



UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

MAY 03 2017

Refer to NMFS No: F/WCR-2017-6766

Mr. Jim Unsworth, Director
Washington Department of Fish and Wildlife
600 Capitol Way North
Olympia, Washington 98501

Honorable Lorraine Loomis, Chair
Northwest Indian Fisheries Commission
6730 Martin Way East
Olympia, Washington 98516

Dear Chair Loomis and Director Unsworth:

This letter transmits the biological opinion issued under section 7 of the Endangered Species Act (ESA) and Magnuson-Stevens Fishery Conservation and Management Act (MSA) essential fish habitat (EFH) consultation prepared by NOAA Fisheries on the co-managers' fishery plan for Puget Sound salmon and steelhead fisheries, including U.S. Fraser Panel fisheries occurring from May 1, 2017 through April 30, 2018. This biological opinion evaluates the impacts of the fisheries on the Puget Sound Chinook Salmon Evolutionarily Significant Unit (ESU), the Puget Sound Steelhead Distinct Population Segment (DPS), the Southern Resident killer whale DPS and the two Puget Sound/Georgia Basin rockfish DPS's listed under the ESA. Other listed species occurring in the action area are either covered under existing, long-term ESA opinions or 4(d) determinations, or NMFS anticipates the proposed actions are not likely to affect the species. The opinion expires April 30, 2018.

NOAA Fisheries concluded in the biological opinion that the fisheries, if conducted consistent with the terms of the incidental take statement, are not likely to jeopardize the continued existence of the listed species that are subject of the opinion, or to destroy or to adversely modify critical habitat. Our conclusion for Puget Sound Chinook salmon is predicated in part on the co-managers' (2) completion of a performance assessment for the Puyallup and Skokomish Chinook populations and use of the results to take corrective measures to assure that fisheries will remain within exploitation rate ceilings, and (2) completion of a revised long-term transitional strategy for the Nisqually Chinook population (Speaks 2017). We have included these tasks as terms and conditions in the Incidental Take Statement of the biological opinion (section 2.9.4). The terms and conditions are non-discretionary.

Please let Susan Bishop (206.526.4587, susan.bishop@noaa.gov) know if you have any questions. I look forward to our continued collaboration.

Sincerely,

Ryan J. Wulff
Acting Assistant Regional Administrator
Sustainable Fisheries Division

Cc: WDFW: Ron Warren, Kyle Adicks
NWIFC: Craig Bowhay, Rob Jones, Chris James
SFD: Peter Dygert, Tim Tynan



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

Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2017-2018 Puget Sound Chinook Harvest Plan, Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service, and Fisheries Authorized by the U.S. Fraser Panel in 2017

NMFS Consultation Number: F/WCR-2017-6766

Action Agency: Bureau of Indian Affairs (BIA)
U.S. Fish and Wildlife Service (USFWS)
National Marine Fisheries Service (NMFS)

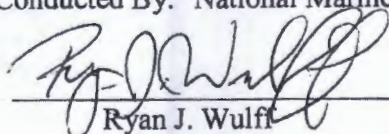
Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Puget Sound Chinook Salmon (<i>Oncorhynchus tshawytscha</i>)	Threatened	Yes	No	No	No
Puget Sound Steelhead (<i>O. mykiss</i>)	Threatened	Yes	No	No	No
Puget Sound/Georgia Basin (PS/GB) bocaccio (<i>Sebastes paucispinis</i>)	Endangered	Yes	No	No	No
PS/GB yelloweye rockfish (<i>S. ruberrimus</i>)	Threatened	Yes	No	No	No
Southern Resident killer whales (<i>Orcinus orca</i>)	Threatened	Yes	No	No	No
Eulachon (<i>Thaleichthys pacificus</i>)	Threatened	No	No	No	No
Green Sturgeon (<i>Acipenser medirostris</i>)	Threatened	No	No	No	No

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	No	No
Coastal Pelagic Species	No	No
Pacific Coast Groundfish	Yes	Yes

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

Issued by:


Ryan J. Wulff

Acting Assistant Regional Administrator
Sustainable Fisheries Division

Date:

MAY 03 2017

(Date expires: April 30, 2018)

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LIST OF ACRONYMS

BIA	Bureau of Indian Affairs
BRT	Biological Review Team
C&S	Ceremonial and Subsistence
CHART	Critical Habitat Analytical Review Team
CO ₂	Carbon Dioxide
CPS	Coastal Pelagic Species
CWT	Coded Wire Tag
DIP	Demographically Independent Population
DFO	Department of Fisheries and Oceans Canada
DPS	Distinct Population Segment
EFH	Essential Fish Habitat
ER	Exploitation Rate
ESA	Endangered Species Act
ESS	Early summer steelhead
EWS	Early winter steelhead
ESU	Evolutionarily Significant Unit
FRAM	Fishery Regulation and Assessment Model
HCSMP	Hood Canal Salmon Management Plan
HOR	Hatchery Origin Recruit
HR	Harvest Rate
HUC	Hydrologic Unit Code
ITS	Incidental Take Statement
MIT	Muckleshoot Indian Tribe
MPG	Major Population Group
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSY	Maximum Sustainable Yield
NMFS	National Marine Fisheries Service
NOR	Natural Origin Recruit
NWFSC	Northwest Fisheries Science Center
NWIFC	Northwest Indian Fisheries Commission
NWR	[NMFS] Northwest Region
OA	Ocean Acidification
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyls
PCE	Primary Constituent Element(s)

