Fin whales are distributed widely in the world's oceans and occur in both the Northern and Southern Hemispheres. In the northern hemisphere, they migrate from high Arctic feeding areas to low latitude breeding and calving areas. The North Pacific population summers from the Chukchi Sea to California, and winters from California southward. Fin whales occur year-round off California, Oregon, and Washington in the CCRA, with aggregations in southern and central California (Carretta et al. 2015 and citations therein). Association with the continental slope is common (Schorr et al. 2010). Fin whales feed on planktonic crustaceans, including *Thysanoessa* sp. euphausiids and *Calanus* sp. copepods, and schooling fish, including herring, capelin and mackerel (Aguilar 2009).

The best estimate of fin whale abundance in California, Oregon, and Washington waters out to 300 nmi is 3,051 whales for 2008, based on trend-model analysis of line-transect data from 1991 through 2008. The minimum population estimate is 2,598 fin whales with a calculated PBR of 16 whales per year (Carretta et al. 2015). Barlow and Forney (2007) estimated the density of fin whales off California, Oregon, and Washington at 1.84 whales/1000 km2. The total incidental mortality due to fisheries (0.6/yr) and ship strikes (1.6/yr) from 2007 to 2011 is less than the PBR. Total fishery mortality is less than 10% of PBR and the mortality and serious injury rate may be approaching zero (Carretta et al. 2015).

Humpback whales

We listed humpback whales as endangered under the Endangered Species Conservation Act (ESCA) in June 1970 (35 FR 18319). The ESA replaced the ESCA in 1973 and continued to list humpback whales as endangered. We issued the final recovery plan for humpback whales in November 1991 (NMFS 1991). In April 2015 NMFS published a proposed rule to identify 14 DPSs of humpback whales and list two as threatened and two as endangered (80 FR 22304). On September 8, 2016, NMFS published a final rule to divide the globally listed endangered humpback whale into 14 DPSs, remove the species-level listing, and place four DPSs as endangered and one as threatened (81 FR 62259). NMFS has identified three DPSs of humpback whales that may be found off the coasts of Washington, Oregon and California. These are the Hawaiian DPS (found predominately off Washington and southern British Columbia) which is not listed under the ESA; the Mexico DPS (found all along the coast) which is listed as threatened under the ESA; and the Central America DPS (found predominately off the coasts of Oregon and California) which is listed as endangered under the ESA. NMFS is in the process of evaluating the distribution and relative abundance of the DPSs that occur in the waters off the United States West Coast.

Humpback whales are found in all oceans of the world and migrate from high latitude feeding grounds to low latitude calving areas. They are typically found in coastal or shelf waters in summer and close to islands and reef systems in winter (Clapham 2009). Humpbacks primarily occur near the edge of the continental slope and deep submarine canyons, where upwelling concentrates zooplankton near the surface for feeding. They often feed in shipping lanes which makes them susceptible to mortality or injury from large ship strikes (Douglas et al. 2008). Humpback whales feed on euphausiids and various schooling fishes, including herring, capelin, sand lance, and mackerel (Clapham 2009). The feeding aggregation off Washington occurs primarily in the northwest Washington-British Columbia border area; a small number are periodically seen within Puget Sound (Calambokidis et al. 2004, Calambokidis et al. 2009). Humpbacks were one of the most commonly sighted large whales in Washington Inland waters and Puget Sound in the early 1900s, but are only seen occasionally now (Calambokidis and Steiger 1994). Although uncommon, humpback sightings in the Strait of Georgia and Puget Sound increased during the early 2000s to include 13 individually identified whales (Falcone et al. 2005). Humpback whales also occur along the outer coast of Washington in waters greater than 50 m depth on the continental shelf (Oleson et al. 2009). Barlow and Forney (2007) estimated the density of humpback whales off California, Oregon, and Washington at 0.83 whales/1000 km2.

The endangered Central America DPS and the threatened Mexico DPS both at times travel and feed off the U.S. west coast. Current estimates of abundance for the Central America DPS range from approximately 400 to 600 individuals (Bettridge et al. 2015, Wade et al. 2016). The size of this population is relatively low compared to most other North Pacific breeding populations. The population trend for the Central America DPS is unknown (Bettridge et al. 2105). The Mexico DPS, which also occurs in the action areas, is estimated to be 6,000 to 7,000 from the SPLASH project (Calambokidis *et al.* 2008) and in the status review (Bettridge *et al.* 2015). The population growth of California/Oregon feeding population of the North Pacific humpback whales has been estimated as increasing about 8 percent annually (the population growth rate for the entire North Pacific population is approximately 4.9 percent) (Calambokidis *et al.* 2008).

Until new stock assessment reports (SARs) are available reflecting the new listing, we will describe the status of the populations that are found in the action area using the previous SARs. There are at least two separate populations that may occur in the NWFSC research areas, the formerly known California/Oregon/Washington stock and the Central North Pacific stock. The California/Oregon/Washington stock spends the winter primarily in coastal waters of Mexico and Central America, and the summer along the West Coast from California to British Columbia. The Central North Pacific stock primarily spends winters in Hawaii and summers in Alaska, and its distribution may partially overlap with that of the California/Oregon/Washington stock off the coast of Washington and British Columbia (Clapham 2009). There is some mixing between these populations, though they are still considered distinct stocks. Humpbacks in northern Washington and southern British Columbia may be a distinct feeding population or stock (Calambokidis et al. 2008).

The current best estimate of 1,918 whales for the California/Oregon/Washington stock is the sum of recent abundance estimates for California/Oregon (1,729) and Washington/southern British Columbia (189) feeding groups (Carretta et al. 2015). The feeding aggregation off Washington was previously estimated to be approximately 500 animals, most of which occur in the northwest Washington-British Columbia border area; a small number are periodically seen within Puget Sound (Calambokidis et al. 2009). The minimum estimate for humpback whales in the California/Oregon/Washington population based on line-transect and mark-recapture methods is 1,876. The population was increasing at a rate of approximately 7.5 percent per year, but recent trends are more variable (Calambokidis and Barlow 2013, Carretta et al. 2015). The PBR level for this stock is 22 whales. This stock spends approximately half its time outside the U.S. EEZ, so the PBR allocation for U.S. waters is 11 whales per year. The estimated annual mortality and serious injury due to entanglement (4.4/yr), other anthropogenic sources (zero), plus ship strikes (1.1/yr) in California is less than the PBR for U.S. waters. Annual mortality and serious injury in commercial fisheries is greater than 10% of the PBR, and is, therefore, not approaching a zero mortality and serious injury rate (Carretta et al. 2015).

The minimum population estimate for the Central North Pacific stock of humpback whales, based on counts of unique individuals, is 7,890 whales, with a calculated PBR for this stock of 82.8 whales (Allen and Angliss 2015). The minimum population estimate for the Southeast

Alaska/northern British Columbia feeding aggregation component of the Central North Pacific stock is 2,251, with a PBR of 23.6 (Allen and Angliss 2015). The minimum estimated annual mortality and serious injury rate for the entire stock (15.89) does not exceed PBR for this stock. The minimum estimated U.S. commercial fishery-related mortality and serious injury (1.65) in observed fisheries is less than 10% of PBR and, therefore, considered insignificant and approaching a zero mortality and serious injury rate (Allen and Angliss 2015).

North Pacific right whales

We listed northern right whales as endangered under the Endangered Species Conservation Act (ESCA) in December 1970 (35 FR 18319). In 2008, the NMFS reclassified the northern right whale as two separate endangered species, North Pacific right whale (*E. japonica*) and North Atlantic right whale (*E. glacialis*) (73 FR 12024, March 6, 2008). We issued the final recovery plan for North Pacific right whales in June 2013 (NMFS 2013).

Right whales primarily occur in coastal or shelf waters, although movements over deep waters are known. Sightings have been reported as far south as central Baja California in the eastern North Pacific, as far south as Hawaii in the central North Pacific, and as far north as the sub-Arctic waters of the Bering Sea and sea of Okhotsk in the summer (Herman et al. 1980, Berzin and Doroshenko 1982, Brownell et al. 2001). However, most recent sightings have occurred in the southeast Bering Sea and in the Gulf of Alaska (Waite et al. 2003, Shelden et al. 2005, Wade et al. 2011a, 2011b). Migratory patterns of the North Pacific right whale are unknown, although it is thought the whales spend the summer on high-latitude feeding grounds and migrate to more temperate waters during the winter, possible well offshore (Braham and Rice 1984, Scarff 1986, Clapham et al. 2004).