PBF	Physical or Biological Feature(s)
PFMC	Pacific Fishery Management Council
PRA	Population Recovery Approach
PSA	Puget Sound Anglers
PSIT	Puget Sound Indian Tribes
PSTIT	Puget Sound Treaty Indian Tribes
PSTRT	Puget Sound Technical Recovery Team
PSSMP	Puget Sound Salmon Management Plan
PSSTRT	Puget Sound Steelhead Technical Recovery Team
PST	Pacific Salmon Treaty
PVA	Population Viability Assessment
QET	Quasi-extinction Threshold
RCA	Rockfish Conservation Area
RER	Rebuilding Exploitation Rate
RMP(s)	Resource Management Plan(s)
RPA	Reasonable and Prudent Alternative
ROV	Remotely Operated Vehicle
SaSI	Salmonid Stock Inventory
SUS	Southern United States
USFWS	U.S. Fish and Wildlife Service
VRAP	Viable Risk Assessment Procedure
VSP	Viable Salmonid Populations
WCA	Washington Conservation Area
WCR	[NMFS] West Coast Region
WDFW	Washington Department of Fish and Wildlife

1 INTRODUCTION

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

Background

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

We also completed an essential fish habitat (EFH) consultation on the proposed actions, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

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

This document constitutes the NMFS' biological opinion under section 7 of the ESA and MSA Essential Fish Habitat consultation for federal actions proposed by NMFS, the Bureau of Indian Affairs (BIA), and the U.S. Fish and Wildlife Service (USFWS). The federal actions include:

- (1) The BIA's authority to assist with the development and implementation of the co-managers 2017-2018 Plan as reflected in BIA's April 21, 2017 request for consultation to NMFS and BIA's Environmental Assessment. This action is similar to BIA's action for the 2016-17 fisheries, described in NMFS' 2016 biological opinion.
- (2) The proposed USFWS authorization of fisheries, as party to the Hood Canal Salmon Management Plan (*U.S. v. Washington*, Civil No. 9213, Ph. I (Proc. 83-8)), from May 1, 2017-April 30, 2018.
- (3) Two actions associated with the management of the 2017 U. S. Fraser Panel sockeye and pink fisheries under the Pacific Salmon Treaty (PST):
 - (a) the U.S. government's relinquishment of regulatory control to the bilateral Fraser Panel within specified time periods and,
 - (b) the issuance of orders by the Secretary of Commerce that establish fishing times and areas consistent with the in-season implementing regulations of the U.S. Fraser River Panel. This regulatory authority has been delegated to the Regional Administrator of NMFS' West Coast Region.

NMFS is grouping these proposed Federal actions in this consultation pursuant to 50 CFR 402.14(c) because they are similar actions occurring within the same geographical area. Puget Sound non-treaty salmon fisheries and related enforcement, research, and monitoring projects

associated with fisheries other than those governed by the U.S. Fraser Panel, are included as interrelated and interdependent actions, because the state of Washington and the Puget Sound treaty tribes have submitted a joint proposal for management of the 2017-18 Puget Sound salmon fisheries, as provided under the Puget Sound Salmon Management Plan, implementation plan for *U.S. v Washington* (see 384 F. Supp. 312 (W.D. Wash. 1974)).

This opinion considers impacts of the proposed actions on the Puget Sound Chinook salmon Evolutionarily Significant Unit (ESU), the Puget Sound Steelhead Distinct Population Segment (DPS), the Southern Resident killer whale DPS, and two listed Puget Sound rockfish DPSs under the ESA. Other listed species occurring in the action area are either covered under existing, long-term ESA opinions or 4(d) determinations as shown in Table 1, or NMFS has determined that the proposed actions are not likely to adversely affect the species (Section 2.12).

1.1 Consultation History

On July 10, 2000, NMFS issued the ESA 4(d) Rule establishing take prohibitions for 14 threatened salmon ESUs and steelhead DPSs, including the Puget Sound Chinook Salmon ESU (65 Fed. Reg. 42422, July 10, 2000). The ESA 4(d) Rule provides limits on the application of the take prohibitions, i.e., take prohibitions would not apply to the plans and activities set out in the rule if those plans and activities met the rule's criteria. One of those limits (Limit 6, 50 CFR 223.203(b)(6)) applies to joint tribal and state resource management plans. In 2005, as part of the final listing determinations for 16 ESUs of West Coast salmon, NMFS amended and streamlined the previously promulgated 4(d) protective regulations for threatened salmon and steelhead (70 Fed. Reg. 37160, June 28, 2005). Under these regulations, the same set of 14 limits was applied to all threatened Pacific salmon and steelhead ESUs or DPSs. As a result of the Federal listing of the Puget Sound Steelhead DPS in 2007 (72 Fed. Reg. 26722, May 11, 2007), NMFS applied the 4(d) protective regulations adopted for the other Pacific salmonids (70 Fed. Reg. 37160, June 28, 2005) to Puget Sound steelhead (73 Fed. Reg. 55451, September 25, 2008).

Since 2001, NMFS has received, evaluated, and approved a series of jointly developed resource management plans (RMP) from the Puget Sound Treaty Indian Tribes (PSIT) and the Washington Department of Fish and Wildlife (WDFW) (collectively the co-managers) under Limit 6 of the 4(d) Rule. These RMPs provided the framework within which the tribal and state jurisdictions jointly managed all recreational and commercial salmon fisheries, and steelhead gillnet fisheries impacting listed Chinook salmon within the greater Puget Sound area. The most recent RMP approved in 2011 expired April 30, 2014 (NMFS 2011b). The Federal actions consulted on in the associated biological opinions included NMFS' 4(d) determinations, BIA program oversight and USFWS Hood Canal Salmon Plan related actions. Since 2014, NMFS has consulted under section 7 of the ESA on single year actions by the BIA, USFWS and NMFS similar to those described above. The consultations considered the effects of Puget Sound salmon fisheries on listed species based on the general management framework described in the 2010-2014 RMP as amended for stock specific management changes. NMFS issued one-year biological opinions for the 2014, 2015 and 2016 fishery cycles (May 1, 2014 through April 30, 2017) that considered actions based on this framework including similar actions by the BIA and USFWS (NMFS 2014a, NMFS 2015b, NMFS 2016a).

NMFS previously consulted on the effects of the Puget Sound Chinook Resource Management Plan pursuant to section 4(d) of the ESA and analyzed effects to Southern Resident killer whales for fisheries from 2010 through April 2014 (NMFS 2011a), from May 2014 to April 2015 (NMFS 2014a), from May 2015 to April 2016 (NMFS 2015b), and from May 2016 to April 2017 (NMFS 2016a). In these biological opinions, NMFS concluded that the proposed fisheries were likely to adversely affect, but not likely to jeopardize the continued existence of Southern Resident killer whales (NMFS 2011a, NMFS 2014a, NMFS 2015b, NMFS 2016a). Based on our review of new available science subsequent to our 2011, 2014, 2015, and 2016 opinions, we have determined that our conclusions remain valid. We therefore incorporate by reference NMFS' previous biological opinions and NMFS' previous Southern Resident killer whale and critical habitat analyses and findings regarding the Puget Sound Chinook Resource Management Plan as well as the conclusion that the harvest was likely to adversely affect, but not likely to jeopardize the continued existence of Southern Resident killer whales (NMFS 2011a, NMFS Consultation Number: F/NWR/2010/0605; NMFS 2014a, NMFS Consultation Number: F/WCR-2014-578; NMFS 2015b, NMFS Consultation Number: F/WCR-2015-2433; NMFS 2016a, NMFS Consultation Number: F/WCR-2016-4914). We incorporate the previous analyses and findings by reference (and therefore the status, environmental baseline, effects, and conclusions), as supplemented by the information presented in this opinion. The fisheries currently proposed would only have a limited effect on Puget Sound Chinook stocks during the May 1, 2017-April 30, 2018 fishing season, and any effects during this time are not likely to be more than the effects previously considered in the previous opinions. The previous opinions incorporated the best available information at the time for the relevant sections, and in this opinion we supplement with new information available subsequent to the 2016 biological opinion.

On April 21, 2017, the BIA formally requested consultation, regarding its role in providing assistance to the Treaty Tribes and pursuant to obligations in *United States v. Washington*, on the co-manager jointly-submitted 2017-2018 Puget Sound Chinook Harvest Plan, as described in Speaks (2017). The request relies on, as its basis, the information and commitments of the 2010-2014 RMP as amended by the Summary of Modifications to Management Objectives of the 2010 Puget Sound Chinook Harvest Management Plan for the 2017-2018 Season (Unsworth and Parker 2017). The consultation request (Speaks 2017, Unsworth and Parker (2017, Appendix A) also includes an addendum related to on-going management of the late-timed fall Chinook hatchery program in the Skokomish River, anticipated impacts to Puget Sound steelhead and the specifics of several research studies.

This opinion is based on information provided in the letter from the BIA requesting consultation to NMFS and associated documents as described above (Speaks 2017), the Final Environmental Impact Statement on the 2004 Puget Sound Comprehensive Chinook Harvest Management Plan (NMFS 2004c), the Environmental Assessment on the 2017 Puget Sound Chinook Harvest Plan (Speaks 2017), discussions with Puget Sound tribal, WDFW and Northwest Indian Fisheries Commission staffs, consultations with Puget Sound treaty tribes, published and unpublished scientific information on the biology and ecology of the listed species in the action area, and other sources of information.

We have previously considered the effects of Puget Sound salmon fisheries on listed species under NMFS' jurisdiction for ESA compliance through completion of biological opinions or the ESA 4(d) Rule evaluation and determination processes. **Table 1** identifies those opinions and determinations still in effect that address impacts to salmonids species that are affected by the Puget Sound salmon fisheries considered in this opinion. In each determination listed in **Table 1**, NMFS concluded that the proposed actions were not likely to jeopardize the continued existence of any of the listed species. NMFS also concluded that the actions were not likely to destroy or adversely modify designated critical habitat for any of the listed species. The **Table 1** determinations take into account the anticipated effects of the Puget Sound salmon fisheries each year through pre-season planning and modeling. Because any impacts to the species listed in **Table 1** from the proposed actions under consultation here were accounted for and within the scope of the associated Table 1 determinations, those species are not discussed further in this opinion.

Table 1. NMFS ESA determinations regarding listed species that may be affected by Puget Sound salmon fisheries and duration of the decision (4(d) Limit or biological opinion (BO)). Only the decisions currently in effect and the listed species represented by those decisions are included.

Date (Coverage)	Duration	Citation	ESU considered
April 1999 (BO) *	until reinitiated	(NMFS 1999)	S. Oregon/N. California Coast coho Central California Coast coho Oregon Coast coho
April 2000 (BO) *	until reinitiated	(NMFS 2000a)	California Central Valley spring-run Chinook
April 2001 (4(d) Limit)	until withdrawn	(NMFS 2001a)	Hood Canal summer-run Chum
April 2001 (BO) *	until reinitiated	(NMFS 2001b)	Upper Willamette River Chinook Columbia River chum Ozette Lake sockeye Upper Columbia River spring-run Chinook Ten listed steelhead ESUs
June 13, 2005*	until reinitiated	(NMFS 2005d)	California Coastal Chinook
December 2008 (BO) (affirmed March 1996 (BO))*	until reinitiated	(NMFS 2008a)	Snake River spring/summer and fall Chinook and sockeye
April 2012 (BO)*	until reinitiated	(NMFS 2012d)	Lower Columbia River Chinook
April 9, 2015 (BO) *	until reinitiated	(NMFS 2015a)	Lower Columbia River coho

* Focus is fisheries under PFMC and US Fraser Panel jurisdiction. For ESUs and DPSs from outside the Puget Sound area, the effects assessment incorporates impacts in Puget Sound, and fisheries are managed for management objectives that include impacts that occur in Puget Sound salmon fisheries.

1.2 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 402.2). Under the MSA Essential Fish Habitat consultation, Federal Action means any action authorized funded, or undertaken, or proposed to

be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910). These actions require consultation with NMFS because Federal agencies (BIA, USFWS, NMFS) are authorizing, funding, or carrying out actions that may adversely affect listed species (section 7(a)(2) of the ESA). NMFS is grouping these three proposed Federal actions in this consultation pursuant to 50 CFR 402.14 (c) because they are similar actions occurring within the same geographical area.