Mark-recapture estimates of abundance of rights whales in the Bering Sea and Aleutian Islands using photographic and genotype data through 2008 resulted in 31 and 28 right whales, respectively (Wade et al. 2011a). The minimum population estimate is 25.7 whales with a calculated PBR of 0.05 (Carretta et al. 2015). Although gillnets were implicated in the death of a right whale off Russia in 1989 (Kornev 1994), and a photograph in the catalogue shows potential fishing gear entanglement, there are no records of fisheries mortalities of eastern North Pacific right whales. Thus, the estimated annual mortality rate incidental to U.S. commercial fisheries approaches zero whales per year (Carretta et al. 2015).

Sei whales

We listed sei whales as endangered under the Endangered Species Conservation Act (ESCA) in December 1970 (35 FR 18319). The ESA replaced the ESCA in 1973 and continued to list sei whales as endangered. We issued the final recovery plan for fin sei whales in December 2011 (NMFS 2011f).

Sei whales have a worldwide distribution, but are found primarily in cold temperate to subpolar latitudes rather than in the tropics or near the poles (Horwood 2009). Sei whales spend the summer months feeding in subpolar higher latitudes and return to lower latitudes to calve in the winter. There is some evidence from whaling catch data of differential migration patterns by reproductive class, with females arriving at and departing from feeding areas earlier than males. For the most part, the location of winter breeding areas is unknown (Horwood 2009). Sei whales are most often found in deep, oceanic waters of the cool temperate zone. They appear to prefer regions of steep bathymetric relief, such as the continental shelf break, canyons, or basins situated between banks and ledges. On feeding grounds, the distribution is largely associated with oceanic frontal systems (Horwood 2009). In the North Pacific, sei whales feed along the cold eastern currents (Perry et al. 1999). Prey includes calanoid copepods, krill, fish, and squid. The dominant food for sei whales off California during June through August is the northern anchovy, while in September and October they eat primarily krill.

Sei whales in the Eastern North Pacific are considered a separate stock (Carretta et al. 2015). The best estimate of abundance for California, Oregon, and Washington waters out to 300 nmi is 126 sei whales, the unweighted geometric mean of the 2005 and 2008 estimates (Barlow and Forney 2007, Forney 2007, Barlow 2010). Barlow and Forney (2007) estimated the density of sei whales off California, Oregon, and Washington at 0.09 whales/1000 km2. The minimum population estimate is 83, with a calculated PBR of 0.17 sei whales per year (Carretta et al. 2015). Total estimated fishery mortality is zero and therefore is approaching zero mortality and serious injury rate. One ship strike death was reported in Washington in 2003. Although sei whales may account for some of the unidentified large whales reportedly injured by ship strikes, the average observed mortality due to ship strikes was zero from 2004 to 2008 (Carretta et al. 2015).

Southern Resident killer whales

The Southern Resident killer whale DPS was listed as endangered under the ESA in 2005 (70 Fed. Reg. 69903, November 18, 2005). On January 26, 2016, NMFS announced the initiation of a five-year status review of Southern Resident killer whales. The public comment period ended April 25, 2016. Limiting factors described in the final recovery plan for Southern Resident killer whales include quantity of prey (data collection and analysis indicates a strong preference for Chinook salmon throughout their geographic range) (NMFS 2008g; Hanson et al. 2010; NWFSC unpubl. data).

The Center for Whale Research conducts an annual census of the Southern Resident population, and census data are now available through July 2016. Between the July 2015 census count of 81 whales and July 2016, three whales died (1 from J pod and 2 from L pod), and five whales were born (3 from J pod and 2 from L pod), bringing the number of whales to 83. The most recent PBR level for this stock (0.13 whales per year) is based on the minimum population size of 82 multiplied by one-half the default maximum net growth rate for cetaceans (half of 3.2 percent) and a recovery factor of 0.1. Total observed fishery mortality and serious injury for this stock is zero. Although there was one ship strike death in 2006, there were no non-fishery human-caused mortalities or serious injuries reported from 2008 to 2012. The total estimated annual human-caused mortality and serious injury for this stock is, therefore, zero and does not exceed PBR (Carretta et al. 2015). None of the other stocks of killer whales that occur in NWFSC research areas (i.e., the Eastern North Pacific Northern Resident, Eastern North Pacific Transient, and Eastern North Pacific Offshore stocks) are listed under the ESA.

The range of Southern Residents during the spring, summer, and fall includes the inland waters of Washington and British Columbia including Puget Sound, Strait of Juan de Fuca, and the southern Georgia Strait. Southern Residents also occur in coastal waters from southeast Alaska to California. They have also been reported off the mouth of the Columbia River coincident to spring Chinook run (NMFS 2008b, Zamon et al. 2007). Most sightings of Southern Residents occur in the summer in inland waters of Washington and southern British Columbia. Data from satellite tagging and acoustic recorder studies has provided new information about the whales' coastal habitat use (Hanson et al. 2013, NWFSC unpubl, data). These data indicate the limited occurrence along the outer coast by J pod and extensive occurrence in inland waters, particularly in the northern Georgia Strait. J pod has also only been detected on one of seven passive acoustic recorders positioned along the outer coast; they do not appear to travel to Oregon or California like K and L pods do (Hanson et al. 2013). Detection rates of K and L pods on the passive acoustic recorders indicate the whales occur with greater frequency off Columbia River and Westport and are most common in March (Hanson et al. 2013). K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months.

Sperm whales

We listed sperm whales as endangered under the Endangered Species Conservation Act (ESCA) in June 1970 (35 FR 18319). The ESA replaced the ESCA in 1973 and continued to list sperm whales as endangered. We issued the final recovery plan for fin sperm whales in December 2010 (NMFS 2010b).

As described by Carretta et al. (2015, and citations therein), populations of sperm whales exist in waters of the California Current Ecosystem throughout the year. They are distributed across the entire North Pacific and into the southern Bering Sea in summer but the majority are thought to be south of 40^{o}N in winter. Sperm whales are found year round in California waters, but they reach peak abundance from April through mid-June and from the end of August through mid-November. Acoustic detections of sperm whales in the offshore waters of the outer Washington coast occurred all months of the year, with peak occurrence April to August. Detections inshore from April to November were generally faint enough to suggest that the whales were offshore (Oleson et al. 2009). Sperm whales consume numerous varieties of deep water fish and cephalopods.

The most recent abundance estimates for sperm whales off California, Oregon, and Washington, out to 300 nm were derived from trend-model analysis of line-transect data collected during six surveys from 1991 to 2008. Using this method, estimates ranged from 2,000 to 3,000 animals (Moore and Barlow 2014). The best estimate for the California Current (2,106 sperm whales) is the trend-estimate that corresponds with the 2008 survey (Carretta et al. 2015). The minimum population estimate is 1,332 whales and the calculated PBR is 2.7 sperm whales per year (Carretta et al. 2015, Moore and Barlow 2014). The mean annual estimated mortality and serious injury attributable to commercial fisheries interactions was 1.7 sperm whales per year, based on observer and stranding data from 2001 to 2012. There were no documented mortalities or serious injuries of sperm whales due to ship strikes from 2008 to 2012. The annual fishery-related and ship strike mortality and serious-injury is less than PBR, but greater than ten percent of PBR, so cannot be considered insignificant and approaching a zero mortality and serious injury rate

(Carretta et al. 2015). Barlow and Forney (2007) estimated the density of sperm whales off California, Oregon, and Washington at 1.70 whales/1000 km2.

Western North Pacific (WNP) gray whales

We listed WNP gray whales as endangered under the Endangered Species Conservation Act (ESCA) in June 1970 (35 FR 18319). The ESA replaced the ESCA in 1973 and continued to list WNP gray whales as endangered. There is currently no recovery plan for this population.

The WNP stock of gray whales feeds in summer and fall in the Okhotsk Sea, Russia and off Kamchatka in the Bering Sea (Carretta et al. 2015 and references within). Historically, wintering areas included waters off Korea, Japan, and China. Recent tagging, photo-identification, and genetics studies found some WNP gray whales migrate to the eastern North Pacific in winter, including off Canada, the U.S., and Mexico (Lang et al. 2011, Mate et al. 2011, Weller et al. 2012, Urbán et al. 2013). Combined, these studies include 27 individual WNP gray whales in the Eastern North Pacific (Carretta et al. 2015).

Photo-identification data collected between 1994 and 2011 were used to calculate an abundance estimate of 140 whales in 2012 (Cooke et al. 2013). This stock has increased approximately 3.3% per annum during 2002 through 2012. The minimum population size is 135 WNP gray whales with a calculated PBR of 0.06 whales per year (Carretta et al. 2015). Coastal net fisheries has been identified as a large threat to this stock (Carretta et al. 2015 and references within). Between 2005 and 2007, four gray whales died in fishing nets off Japan, and one died off China. Approximately 19% of the 150 individual whales identified between 1994 and 2005 had evidence of entanglements in fishing gear (Bradford et al. 2009).

Guadalupe fur seals

In December, 1985, we listed Guadalupe fur seals as threatened under the ESA (50 FR 51252). There is no recovery plan for this species.

Guadalupe fur seals pup and breed mainly at Isla Guadalupe, Mexico (Arnould 2009; Carretta et al. 2015 and citations therein). The population is considered to be a single stock because all individuals are recent descendants from one breeding colony at Isla Guadalupe, Mexico. Individuals have been sighted as far north as central California, and as far south as Zihuatanejo, Mexico. Guadalupe fur seals are seasonally present in low numbers in California waters. Southern fur seals, including the Guadalupe fur seal, feed on a variety of prey including fish, cephalopods and crustaceans, depending on prey abundance and location. Most southern fur seals forage in upwelling zones, oceanic fronts, or continental shelf-edge regions (Arnould 2009). Specific foraging and dive information is not known for the Guadalupe fur seal. But other species in this genus forage mainly in the surface mixed layer (<50-60 m) at night (Arnould 2009).

In 1993, the population was estimated by Gallo (1994) to be about 7,408 and was derived by multiplying the number of pups (counted and estimated) by a factor of 4.0. The minimum size of the population in Mexico was estimated using the actual count of 3,028 hauled out seals.

(Carretta et al. 2015). Information is insufficient to determine whether the fishery mortality in Mexico exceeds the previously calculated PBR of 91. Although drift and set gillnet fisheries may cause incidental mortality of Gualdalupe fur seals, there are no reports of mortality or serious injury in the U.S. and information is not available for human-caused mortality or injuries in Mexico (Carretta et al. 2015 and references within).

2.12.1.2 Effects from the Proposed Action

In this analysis, we consider the effects of the proposed actions described in sections 1.3.1 and 1.3.2, on ESA-listed marine mammals. We identified four potential stressors as a result of these actions: acoustic disturbance, gear entanglement, vessel strikes, and the reduction of prey availability. Below, we first identify the species that are extremely unlikely to be affected by the proposed actions. Second, we evaluate the four stressors respective of the species or species groups that may be affected by the proposed actions.

Species that are extremely unlikely to be affected

North Pacific Right Whales- While it is possible that North Pacific right whales could be present in the proposed action area, it is unlikely that the NWFSC will encounter this species given that the most recent sightings have occurred in the southeast Bering Sea and in the Gulf of Alaska, they likely will be on high-latitude feeding grounds when the majority of the surveys would occur, the NWFSC survey efforts are relatively low, there has been no historical interactions with NWFSC research, and the NWFSC would be implementing the mitigation measures described above. Consequently, the NWFSC did not estimate any MMPA Level B harassment of them and did not request any incidental take authorization for them under the MMPA. As a result, we conclude that effects to North Pacific right whales, acoustic or otherwise, are extremely unlikely to occur. Therefore, the potential for effects is discountable.

WNP gray whales- WNP gray whales could be present in the proposed action area, however, it is unlikely that the NWFSC will encounter this species given that this population feeds in summer and fall in the Okhotsk Sea, Russia when the majority of the surveys would occur, the NWFSC survey efforts are relatively low, there has been no historical interactions with NWFSC research, and the NWFSC would be implementing the mitigation measures described above. Consequently, the NWFSC did not estimate any MMPA Level B harassment of them and did not request any incidental take authorization for them under the MMPA. As a result, we conclude that effects to WNP gray whales, acoustic or otherwise, are extremely unlikely to occur. Therefore, the potential for effects is discountable.

Acoustic Disturbance

Exposure to loud noise is one of the potential stressors to marine species as noise and acoustic influences may seriously disrupt communication, navigational ability, and social patterns. In particular, marine mammals rely substantially upon sound to communicate, navigate, locate prey, and sense their environment. Given the known sensitivities of marine mammals to sound, Southall et al. (2007) provided a comprehensive review of marine mammal acoustic sensitivities including designating functional hearing groups. Because no direct measurements of hearing exist for baleen whales, hearing sensitivity was estimated from behavioral responses (or lack thereof) to sounds, commonly used vocalization frequencies, body size, ambient noise levels at common vocalization frequencies, and cochlear measurements. Table 101 presents the functional hearing groups and representative species or taxonomic groups for each; all of ESA-listed marine mammals found in the proposed project areas are in the first two groups, low frequency cetaceans (baleen whales) and mid frequency cetaceans (odontocetes).

Table 101. Marine mammal functional hearing groups (NMFS 2016).

Functional Hearing Group	Functional Hearing R
Low-frequency (LF) cetaceans+ (baleen whales)	7 Hz to 30 kHz
Mid-frequency (MF) cetaceans (dolphins, toothed whales, beaked whales, bottlenose whales)	150 Hz to 160 kH
High-frequency (HF) cetaceans (true porpoises, *Kogia*, river dolphins, cephalorhynchid, *Lagenorhynchus cruciger* and *L. australis*)	200 Hz to 180 kH
Phocid pinnipeds (true seals)	75 Hz to 100 kH
Otariid pinnipeds (sea lions and fur seals)	100 Hz to 40 kH

* Represents frequency band of hearing for entire group as a composite (i.e., all species within the g where individual species' hearing ranges are typically not as broad.

+ Estimated hearing range for low-frequency cetaceans is based on behavioral studies, recorded vocalizations, and inner ear morphology measurements. No direct measurements of hearing ability l successfully completed.

Exposure to Active Acoustics and the MMPA LOA Application- Different sound exposure criteria are typically used for impulsive and continuous sources (Southall et al. 2007). Under the current NMFS guidelines for calculating Level B harassment under the MMPA, an animal is taken if it is exposed to continuous sounds at a received level of 120 dB RMS (root mean square) or impulsive sounds at a received level of 160 dB RMS. These are simple step-function thresholds that do not consider the repetition or sustained presence of a sound source nor does it account for the known differential hearing capabilities between species. Sound produced by the fisheries acoustic sources described in Section 1.3.1 are very short in duration (typically on the order of milliseconds), intermittent, have high rise times, and are operated from moving platforms. They are consequently considered impulsive sources, which would be subject to the 160 dB RMS criterion.

The DPEA was used to support an application for incidental take authorizations under the MMPA, which took a dual approach in assessing the impacts of high-frequency active acoustic sources used in fisheries research in the CCRA (the only geographical area where it operates these devices). The first approach was a qualitative assessment of potential impacts across marine mammal species and sound types. This analysis considered a number of relevant biological and practical aspects of how marine mammal species likely receive and may be impacted by these kinds of sources. The second approach was a quantitative estimate of the number of marine mammals that could be exposed to sound levels that might reach the harassment threshold under the MMPA (*i.e.*, 160 dB RMS) based on estimated marine mammal densities and the size of the sound fields produced by active acoustic sources. This assessment briefly described here, which is described in greater detail in Appendix C of the DPEA, considered the best available current scientific information on the impacts of noise exposure on marine life and the potential for the types of acoustic sources used in NWFSC surveys to have behavioral and physiological effects.