A recovery plan for the Puget Sound Chinook ESU was completed in 2007. This plan is made up of two documents: a locally developed recovery plan and a NMFS-developed supplement ([Puget Sound Salmon Recovery Plan](http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/PS-Recovery-Plan.cfm) (SSPS 2007) <http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/upload/PS-Supplement.pdf>). Implementation of the proposed fisheries is intended to be consistent with the harvest management component of the recovery plan.

BIA: The BIA has requested consultation on its authority to assist with the development and implementation of the co-managers 2017-2018 Puget Sound Chinook Harvest Plan (Plan) occurring from May 1, 2017 through April 30, 2018 as reflected in BIA's April 21, 2017 request for consultation to NMFS and BIA's Environmental Assessment (Speaks 2017). The Plan encompasses the information and commitments of the 2010-2014 Puget Sound Salmon Resource Management Plan (RMP) as amended by the Summary of Modifications to Management Objectives of the 2010 Puget Sound Chinook Harvest Management Plan for the 2017-2018 Season; the 2017-2018 List of Agreed Fisheries (LOAF); an addendum related to on-going management of the late-timed fall Chinook hatchery program in the Skokomish River and several research programs. This action is similar to BIA's action for the 2016-17 fisheries, described in NMFS' 2016 biological opinion. The BIA is the lead agency on this consultation.

The Puget Sound Salmon and Steelhead Management Plan (PSSMP), which establishes guidelines for management of all marine and freshwater salmon fisheries from the Strait of Juan de Fuca eastward, was adopted by court order as a sub-proceeding related to *U.S. v. Washington*, Civ. No. C70-9213 (W.D. Wash.) (see 384 F. Supp. 312 (W.D. Wash. 1974)). This opinion focuses on Puget Sound salmon and steelhead fisheries managed in accordance with the PSSMP that may impact listed species under NMFS' jurisdiction from May 1, 2017 through April 30, 2018. More detailed information about the fisheries and associated conservation objectives proposed to occur during this period are included in the documents provided in the consultation request as described in Section 1.2 above.

USFWS:

The USFWS proposes to authorize fisheries that are consistent with the implementation of the Hood Canal Salmon Management Plan (HCSMP 1985) from May 1, 2017 through April 30, 2018. The USFWS, along with the State of Washington and the treaty tribes within the Hood Canal, is party to the HCSMP which is a regional plan and stipulated order related to the PSSMP. The state, tribal, and federal parties to the Hood Canal Plan establish management

objectives for stocks originating in Hood Canal including listed Chinook and summer-run chum stocks. Any change in management objectives under the HCSMP requires authorization by the USFWS, as a party to the plan. Management under the HCSMP affects those fisheries where Hood Canal salmon stocks are caught. This opinion focuses on Puget Sound salmon and steelhead fisheries that may impact listed species under NMFS' jurisdiction from May 1, 2017 through April 30, 2018 (see Speaks 2017 for fisheries proposed to occur during this period).

NMFS:

The Fraser Panel controls sockeye and pink fisheries conducted in the Strait of Juan de Fuca and San Juan Island regions in the U.S., the southern Georgia Strait in the U.S. and Canada, and the Fraser River in Canada, and certain high seas and territorial waters westward from the western coasts of Canada and the U.S. between 48 and 49 degrees N. latitude. The Fraser Panel assumes control from July 1 through September, although the exact date depends on the fishing schedule in each year. Fisheries in recent years have occurred in late July into August in non-pink salmon years and into September in pink years. These fisheries are commercial and subsistence net fisheries using gillnet, reef net, and purse seine gear to conduct fisheries targeted on Fraser River-origin sockeye and, in odd-numbered years (e.g., 2013, 2015), pink salmon. Other salmon species are caught incidentally in these fisheries. The U.S. Fraser Panel fisheries are managed in-season to meet the objectives described in Chapter 4 of the PST (the Fraser Annex). The season structure and catches are modified in-season in response to changes in projected salmon abundance, fishing effort or environmental conditions in order to assure achievement of the management objectives, and in consideration of safety concerns. U.S. Fraser Panel fisheries are also managed together with the suite of other Puget Sound and Pacific Fisheries Management Council (PFMC) fisheries to meet conservation and harvest management objectives for Chinook, coho, and chum salmon.

Two Federal actions will be taken during the 2017 fishing season (May 1, 2017 – April 30, 2018) to allow the Fraser Panel to manage Fraser River sockeye and pink fisheries in Fraser Panel Waters. One action grants regulatory control of the Fraser Panel Area Waters by the U.S. and Canadian governments to the Panel for in-season management. The other action is the issuance of in-season orders by NMFS that give effect to Fraser Panel actions in the U.S. portion of the Fraser Panel Area. The Pacific Salmon Treaty Act of 1985 (16 U.S.C. 3631 et seq.) grants to the Secretary of Commerce authority to issue regulations implementing the Pacific Salmon Treaty. Implementing regulations at 50 CFR 300.97 authorize the Secretary to issue orders that establish fishing times and areas consistent with the annual Pacific Salmon Commission regime and in-season orders of the Fraser River Panel. This authority has been delegated to the Regional Administrator of NMFS' West Coast Region.

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). Puget Sound non-treaty salmon fisheries and related enforcement, research and monitoring projects associated with fisheries other than those governed by the U.S. Fraser Panel, are included as interrelated and interdependent actions, because the state of Washington and the Puget Sound treaty tribes have submitted a joint

proposal for management of the 2017-2018 Puget Sound salmon fisheries, as provided under the Puget Sound Salmon Management Plan, implementation plan for *U.S. v Washington* (see 384 F. Supp. 312 (W.D. Wash. 1974)). (50 CFR 402.02).

2 ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

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

This opinion considers impacts of the proposed actions under the ESA on the Puget Sound Chinook salmon ESU, the Puget Sound Steelhead DPS, the Southern Resident killer whale DPS, and the Puget Sound/Georgia Basin bocaccio and yelloweye rockfish DPSs. The NMFS concluded that the proposed actions are not likely to adversely affect southern green sturgeon, southern eulachon, or their critical habitat. Those findings are documented in the "Not Likely to Adversely Affect" Determinations section (2.11).