The results indicate that certain active fisheries acoustic sources (e.g., short range echosounders, acoustic Doppler current profilers) are distinguished by having very high output frequencies (>180 kHz) and generally short duration signals and highly directional beam patterns. Based on the frequency band of transmissions (see Table 102) relative to the functional hearing capabilities of marine species (see Table 101), they are not expected to have any negative effect on marine life. These sources are determined to have essentially no probability of being detected by or resulting in any potential adverse impacts on marine species. This conclusion is based on the relative output frequencies (> 180 kHz) and the fact that this is above the known hearing capabilities of any marine species. Although sounds that are above the functional hearing range of marine animals may be audible if sufficiently loud, the relative output levels of these sources and the levels that would likely be required for animals to detect them would be on the order of a few meters. Therefore, the probability for injury or disturbance from these sources (where the frequency is > 180 kHz) is extremely unlikely.

Some of the lower frequency and higher power systems may be detectable over moderate ranges for some species. For some ESA-listed baleen whales (blue whales, fin whales, and sei whales), we conclude it is unlikely that they will detect most of these active acoustic sources, due primarily to their relative low frequency hearing range. For odontocete cetaceans (sperm whales and Southern Resident killer whales), and to a lesser degree humpback whales and other pinnipeds (Guadalupe fur seals), we conclude that these species could be exposed to and detect at least some of the active acoustic sources used during NWFSC research. The general source parameters for the primary NWFSC vessels operating active acoustic sources is characterized in Table 102. These sources were used in acoustic propagation modeling to estimate the zones within which the 160 dB RMS received level occurred. The full range of sound sources used in fisheries acoustic surveys were considered. In modeling the potential impact areas, the most precautionary estimate of maximum received level ranges (*i.e.* largest insonified area) were used (e.g., lowest operating frequency). While these signals are very brief and intermittent, a very conservative assumption was taken in ignoring the temporal pattern of transmitted pulses in calculating Level B harassment events.

Table 102. Output Characteristics for predominant NWFSC acoustic sources (DPEA).

Acoustic system	Operating frequencies (kHz)	Source level (dB re 1 µPa at 1 m)	Nominal beam width (degrees)	Effective exposure area: Sea surface to 200 m depth (km^2)
Simrad EK60 narrow beam echosounder	18 kHz (38, 70, 120, 200 kHz)	224	11°	0.0142
Simrad ME70 multibeam echosounder	70 kHz (70-120 kHz)	205	140°	0.0201
RDI ADCP Ocean Surveyor	75 kHz	223.6	40° x 100°	0.0086
Simrad ITI trawl monitoring system	27 kHz (-33 kHz)	<200	40° x 100°	0.0032
Simrad FS70 trawl sonar	330 kHz	216	1.9° x 20°	0.0080
Simrad SX90 omni-directional multibeam sonar	70 kHz (70-120 kHz)	206	0°-90° tilt angle from vertical (average)	0.06538

Note: Calculations of effective exposure areas are made with the lowest frequency form sources with multiple frequencies; the full range of frequencies used are shown in parentheses. Abbreviations: dB re 1 µPa at 1 m = decibels reference at one micro Pascal at one meter; km^2 = square kilometer

The NWFSC calculated the ensonified areas along with marine mammal density estimates and information regarding likely depth distributions to produce an estimate of the number of incidents that marine mammal species may be exposed to Level B harassment in each survey area (methodology described in section 6.2 *in* DPEA Appendix C). Table 10 in the proposed rule (84 FR 38516) describes the estimated levels of Level B harassment under the MMPA for marine mammals also protected under the ESA. These include 6 sperm whale Level B takes (4 from exposure to the EK60 and 2 from exposure to the SX90), and 22 Guadalupe fur seal Level B takes (8 from exposure to the EK60, 3 from exposure to the ME70, and 11 from exposure to the SX90). No other Level B harassment under the MMPA for ESA-listed species is expected to occur based on this methodology.

In addition to active acoustic sources, the vessels used for research also produce relatively loud sounds at a much lower frequency. The specific sound profiles of the research vessels used are not readily available. McKenna et al. (2012) described large commercial vessel traffic sound profiles where bulk container and tanker ships produce broadband sounds at or greater than 180 dB re µPa@1m; with highest source level <100 Hz. The research vessels used by the NWFSC vary in length; however, even the largest research vessels are smaller than the commercial vessels that produce these source levels. As a result, we assume that NWFSC research vessels produce low frequency sounds that are loud, but at somewhat lower levels than very large container ships.

As part of mitigation measures being implemented to reduce marine mammal bycatch in research survey trawls, the NWFSC would deploy pingers with variable frequency (10-160 kHz) and duration (200 – 400 microseconds), repeated every 5 to 6 seconds. The pingers generate a maximum sound pressure level of 145 dB RMS referenced to 1 micropascal at 1m. By definition, the intention of these pingers is to influence the behavior of marine mammals, including ESA-listed species, to detect and otherwise avoid capture in survey gear. The exact mechanisms of how pingers have contributed to successful deployment and reduction of some marine mammal bycatch in other commercial fishing settings, or if these pingers will contribute to reduced bycatch in survey trawl gear is unclear. Section 109(h) of the MMPA (16 U.S.C. 1379(h)) allows for the taking of marine mammals in a humane manner by federal, state, or local government officials or employees in the course of their official duties if the taking is necessary for "the protection or welfare of the mammal," "the protection of the public health and welfare," or "the non-lethal removal of nuisance animals." NWFSC use of pingers as a deterrent device, which may cause Level B harassment of marine mammals under the MMPA, is intended solely for the avoidance of potential marine mammal interactions with NWFSC research gear (*i.e.*, avoidance of Level A harassment, serious injury, or mortality). Therefore, use of such deterrent devices, and the taking that may result, is for the protection and welfare of the mammal and is covered explicitly under MMPA section 109(h)(1)(A). Under the ESA, the action of preempting bycatch events is considered beneficial, as long as no other contemporaneous adverse effects are occurring as a result. At this point, we assume pingers are beneficial in helping to reduce the chances of bycatch for ESA-listed marine mammals, and we have not identified any adverse effect likely to occur as a result of them. The sounds produced by these pingers are at least partially audible to ESA-listed marine mammals, but are still well under the levels of sound being produced by other active acoustic equipment used. As a result, we do not expect these pingers to produce any injurious effects to any ESA-listed species.

Potential Responses from Active Acoustics- Based on the characterization of active acoustic sounds sources, we conclude that some of the sources used are likely to be entirely inaudible to all marine mammal species (other than maybe in the immediate vicinity of sound sources) including the ESA-listed species considered in this opinion. We also conclude that some of the lower frequencies may be detectable over moderate distances from sound sources for some ESA-listed species, although this depends strongly on inter-specific differences in hearing capabilities. Based on past studies and observations, we consider that sounds generated by active acoustic sources used during NWFSC research activities could cause the following possible impacts or responses: masking of natural sounds; temporary or permanent hearing impairment; non-auditory physical or physiological effects; or temporary behavioral disturbance (Richardson et al. 1995; Gordon et al. 2004; Nowacek et al. 2007; Southall et al. 2007). Below we briefly discuss these four potential impacts.

The term masking refers to the inability of a subject to recognize the occurrence of an acoustic stimulus as a result of the interference of another acoustic stimulus (Clark et al. 2009), which can reduce the effective communication distance of a marine mammal species if the frequency of the source is close to that used as a signal by the marine mammal, and if the anthropogenic sound is present for a significant fraction of the time (Richardson et al. 1995). Masking can also interfere with detection of acoustic signals such as communication calls, echolocation sounds, and environmental sounds important to marine mammals. There is some evidence that whales can, but sometimes do not, compensate for such changes in their ambient noise environment. For example, killer whales increase the amplitudes of their calls with increasing noise in the 1–40 kHz frequency band (Holt et al. 2009). In order for negative impacts associated with masking to occur, we would expect that important sounds associated with echolocation, communication, or other environmental cues would likely need to occur over a sustained period of time in order to produce a discernable or detectable effect on health or fitness of an individual that would constitute an adverse effect under the ESA. Largely these active acoustic sources do not overlap well with any other sounds that are important to species other than mid/high-frequency cetaceans such as sperm whales and killer whales, although the lower ranges of NWFSC active acoustics are likely detectable by humpback whales and pinnipeds as well. Even for these species that can detect the use of high frequency active acoustics, it does not seem likely that the duration of exposure would last long enough to produce significant adverse effects related to masking of important biological or environmental cues.