2.1 Analytical Approach

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

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

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

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

- *Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.* Section 2.2 describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. For listed salmon and steelhead, NMFS has developed specific guidance for analyzing the status of the listed species' component populations in a "viable salmonid populations" paper (VSP; McElhany et al. 2000). Similar criteria are used to analyze the status of ESA-listed rockfish because these parameters are applicable for a wide variety of species. The VSP approach considers the abundance, productivity, spatial structure, and diversity of each population as part of the overall review of a species' status. For listed salmon and steelhead, the VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" (50 CFR 402.02). In describing the rangewide status of listed species, we rely on viability assessments and criteria in technical recovery team documents and recovery plans, and other information where available, that describe how VSP criteria are applied to specific populations, major population groups, and species. We determine the rangewide status of critical habitat by examining the condition of its physical or biological features (also called "primary constituent elements" or PBFs in some designations) which were identified when the critical habitat was designated.
- *Describe the environmental baseline in the action area.* The environmental baseline (Section 2.3) includes the past and present impacts of Federal, state, or private actions and other human activities in the action area. It includes the anticipated impacts of proposed Federal projects that have already undergone formal or early section 7 consultation and the impacts of state or private actions that are contemporaneous with the consultation in process.
- *Analyze the effects of the proposed action on both species and their habitat using an "exposure-response-risk" approach.* In this step (Section 2.4), NMFS considers how the proposed action would affect the species' reproduction, numbers, and distribution or, in the case of salmon and steelhead, their VSP and other relevant characteristics. NMFS also evaluates the proposed action's effects on critical habitat features.
- *Describe any cumulative effects in the action area.* Cumulative effects (Section 2.5), as defined in our implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.
- *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. (Section 2.6).
- *Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.* These conclusions (Section 2.7) flow from the logic and rationale presented in

the Integration and Synthesis section (2.6).

- *If necessary, define a reasonable and prudent alternative to the proposed action.* If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat, we must identify a reasonable and prudent alternative (RPA) to the action in Section 2.8. The RPA must not be likely to jeopardize the continued existence of listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

2.2 Range-wide Status of the Species and Critical Habitat

This opinion examines the status of each species that would be affected by the proposed actions. 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, listing decisions, and other relevant information. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the essential physical and biological features that help to form that conservation value.

2.2.1 Status of Listed Species

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

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

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

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

“Productivity,” as applied to viability factors, refers to the entire life cycle or portions of a life cycle; i.e., the number of progeny or 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, guidance documents from technical recovery teams and regional guidance. 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).

One factor affecting the status of salmonids and Puget Sound rockfish, and aquatic habitat at large, is climate change. The following section describes climate change and other ecosystem effects on Puget Sound Chinook salmon and steelhead. It precedes the status discussion of these species because it applies to both. A similar discussion for listed Puget Sound rockfish is included in the status discussion on those species. Climate change effects on Southern Resident killer whales are incorporated by reference in the status discussion on that species and primarily address how it is anticipated to affect its primary prey species, salmon.

Climate change and other ecosystem effects

One factor affecting the rangewide status of listed Puget Sound salmon and steelhead, and aquatic habitat at large is climate change. Changes in climate and ocean conditions happen on several different time scales and have had a profound influence on distributions and abundances of marine and anadromous fishes. Salmon and steelhead throughout Washington are also likely affected by climate change. Several studies have revealed that climate change has the potential to affect ecosystems in nearly all tributaries throughout the state (Battin et al. 2007; ISAB 2007). While the intensity of effects will vary by region (ISAB 2007), climate change is generally expected to alter aquatic habitat (water yield, peak flows, and stream temperature). As climate change alters the structure and distribution of rainfall, snowpack, and glaciations, each factor will in turn alter riverine hydrographs. Given the increasing certainty that climate change is occurring and is accelerating (Battin et al. 2007), NMFS anticipates salmonid habitats will be affected and this in turn is likely to affect the distribution and productivity of salmon populations in the region (Beechie et al. 2006). Climate and hydrology models project significant reductions in both total snow pack and low-elevation snow pack in the Pacific Northwest over the next 50 years (Mote and Salathé 2009)—changes that will shrink the extent of the snowmelt-dominated habitat available to salmon. Such changes may restrict our ability to conserve diverse salmon and steelhead life histories and make recovery targets for these salmon populations more difficult to achieve.

In Washington State, most models project warmer air temperatures, increases in winter precipitation, and decreases in summer precipitation. Average temperatures in Washington State are likely to increase 0.1-0.6°C per decade (Mote and Salathé 2009). Warmer air temperatures will lead to more precipitation falling as rain rather than snow. As the snow pack diminishes, seasonal hydrology will shift to more frequent and severe early large storms, changing stream flow timing and increasing peak river flows, which may limit salmon survival (Mantua et al. 2009). The largest driver of climate-induced decline in salmon and steelhead populations is projected to be the impact of increased winter peak flows, which scour the streambed and destroy salmonid eggs (Battin et al. 2007, Mantua et al. 2009).

Higher water temperatures and lower spawning flows, together with increased magnitude of winter peak flows are all likely to increase salmonid mortality. Higher ambient air temperatures will likely cause water temperatures to rise (ISAB 2007). Salmonids require cold water for spawning and incubation. As climate change progresses and stream temperatures warm, thermal refugia will be essential to persistence of many salmonid populations. Thermal refugia are important for providing salmonids with patches of suitable habitat while allowing them to undertake migrations through or to make foraging forays into areas with greater than optimal temperatures. To avoid waters above summer maximum temperatures, juvenile rearing may be increasingly found only in the confluence of colder tributaries or other areas of cold water refugia (Mantua et al. 2009). Summer steelhead stocks within the Puget Sound DPS may be more vulnerable to climate change since there are few summer run populations that reside in the DPS as compared to winter run populations, they exhibit relatively small abundances, and they occupy limited upper river tributary habitat.

In marine habitat, scientists are not certain of all the factors impacting steelhead survival but several ocean-climate events are linked with fluctuations in steelhead health and abundance such as El Niño/La Niña, the Aleutian Low, and coastal upwelling (Pearcy and Mantua 1999). Steelhead, along with Chinook and coho salmon, have experienced tenfold declines in survival during the marine phase of their lifecycle, and their total abundance remains well below what it was 30 years ago (LLTK 2015). The marine survival of coastal steelhead, as well as Columbia River Chinook and coho, do not exhibit the same declining trend as the Salish Sea populations. Specifically, marine survival rates for steelhead in Washington State have declined in the last 25 years with the Puget Sound steelhead populations declining to a greater extent than other regions (i.e., Washington Coast and Lower Columbia River) and are at near historic lows (Moore et al. 2014). Climate changes have included increasing water temperatures, increasing acidity, more harmful algae, the loss of forage fish and some marine commercial fishes, changes in marine plants, increased populations of seals and porpoises, etc. (LLTK 2015). Climate change plays a part in steelhead mortality but more studies are being conducted to determine the specific causes of this marine survival decline in Puget Sound.

NWFSC (2015) recently reported that climate conditions affecting Puget Sound salmonids were not optimistic; recent and unfavorable environmental trends are expected to continue. A positive

pattern in the Pacific Decadal Oscillation¹ is anticipated to continue. This and other similar environmental indicators suggest the continuation of warming ocean temperatures; fragmented or degraded freshwater spawning and rearing habitat; reduced snowpack; altered hydrographs producing reduced summer river flows and warmer water; and low marine survival for salmonids in the Salish Sea (NWFSC 2015). Specifically, the exceptionally warm marine water conditions in 2014 and 2015 combined with warm freshwater stream temperatures lowered steelhead marine and freshwater survival (NWFSC 2015). Any rebound in VSP parameters for Puget Sound steelhead are likely to be constrained under these conditions (NWFSC 2015).

Variation in fish populations in Puget Sound may reflect broad-scale shifts in natural limiting conditions, such as predator abundances and food resources in ocean rearing areas. NMFS has noted that predation by marine mammals has increased as marine mammal numbers, especially harbor seals (*Phoca vitulina*) and California sea lions (*Zalophus californianus*) increase on the Pacific Coast (Myers et al. 1998; Jeffries et al. 2003; Pitcher et al. 2007; DFO 2010; Jeffries 2011, Chasco et al. 2017). In addition to predation by marine mammals, Fresh (1997) reported that 33 fish species and 13 bird species are predators of juvenile and adult salmon, particularly during freshwater rearing and migration stages.

2.2.1.1 Status of Puget Sound Chinook

This ESU was listed as a threatened species in 1999; its threatened status was reaffirmed June 28, 2005 (70 FR 37160). The NMFS issued results of a five-year review on May 26, 2016 (81 FR 33469), and concluded that this species should remain listed as threatened. As part of the review, NOAA's Northwest Fisheries Science Center evaluated the viability of the listed species undergoing 5-year reviews and issued a status review update providing updated information and analysis of the biological status of the listed species (NWFSC 2015). The status review incorporated the findings of the Science Center's report, summarized new information concerning the delineation of the ESU and inclusion of closely related salmonid hatchery programs, and included an evaluation of the listing factors (NMFS 2017a). Where possible, particularly as new material becomes available, the status review information is supplemented with more recent information and other population specific data that may not have been considered during the status review so that NMFS is assured of using the best available information.

The NMFS adopted the recovery plan for Puget Sound Chinook on January 19, 2007 (72 FR 2493). The recovery plan consists of two documents: the Puget Sound Salmon Recovery Plan prepared by the Shared Strategy for Puget Sound and NMFS' Final Supplement to the Shared Strategy Plan. The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Ruckelshaus et al. 2002). The PSTRT's Biological Recovery Criteria will be met when the following conditions are achieved:

1. All watersheds improve from current conditions, resulting in improved status for the species;

¹ A positive pattern in the PDO has been in place since 2014.

2. At least two to four Chinook salmon populations in each of the five biogeographical regions of Puget Sound attain a low risk status over the long-term²;
3. At least one or more populations from major diversity groups historically present in each of the five Puget Sound regions attain a low risk status;
4. Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario;
5. Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery.

Spatial Structure and Diversity

The PSTRT determined that 22 historical populations currently contain Chinook salmon and grouped them into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity (**Figure 2**). Based on genetic and historical evidence reported in the literature, the PSTRT also determined that there were 16 additional spawning aggregations or populations in the Puget Sound Chinook Salmon ESU that are now putatively extinct³ (Ruckelhaus et al. 2006). This ESU includes all naturally spawned Chinook salmon originating from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound and the Strait of Georgia. Also, Chinook salmon from 26 artificial propagation programs: the 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 (79 FR 20802).

Three of the five regions (Strait of Juan de Fuca, Georgia Basin, and Hood Canal) contain only two populations, both of which must be recovered to viability to recover the ESU (NMFS 2006c). Under the Puget Sound Salmon Recovery Plan, the Suiattle and one each of the early, moderately early, and late run-timing populations in the Whidbey Basin Region, as well as the

² The number of populations required depends on the number of diversity groups in the region. For example, three of the regions only have two populations generally of one diversity type; the Central Sound Region has two major diversity groups; the Whidbey/Main Region has four major diversity groups.

³ It was not possible in most cases to determine whether these Chinook salmon spawning groups historically represented independent populations or were distinct spawning aggregations within larger populations.

White and Nisqually (or other late-timed) populations in the Central/South Sound Region must also achieve viability (NMFS 2006c). The TRT did not define the relative roles of the remaining populations in the Whidbey and Central/South Sound Basins to ESU viability.

Table 2. Extant PS Chinook salmon populations in each geographic region (Ruckelshaus et al. 2006).