Marine mammals exposed to high intensity sound repeatedly or for prolonged periods can experience hearing threshold shift, which is the loss of hearing sensitivity at certain frequency ranges (Kastak et al. 1999; Schlundt et al. 2000; Finneran et al. 2002, 2005). Threshold shift can be permanent (PTS), in which case the loss of hearing sensitivity is not recoverable, or temporary (TTS), in which case the animal's hearing threshold would recover over time (Southall et al. 2007). However, the impact of TTS depends on the frequency and duration of TTS, as well as the biological context in which it occurs. TTS of limited duration, occurring in a frequency range that does not coincide with that used for recognition of important acoustic cues, would have little to no effect on an animal's fitness. Repeated sound exposures that lead to TTS could cause PTS. However, as discussed above and in more detail (see DPEA Appendix C), current scientific information supports the conclusion that direct physiological harm is extremely unlikely. Lurton and DeRuiter (2011) modeled the potential impacts (permanent threshold shift [PTS] and behavioral reaction) of conventional echosounders on species of marine mammals. They estimated PTS onset at typical distances of 10 to 20 meters at most for the kinds of sources in the fisheries surveys considered here. They also emphasized that these effects would very likely only occur in the cone ensonified below the ship and that animal responses to the vessel itself at these extremely close ranges would very likely influence their probability of being exposed to these levels. They conclude that, while echosounders may transmit at high sound pressure levels, the very short duration of their pulses and their high spatial selectivity make them unlikely to cause damage to marine mammal auditory systems. Recent measurements by Finneran and Schlundt (2010) of TTS in mid-frequency hearing cetaceans from high frequency sound stimuli indicate a higher probability of TTS in marine mammals for sounds within their region of best sensitivity; the TTS onset values estimated by Southall et al. (2007) were calculated with values available at that time and were from lower frequency sources. Thus, there is a potential for TTS from some active sources, particularly for mid/high-frequency cetaceans. However, even given the more recent data, animals would have to be relatively close and remain near sources for many repeated pings to receive overall exposures sufficient to cause TTS onset (Lucke et al. 2009; Finneran and Schlundt 2010).

Non-auditory physiological effects or injuries that theoretically could occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, resonance, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007).

Studies examining such effects are limited, however. In general, very little is known about the potential for strong underwater sounds to cause non-auditory physical effects in marine mammals. Such effects, if they occur at all, would presumably be limited to short distances from the sound source and to activities that extend over a prolonged period.

Marine mammals may behaviorally react to sound when exposed to anthropogenic noise. Disturbance includes a variety of effects, including subtle to conspicuous changes in behavior, movement, displacement, or other behavioral changes suggesting discomfort (see Nowacek et al. 2007 and Southall et al. 2007 for reviews). While low frequency cetaceans (e.g., blue whales) have been observed to respond behaviorally to low- and mid-frequency sounds, there is little evidence of behavioral responses in these species to high frequency sound exposure (see e.g., Jacobs and Terhune 2002; Kastelein et al. 2006). Sperm whales have been observed to interrupt their activities by frequently stopping echolocation and leaving the area in the presence of underwater pulses made by echosounders and military submarine sonar near where the sperm whales are located (Watkins and Schevill 1975; Watkins et al. 1985). There is relatively little direct information about behavioral responses of marine mammals exposed to loud sound, including odontocetes, but the responses that have been measured in a variety of species to audible suggest that the most likely behavioral responses (if any) would be short-term avoidance behavior of the active acoustic sources sounds (see Nowacek et al. 2007; Southall et al. 2007 for reviews).

If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to result in a change to the individual’s fitness. Although we expect that some behavioral disturbance as a result of the proposed action could occur as individuals may avoid vessels, we expect that this disturbance would be localized to a relatively small area surrounding a research vessel, and would last only a short time because vessels are expected to be moving through and away from areas at the same time marine mammals might be simultaneously avoiding those vessels. Even if vessels are stationary for a period of time, we expect animals to move away from the “zone of influence” to avoid the disturbing sound. The distance required to escape this area is going to be on the order of a few hundred meters, based on the sound profile described in the DPEA. Movement of this distance is expected to occur relatively quickly in a matter of minutes, assumed to be well within their normal daily activity. Because sound levels surrounding any area that a vessel has occupied or traveled through would return to ambient levels relatively quickly, we expect that marine mammals would be able to resume any activity that might have been temporarily affected, in the unlikely event that any behaviors were affected to begin with.

Additionally, given the short time period that avoidance behavior is expected in comparison to the normal expenditures that may occur during most any day for an individual, we do not expect an individual to experience a significant depletion of energy reserves. As a result, we expect that any stress or increased energy expenditure to be temporary and have no or a negligible effect on the individual’s fitness that exceed the natural variability for animals in the environment. Also, we do not expect this short term disturbance to be significant enough to result in behavioral modifications (e.g., prolonged changes in diving/surfacing patterns, habitat abandonment due to loss of desirable acoustic environment, or more than brief cessation of feeding or social interaction) that would lead to a discernable effect on growth, survival, reproduction, or any aspect of fitness or overall health of individuals.

It is possible that an individual could receive multiple exposures to NWFSC active acoustics over time, either by encountering the same vessel again as the boats and whales continue moving around (different than whales or vessels actually following each other around), or a different NWFSC research vessel conducting a different survey at another time and/or place. It is also possible that marine mammals may elect to remain in the "zone of influence" despite the sound levels due to sufficient impetus to remain in that area to continue foraging in the presence of a desired prey field. However, based on the temporary nature of any behavioral reaction or impact that each encounter is expected to result in, and that these events will likely be separated in space and time, we conclude that those incidents can be considered isolated where animals have resumed activities and recovered from any previous temporary exposure. Considering the relatively low total number of instances of exposures to potentially disturbing sound levels each year that have been predicted for ESA-listed marine mammals that may be able to detect the active acoustics as a result of the proposed action (e.g., 6 sperm whale exposures and 22 Guadulupe fur seal exposures in the CCRA; Table 13 *in* 81 FR 38516) and the large extent of area that NWFSC covers during the course of a year, we conclude it is extremely unlikely that any individual will accumulate a large number of exposures to NWFSC research vessels over the course of a year, and that exposure will dispersed throughout the population over the range of NWFSC activities.

As mentioned above, the vessels used for research also produce relatively loud sounds at a much lower frequency. However, the transitory nature of NWFSC research cruises that typically cover vast areas of ocean and do not remain in the same places for many days and weeks should preclude any sustained lasting impacts from sound produced by NWFSC research vessels to any individuals that would lead to significant or sustained changes in behavior that would be expected to produce decreased fitness or survival that could warrant consideration as take under the ESA. The sheer size of the proposed project area covered by research activities and the relative frequency and footprint of the NWFSC vessels coming through any same area at most a few times a year leads us to conclude that the potential for impacts accumulating in any one area during the year in a significant or detectable manner is discountable. Accumulation of anthropogenic noise, and specifically vessel noise, is a known problem for marine life including many of the ESA-listed marine mammal species considered in this opinion. However, it is currently not possible to assess the contribution that a relative small number of research cruise trips spread throughout a vast area of the ocean over the course of a year may be contributing to overall magnitude of this problem in a meaningful way. Based on the transitory nature of NWFSC research and the relatively limited presence of NWFSC vessels throughout the action area during the year, we conclude the effects of vessels noise on ESA-listed marine mammals are insignificant.