Geographic Region	Population (Watershed)
Strait of Georgia	North Fork Nooksack River
	South Fork Nooksack River
Strait of Juan de Fuca	Elwha River
	Dungeness River
Hood Canal	Skokomish River
	Mid Hood Canal River
Whidbey Basin	Skykomish River (late)
	Snoqualmie River (late)
	North Fork Stillaguamish River (early)
	South Fork Stillaguamish River (moderately early)
	Upper Skagit River (moderately early)
	Lower Skagit River (late)
	Upper Sauk River (early)
	Lower Sauk River (moderately early)
	Suiattle River (very early)
	Cascade River (moderately early)
Central/South Puget Sound Basin	Cedar River
	North Lake Washington/ Sammamish River
	Green/Duwamish River
	Puyallup River
	White River
	Nisqually River

NOTE: NMFS has determined that the bolded populations in particular are essential to recovery of the Puget Sound ESU. In addition, at least one other population within the Whidbey Basin and Central/South Puget Sound Basin regions would need to be viable for recovery of the ESU. The PSTRT noted that the Nisqually watershed is in comparatively good condition, and thus the certainty that the population could be recovered is among the highest in the Central/South Region. NMFS concluded in its supplement to the Puget Sound Salmon Recovery Plan that protecting the existing habitat and working toward a viable population in the Nisqually watershed would help to buffer the entire region against further risk (NMFS 2006c).

Therefore, NMFS developed additional guidance which considers distinctions in genetic legacy and watershed condition among other factors in assessing the risks to survival and recovery of the listed species by the proposed actions across all populations within the Puget Sound Chinook ESU. In doing so it is important to take into account whether the genetic legacy of the population

is intact or if it is no longer distinct. Populations are defined by their relative isolation from each other, and by the unique genetic characteristics that evolve as a result of that isolation to adapt to their specific habitats. If these are populations that still retain their historic genetic legacy, then the appropriate course to insure their survival and recovery is to preserve that genetic legacy and rebuild those populations. Preserving that legacy requires both a sense of urgency and the actions necessary and appropriate to preserve the legacy that remains. However, if the genetic legacy is gone, then the appropriate course is to recover the populations using the individuals that best approximate the genetic legacy of the original population, reduce the effects of the factors that have limited their production, and provide the opportunity for them to readapt to the existing conditions.

In keeping with this approach, NMFS further classified Puget Sound Chinook populations into three tiers based on a systematic framework that considers the population's life history and production and watershed characteristics (Puget Sound Domain Team 2010) (**Figure 1**). This framework, termed the *Population Recovery Approach*, carries forward the biological viability and delisting criteria described in the Supplement to the Puget Sound Salmon Recovery Plan

(Ruckelshaus et al. 2002, NMFS 2006c). The assigned tier indicates the relative role of each of the 22 populations comprising the ESU to the viability of the ESU and its recovery. Tier 1 populations are most important for preservation, restoration, and ESU recovery. Tier 2 populations play a less important role in recovery of the ESU. Tier 3 populations play the least important role. When we analyze proposed actions, we evaluate impacts at the individual population scale for their effects on the viability of the ESU. We expect

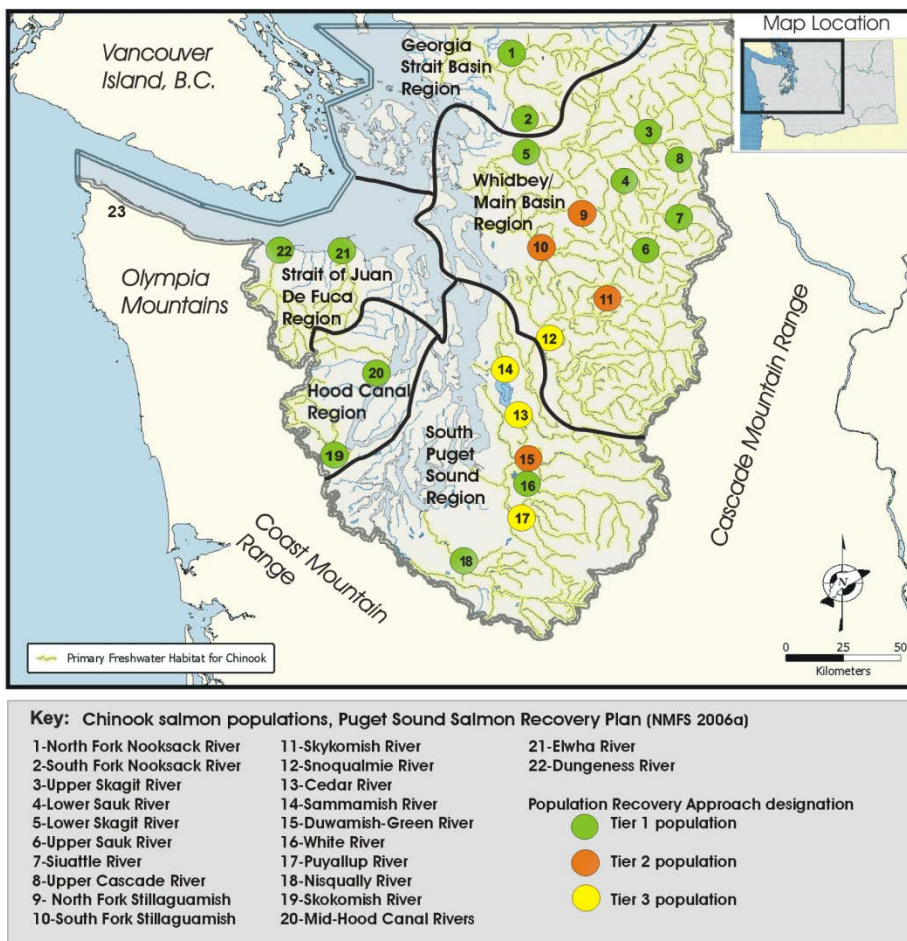


Figure 1. Puget Sound Chinook populations

that impacts to Tier 1 populations would be more likely to affect the viability of the ESU as a whole than similar impacts to Tier 2 or 3 populations, because of the relatively greater importance of Tier 1 populations to overall ESU viability. NMFS has incorporated this and similar approaches in previous ESA section 4(d) determinations and opinions on Puget Sound salmon fisheries and regional recovery planning (NMFS 2005b, 2005c, 2008a, 2008e, 2010a, 2011b, 2013b, 2014a, 2015c, 2016b).