Summary of Potential Responses to Active Acoustics- Given that NWFSC research vessels are not expected to remain in the same area for multiple days and weeks, any masking of communication or other sounds will be temporary, and animals would be expected to either continue those communications while avoiding NWFSC vessels and/or resuming them in the area shortly after the departure of those vessels. We do not expect the project to result in any cases of temporary or (especially) permanent hearing impairment, any significant non-auditory physical or physiological effects, or significant effects as a result of masking. Most likely, if any ESA-listed marine mammals detect active acoustic sound sources at all, they are likely to show some temporary avoidance of the proposed action area where received levels of sound are high enough that hearing impairment could potentially occur. In those cases, the avoidance responses of the animals themselves would reduce or (most likely) avoid the significant effects that may only occur during extended exposures at close proximity to these sounds. Therefore, we conclude the risks of hearing impairment, non-auditory physical injuries, and adverse effects from masking resulting from exposure to active acoustics are discountable.

We also conclude it is likely that animals that have been temporarily disturbed and/or displaced by avoiding the active acoustics of NWFSC research will not experience energetic costs that lead to measurable or biologically meaningful impacts that could affect the fitness of individuals with respect to survival, growth, and reproduction. We expect the effects of disturbance and avoidance from this proposed action to be temporary and insignificant. As a result, we conclude that the risks associated with exposure to active acoustics leading to short term disturbance and effects on foraging habitat are insignificant.

For some ESA-listed baleen whales (blue whales, fin whales, and sei whales), we conclude it is unlikely that they will detect most of these active acoustic sources, due primarily to their relative low frequency hearing range. For odontocete cetaceans (sperm whales and Southern Resident killer whales), and to a lesser degree humpback whales and other pinnipeds (Guadalupe fur seals), we conclude that these species could be exposed to and detect at least some of the active acoustic sources used during NWFSC research.

We conclude that short term exposure to active acoustic sources aboard NWFSC research vessels do not present significant risks for ESA-listed marine mammals. We expect exposures that are actually detectable may lead to a temporary disturbance and avoidance of NWFSC vessels that, if it occurs, will not have any discernable effects to health or fitness as a result of this exposure, for any of these ESA-listed marine mammals listed above. This response would result primarily from temporary exposure to relatively high frequency sounds for short durations as the NWFSC research vessels transit through while actively conducting research or en-route to a new sampling location, or remain stationary for a relative short period of time.

Based on the analyses presented above, we conclude that the impacts expected to result from the proposed use of active sound sources by the NWFSC are insignificant, and the risks of injury or disturbance that could lead to adverse effects on the health, behavioral ecology, and social dynamics of individuals of any ESA-listed marine mammal species in ways or to a degree that would reduce their fitness are discountable. Because our analysis indicates that the expected behavioral responses of these animals are not expected to disrupt the foraging, migrating or other behaviors of these animals to such an extent that we would expect reduced growth, reproduction or survival, these expected responses do not appear to result in “take” under the ESA. Consequently, no incidental ESA take of ESA-listed marine mammals as a result of exposure to active acoustic sources used during NWFSC research activity is anticipated.

Gear Interaction and Entanglement

NWFSC surveys involve the use of gear that has the potential to take marine mammals, including bottom, midwater, and surface trawls, purse seine gear, tangle net gear, and hook and line gear (including rod and reel, troll, and longline deployments) in the PSRA, LCRRA, and CCRA. These takes may occur in two forms: (1) take by accidental entanglement that may cause mortality and serious injury, and (2) take by accidental entanglement that may cause non-serious injury ("Level A" harassment take).

From 1999-2014, the NWFSC incidentally caught 42 marine mammals during fisheries related research activities (see Table 4.2-16 *In* the DPEA). Although marine mammals have the potential to be caught in numerous gear types used by the NWFSC, historical interactions have only occurred with the Nordic 264 surface trawl and modified Cobb trawl nets. The majority (33) were taken during the Juvenile Salmon PNW Coastal Survey. Species involved were Pacific white-sided dolphins (24), Steller sea lions (8), California sea lions (4, including one released alive), harbor seals (3), including one released alive), northern fur seal (1), and unidentified porpoise/dolphin (2). The three other surveys with reported marine mammal takes are the Juvenile Rockfish Survey (2), the Skagit Bay Juvenile Salmon Survey (1), and the PNW Piscine Predator and Forage Fish Survey (6). The last survey is no longer being conducted. However, no currently ESA-listed marine mammal species have ever been reported captured/entangled during any NWFSC research activity (the Eastern DPS of Steller sea lions were delisted in 2013). As a result, the NWFSC did not request any lethal or serious injury take, or any Level A (non-serious injury) harassment takes under the MMPA for any ESA-listed marine mammals in their LOA application.

Entanglement of ESA-listed marine mammals, including some species of whales, is known to be an issue with commercial fishing gear on the U.S. west coast (Saez et al. 2013), although usually associated with fixed pot/trap and gillnet gear. While the bycatch of large whales in commercial trawl fishing gear is not unprecedented, it is not a common event in any U.S. west coast fishery (NMFS observer data), nor would it ever be expected to occur in a NWFSC survey trawl. For most of the ESA-listed marine mammal species, the risk of incidental capture or entanglement is very low in trawl gear given the slow speed and relatively small size of survey trawls fished at/near the surface. However, smaller ESA-listed marine mammals, such as Guadalupe fur seals, could be at more risk of capture if they encountered NWFSC survey trawls, as evidenced by the historical capture of other pinnipeds and dolphins. Mitigation measures include a move-on rule to minimize chances for gear to be deployed with marine mammals nearby and modified net retrieval procedures if marine mammals are sighted while gear is in the water. Use of dedicated marine mammal observers prior to and during survey trawl operations should help research vessels identify the presence of ESA-listed marine mammals during operations, and vessels can take necessary evasive action. Use of marine mammal excluder devices should also help any smaller ESA-listed marine mammal escape relatively unharmed if they do enter a trawl net.

Risks of interactions between longline gear and ESA-listed marine mammals include hooking or entanglement with the gear, especially for pelagic longlines. These interactions could result from direct predation of bait or depredation on fish that are already captured by the longline, or by unknowingly swimming into the gear and becoming entangled. Bottom longlines do present some risk of entanglement due to vertical lines running from the surface to the bottom, but gangions and hooks are relatively low in profile on the bottom and likely less vulnerable to hooking or predation by marine mammals than the profile of hooks suspended in the water column in pelagic longline gear. Compared to commercial longline fishing gear operations, NWFSC research gear is typically shorter in length, uses less hooks, and soaks for less time, which may contribute to the lack of ESA-listed marine mammal bycatch that has occurred historically during NWFSC research activities. Use of dedicated marine mammal observers prior to and during longline survey operations is expected to help research vessels identify the presence of ESA-listed marine mammals, and act accordingly to minimize incidental capture and entanglement risks.

The prediction of future events occurring that have never occurred before, given that no incidental captures or entanglements with currently ESA-listed marine mammals has ever been documented, is challenging because these risks cannot be completely eliminated. At this time, we conclude that the lack of historical incidental capture or entanglements between survey gear and ESA-listed marine mammals species, even when risks of such interactions have been and continue to remain possible, is a reflection that the mitigation measures that have been used in the past and are expected to be used in the future are effective, either individually or in total, at minimizing the likelihood of these events happening. Any future take events could change this assessment, but until that time, given the historical performance of NWFSC research activities, we conclude that the likelihood of incidental capture or entanglement of ESA-listed marine mammals is discountable

Vessel Strikes or Collisions

Collisions of ships and marine mammals can cause major wounds, which may lead to the death of the animal. An animal at the surface could be struck directly by a vessel, a surfacing animal could hit the bottom of a vessel, or an animal just below the surface could be cut by a vessel's propeller. The severity of injuries typically depends on the size and speed of the vessel (Knowlton and Kraus 2001; Laist et al. 2001; Vanderlaan and Taggart 2007), but can included death by massive trauma, hemorrhaging, broken bones, or propeller wounds (Knowlton and Kraus 2001). Large whales, such as fin whales, are occasionally found draped across the bulbous bow of large ships upon arriving in port. Massive propeller wounds can be immediately fatal. However, if the wounds are more superficial, the whales may survive the collisions (Silber et al. 2009).

Jensen and Silber (2003) summarized large whale ship strikes world-wide from 1975 to 2003 and found that most collisions occurred in the open ocean involving large vessels. Commercial fishing vessels were responsible for four of 134 records (3%), and one collision (0.75%) was reported for a research boat, pilot boat, whale catcher boat, and dredge boat. Williams and O'Hara (2009) summarized their modeling efforts to characterize ship strikes of large cetaceans in British Columbia. With few exceptions, high-risk ship strike areas were found in geographic bottlenecks, such as narrow straits and passageways (Williams and O'Hara 2009). Although not included in the geographic area of the Williams and O'Hara study, the NWFSC survey area is such an area where large numbers of cargo ships transit the area each year, yet evidence for ship collisions are rare.

No marine mammals are likely to be injured or killed by collisions with NWFSC research vessels. The probability of vessel and marine mammal interactions occurring during NWFSC research operations is negligible due to the vessel's slow operational speed. Vessel speed during active sampling would rarely exceed 5 knots, with typical speeds likely being 2–4 knots. Transit speeds would likely vary from 6–14 knots but average 10 knots, which is below the speed at which studies have generally noted reported increases in marine mammal injury or death from collisions (~ 14 knots; Laist et al. 2001; Pace and Silber 2005). Higher speeds during collisions result in greater force of impact, but higher speeds also appear to increase the chance of severe injuries or death by pulling whales toward the vessel. Computer simulation modeling showed that hydrodynamic forces pulling whales toward the vessel hull increase with increasing speed (Clyne 1999; Knowlton et al. 1995).

Preventative measures during cruises would include the NWFSC maintaining constant watch and slowing down or taking evasive maneuvers to avoid collisions with marine mammals or other species. The officer on watch, Chief Scientist (or other designated member of the Scientific Party), and crew standing watch on the bridge would visually scan for marine mammals during all daytime operations. At any time during a survey or in transit, if a crew member standing watch or dedicated marine mammal observer sights marine mammals that may intersect with the vessel course that individual would immediately communicate the presence of marine mammals to the bridge for appropriate course alteration or speed reduction, as possible, to avoid incidental collisions.

Based on the slow speeds of the NWFSC vessels, and the preventative measures proposed, the probability of vessel and marine mammal interactions occurring during NWFSC operations is negligible, and we conclude the risk of adverse effects to ESA-listed marine mammals as a result of collisions with NWFSC research vessels is discountable.

Reductions in Prey

NWFSC research surveys, primarily use of trawl gear, results in the capture of many species of fish and invertebrates that are sources of prey for ESA-listed species. The species of primary concern in regard are Pacific hake (whiting), the small, energy-rich, schooling species such as Northern anchovy and Pacific herring, and salmonids. However, the total amount of these species taken in the research surveys is very small relative to their overall commercial and recreational catches and biomass. For example, approximately 1,181 metric tons of Pacific hake may be harvested to assess abundance and age composition in the NWFSC survey; however, this results only in about 1.8 percent of the commercial catch (See Table 9-1 In the LOA application). In most cases for which there are fishing metrics for comparison, the NWFSC research catch represents much less than 1 percent of the overfishing limit or other metric for the target species (See Table 9-1 In the LOA application).

Southern Resident killer whales (SRKWs) consume a variety of fish species, but are known to rely heavily upon salmon for prey, especially Chinook salmon (Ford and Ellis 2006; Hanson et al. 2010). Statistical associations between broad indices of summer/fall Chinook abundance and Southern Resident killer whale survival, fecundity, and rates of population increase on an annual time scale have been identified (Ward et al. 2013), and are the subject of ongoing investigation by NMFS, the Canadian Department of Fisheries and Oceans (DFO), and others. In 2011 and 2012, an independent scientific panel (Panel) held a series of workshops to evaluate the available information regarding the relationship between Chinook abundance and SRKW population dynamics. The Panel found good evidence that Chinook salmon are a very important part of the SRKW diet and good evidence that some Southern Residents have been observed in poor condition and poor condition is associated with higher mortality rates. They further found that the available data do provide some support for a cause and effect relationship between salmon abundance and SRKW survival and reproductions. They identified "reasonably strong" evidence that vital rates of SRKW are, to some degree, ultimately affected by broad-scale changes in their primary Chinook salmon prey, although they cautioned against over-reliance on any particular correlative study (see Hilborn et al. 2012 for complete discussion of the Panel workshops). Because the NWFSC incidentally captures Chinook salmon during their research trawls and there is evidence that Chinook salmon are a very important food source for Southern Residents, we consider the possible impact of those captures on the available prey base of Southern Residents, and the likelihood of any adverse effect to the fitness of any individuals as a result of this activity.

Here we only analyze the effects from prey reductions of Chinook salmon from the activities or components of the research described in section 1.3.3. All other take of Chinook salmon from NWFSC research has been analyzed in the biological opinions listed in Table 1, which includes effects of reduction of prey to Southern Resident killer whales. As shown in Table 100, 121 adult Chinook salmon and 1,190 juvenile Chinook salmon would be taken lethally. This reduction would occur across several ESUs and therefore would be spread across the whales' geographic range. Given the total quantity of prey available to Southern Resident killer whales throughout their range, this annual reduction in prey of is extremely small. Because this reduction is so small, there is also a low probability that any of the Chinook salmon that would have survived if there were no NWFSC research surveys could be intercepted by the killer whales in any case due to the whales' vast range. Thus, the magnitude of prey reduction associated with NWFSC research, assuming all captures actually lead to mortality and prey removal, is insignificant compared to the overall amount of prey that is expected to be available for ESA-listed species in the action area.

In addition to the small magnitude of prey reductions that are expected to result from NWFSC research, the temporal and spatial distributions are also important to consider. Because of the random sampling design, surveys generally are spread out systematically over large areas such that prey removals are highly localized and unlikely to affect the spatial concentrations and availability of prey for any marine mammal species. This is especially true for pinnipeds, which are opportunistic predators that consume a wide assortment of fish and squid and, judging by their increasing populations and expanding ranges in the Pacific Northwest (Caretta et al. 2011), food availability does not appear to be a limiting factor (Baraff and Loughlin 2000, Scordino 2010). As a result, we anticipate that the proposed action is not expected to have anything other than very minor and transitory impacts on prey used by the ESA-listed marine mammal species in the action area, and the risks of local depletions that could have an impact on the overall health and fitness of ESA-listed marine mammals are insignificant.

2.12.2 Hawskbill Sea Turtle

Once abundant, hawksbills are now rare in the eastern Pacific (Cliffton et al. 1982; Gaos et al. 2010; Seminoff et al. 2003). Within the eastern Pacific, approximately 300 females are estimated to nest each year along the coast from Mexico south to Peru (Gaos et al. 2010). Bycatch in commercial fisheries is acknowledged as a threat to hawksbill turtles, more commonly associated with nearshore artisanal fisheries in the eastern Pacific (NMFS and USFWS 2013b).

In 2013, a hawksbill turtle stranding was recorded in Southern California near San Diego (NMFS stranding data). This was the first account of a hawksbill in the stranding record on the U.S. west coast and it isn't clear what this stranding may be representing in terms of expected distributions for this species. A subsequent necropsy conducted by the SWFSC concluded the turtle was emaciated, consistent with a determination this individual was not feeding well outside of its normal habitat. Hawksbills are more commonly found in the Eastern Tropical Pacific, but they may occur in the far southern end of the CCRA. As recently as 2007, the species had been considered largely extirpated in the region (Gaos et al 2010).

Considering the relatively low population numbers that exist, the occurrence in waters where NWFSC surveys are expected to occur is likely relatively low, and there has been no historical interactions with NWFSC research, we conclude that the risk of incidental capture/entanglement is discountable. Since there is relatively little chance of interactions between NWFSC research activity and hawksbill sea turtles, NMFS the potential for effects is discountable.

2.12.3 Invertebrates (white abalone, and black abalone)

White abalone were listed as endangered in 2001 (66 FR 29046). Black abalone were listed as endangered in 2009 (74 FR 1937).
These two ESA-listed species of invertebrates may be found in the proposed action areas of the CCRA. Both of these invertebrate species are benthic, except for early larval stages. White abalone are found in open low and high relief rock or boulder habitat that is interspersed with sand channels, usually at depths of 80-100 feet, making them the deepest occurring abalone species in California. They currently are known to occur at some of the offshore islands and banks of the Southern California Bight and along the coast of Baja California. Black abalone are found in shallow subtidal and intertidal areas along rocky habitats stretching from central California south into Baja California, including some of the offshore Channel Islands in the Southern California Bight.

As benthic invertebrate species, abalone are not expected to be affected by NWFSC research through incidental capture or entanglement, vessel collisions, or disturbance from loud sounds. Most NWFSC research activities take place well beyond the relatively shallow waters where abalone occur. Trawl survey gear pose no risk to abalone living on the seafloor bottom. Activities such as ROV survey operations occur with use of cameras which are not expected to harm or impact abalone. Abalone feed primarily on kelp and algae, which is not subject to any impacts from NWFSC research. There has been no history of bycatch of black or white abalone during NWFSC research surveys. As a result, we conclude that the risks of adverse effects to white or black abalone are discountable.

2.12.4 Southern California steelhead

The geographic range of this DPS extends from the Santa Maria River, near Santa Maria, to the California–Mexico border, which represents the known southern geographic extent of the anadromous form of *O. mykiss*. Very little data regarding abundances of Southern California Coast steelhead are available, but the picture emerging from available data suggest very small (<10 fish) but surprisingly consistent annual runs of anadromous fish across the diverse set of basins that are currently being monitored (Williams et al. 2011). The most significant population that has been recently monitored is in Topanga Creek, where mark-recapture studies were done in 2007-2008. According to the authors (Bell et al. 2011), that data indicated a population of resident fish whose abundance is on the order of 500 individuals, including all size and age classes in Topanga Creek. It is believed that population abundance trends can significantly vary based on yearly rainfall and storm events within the range of the Southern California Coast DPS (Williams et al. 2011). A relatively large number of adult steelhead were observed in 2008, two years after an extended wet spring that presumably gave smolts ample opportunity to migrate to the ocean. However, there is little new evidence to suggest that the status of the Southern California DPS has changed appreciably in either direction since publication of the most recent collections of status reviews (Good et al. 2005; NMFS 2011d; Williams et al. 2011).

While it is possible that Southern California steelhead could be present in the proposed action area, it is unlikely that the NWFSC will encounter this species given that the most recent abundance estimates reveal relatively small numbers of fish, their distribution is in the southern range of the action area so the overlap in research activities would be minimal, and there has been no historical take with NWFSC research. As a result, we conclude that the risks of adverse effects to Southern California steelhead are discountable.

2.12.5 Critical Habitat

2.12.5.1 Southern Resident Killer Whale

The final designation of critical habitat for the SR killer whale DPS was published on November 29, 2006 (71 FR 69054). Critical habitat consists of three specific areas: (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 the following physical or biological features essential to conservation: (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. On February 24, 2015, NOAA Fisheries announced a 12-month finding on a petition to revise the critical habitat designation was warranted. In the FR notice, NOAA Fisheries outlined the next steps for collecting and analyzing data, and for developing a proposed rule to revise critical habitat expected in 2017.

As described in the opinion, the proposed action (described in sections 1.3.3 and 1.3.4) is likely to adversely affect Chinook salmon (the primary prey of Southern Resident killer whales). Any salmonid take up to the aforementioned maximum extent and amount would result in an insignificant reduction in prey resources for Southern Residents that may intercept these species within their range. Therefore, the NMFS anticipates indirect effects on killer whale prey quantity would be insignificant. The potential for vessels from the proposed project (described in section 1.3.1) to interfere with Southern Resident killer whale passage is expected to be insignificant because any vessel disturbance will be short-term and localized with no lasting effects. There are no acoustic surveys that are performed in designated killer whale critical habitat and no anticipated effects to water quality. Therefore, the potential effects on Southern Resident critical habitat from a decrease in prey base or interference with passage are insignificant.

2.12.5.2 Marine Fishes

The critical habitat that overlaps with the NWFSC research areas include eulachon critical habitat in the Columbia River and select tributaries (within LCRRA); Green sturgeon critical habitat in marine waters of the West Coast from Cape Flattery to Monterey Bay (within CCRA), sections of Puget Sound (within PSRA), and the Columbia River estuary (within LCRRA); rockfish critical habitat in many parts of Puget Sound (within PSRA), and salmonid critical habitat in marine waters of the West Coast from Cape Flattery to San Diego Bay (within CCRA), sections of Puget Sound (within PSRA), and the Columbia River estuary (within LCRRA).

In general, the activities described above would be (1) capturing fish with angling equipment and nets of various types, (2) collecting biological samples from live fish, and (3) collecting deceased fish for biological sampling. All of these techniques are minimally intrusive in terms of their effect on habitat because they would involve very little, if any, disturbance of streambeds or adjacent riparian zones. Moreover, the proposed activities are all of short duration. The only potential impact of NWFSC research activities to fish critical habitat is removal of prey during trawl surveys. However, as described above for reductions in prey for marine mammals, the total amount of prey species taken in the research surveys is very small relative to their overall commercial and recreational catches and biomass. In most cases for which there are fishing metrics for comparison, the NWFSC research catch represents much less than 1 percent of the overfishing limit or other metric for the target species (See Table 9-1 In the LOA application). It is not clear exactly how much NWFSC research and overall prey removal occurs within the designated critical habitat for ESA-listed fishes, but any removals of potential prey are likely to be limited to very small localized totals that are scattered across a relatively large survey area. The overall density of prey items in any area should not be affected in a significant way that would be detectable by individuals. Thus, the removal of fish and invertebrate species by NWFSC survey trawls is not expected to significantly reduce the quality or quantity of prey resources for green sturgeon within designated critical habitat.

Consequently, marine fishes critical habitat is not likely to be adversely affected by the proposed action.

2.12.5.4 Leatherback Sea Turtle

NMFS revised the current critical habitat for leatherback sea turtles by designating additional areas within the Pacific Ocean on January 26, 2012. This designation includes approximately 16,910 square miles along the California coast from Point Arena to Point Arguello east of the 3,000 meter depth contour; and 25,004 square miles from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter depth contour. The designated areas comprise approximately 41,914 square miles of marine habitat and include waters from the ocean surface down to a maximum depth of 262 feet. NMFS identified the feature essential to conservation as: the occurrence of prey species, primarily scyphomedusae of the order Semaeostomeae (e.g., *Chrysaora*, *Aurelia*, *Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance and density necessary to support individual as well as population growth, reproduction, and development of leatherbacks.

As described in section 2.5.2, the amount of jellyfish removed as a result of NWFSC surveys is considered insignificant to the total prey available. Due to the extremely high densities of jellyfish encountered in leatherback foraging areas, the amount of jellyfish removed as a result of NWFSC surveys would have no measurable effects on the availability of jellyfish as a food source or the quality of critical habitat for leatherback sea turtles. Considering the relative small amount of available jellyfish prey that is expected to be removed, which may only be temporarily until jellyfish are returned to the water, and that jellyfish removal is expected to be spread out over space and time to a degree, the capture of jellyfish by NWFSC survey trawls is not expected to significantly reduce the quality or quantity of prey resources for leatherbacks within designated critical habitat. Consequently, leatherback critical habitat is not likely to be adversely affected by the proposed action.

2.12.5.5 Black abalone

Black abalone critical habitat was designated in 2011 (76 FR 66806). Black abalone critical habitat includes approximately 360 square kilometers of rocky intertidal and subtidal habitats along the California coast between the Del Mar Landing Ecological Reserve to the Palos Verdes Peninsula, from the mean higher high water (MHHW) line to a depth of 6 meters relative to the mean lower low water (MLLW) line, as well as the coastal marine waters encompassed by these areas. Critical habitat also extends offshore to the Farallon Islands, Año Nuevo Island, San Miguel Island, Santa Rosa Island, Santa Cruz Island, Anacapa Island, Santa Barbara Island, and Santa Catalina Island. No NWFSC research activity considered in this opinion occurs in such shallow water habitats, and no impact to black abalone critical habitat is expected from this proposed action.

3. 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.

5.1 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 NMFS NWFSC and OPR. Individual copies of this opinion were provided to the NMFS NWFSC and OPR. This opinion will be posted on the Public Consultation Tracking System website (https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts). The format and naming adheres to conventional standards for style.

5.2 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.

5.3 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.

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