Indices of spatial distribution and diversity have not been developed at the population level, though diversity at the ESU level is declining. Abundance is becoming more concentrated in fewer populations and regions within the ESU. The Whidbey Basin Region is the only region with consistently high fraction natural-origin spawner abundance, in six of the 10 populations within the Region. All other regions have moderate to high proportions of hatchery-origin spawners (**Table 3**).

In general, the Strait of Juan de Fuca, Georgia Basin, and Hood Canal regions are at greater risk than the other regions due to critically low natural abundance and/or declining growth rates of the populations in these regions. In addition, spatial structure, or geographic distribution, of the White, Skagit, Elwha and Skokomish populations has been substantially reduced or impeded by the loss of access to the upper portions of those tributary basins due to flood control activities and hydropower development. Habitat conditions conducive to salmon survival in most other watersheds have been reduced significantly by the effects of land use, including urbanization, forestry, agriculture, and development (NMFS 2005a; 2006a; 2008b; 2008c; SSPS 2007). It is likely that genetic diversity has also been reduced by this habitat loss.

Abundance and Productivity

Most Puget Sound Chinook populations are well below escapement levels identified as required for recovery to low extinction risk (**Table 3**). All populations are consistently below productivity goals identified in the recovery plan (**Table 3**). Although trends vary for individual populations across the ESU, most populations exhibit a stable or increasing trend in natural escapement (**Table 4**). However, natural-origin abundance across the Puget Sound ESU has generally decreased since the last status review, with only 6 of 22 populations (Cascade, Suiattle and Upper Sauk, Cedar, Mid-Hood Canal, Nisqually) showing a positive change in the 5-year geometric mean natural-origin spawner abundances since the prior status review (NWFSC 2015). While the previous status review in 2010 (Ford 2011) concluded there was no obvious trend for the total ESU, addition of the data to 2014 now does show widespread negative trends in natural-origin Chinook salmon spawner population abundances (NWFSC 2015).⁴

Natural-origin escapements for eight populations are at or below their critical thresholds⁵. Both

⁴ This is a synopsis of information provided in the recent five-year status review and supplemental data and complementary analysis from other sources. Differences in results reported in Tables 3 and 4 from those in the status review are related to the data source, method, and time period analyzed (e.g., 15 vs 25 years).

⁵ After taking into account uncertainty, the critical threshold is defined as a point below which: (1) compensatory processes are likely to reduce the population below replacement; (2) the population is at risk from inbreeding depression or fixation of deleterious mutations; or (3) productivity variation due to demographic stochasticity

populations in three of the five biogeographical regions are below or near their critical threshold: Georgia Strait, Hood Canal and Strait of Juan de Fuca (**Table 3**). When hatchery spawners are included, aggregate average escapement is over 1,000 for one of the two populations in each of these three regions. Four populations are above their rebuilding thresholds; three of them in the Whidbey/Main Basin Region.

Trends in growth rate of natural-origin escapement are generally higher than growth rate of natural-origin recruitment (i.e., abundance prior to fishing) indicating some stabilizing influence on escapement possibly from past reductions in fishing-related mortality (**Table 4**). Since 1990, nine populations show productivity above replacement for natural-origin escapement including populations in all regions. Only six populations in three of the five regions demonstrate positive growth rates in natural-origin recruitment (**Table 4**). Survival and recovery of the Puget Sound Chinook Salmon ESU will depend, over the long term, on remedial actions related to all harvest, hatchery, and habitat related activities. Many of the habitat and hatchery actions identified in the Puget Sound Salmon Recovery Plan are likely to take years or decades to be implemented and to produce significant improvements in natural population attributes, and current trends are consistent with these expectations (NWFSC 2015).

becomes a substantial source of risk (NMFS 2000b). The rebuilding threshold is defined as the escapement that will achieve Maximum Sustainable Yield (MSY) under current environmental and habitat conditions (NMFS 2000b). Thresholds were based on population-specific data where available.

Table 3. Estimates of escapement and productivity (recruits/spawner) for Puget Sound Chinook populations. Natural origin escapement information is provided where available. Populations below their critical escapement threshold are **bolded**. For several populations, hatchery contribution to natural spawning data are limited or unavailable.

Region	Population	1999 to 2015 Geometric mean Escapement (Spawners)		NMFS Escapement Thresholds		Recovery Planning Abundance Target in Spawners (productivity) ²	Average % hatchery fish in escapement 1999- 2015 (min-max) ⁵
		Natural ¹	Natural-Origin (Productivity) ²	Critical ³	Rebuilding ⁴		
Georgia Basin	Nooksack MU	2,233	262	400	500		
	NF Nooksack	1,804	205 ⁸ (0.4)	200 ⁶	-	3,800 (3.4)	85 (63-94)
	SF Nooksack	61	43 ⁸ (1.0)	200 ⁶	-	2,000 (3.6)	85 (62-96)
Whidbey/Main Basin	Skagit Summer/Fall MU						
	Upper Skagit River	10,167	8,887 ⁸ (1.7)	967	7,454	5,380 (3.8)	3 (1-8)
	Lower Sauk River	620	588 ⁸ (1.5)	200 ⁶	681	1,400 (3.0)	1 (0-10)
	Lower Skagit River	2,276	2,046 ⁸ (1.6)	251	2,182	3,900 (3.0)	4 (2-8)
	Skagit Spring MU						
	Upper Sauk River	655	640 ⁸ (2.4)	130	330	750 (3.0)	2 (0-5)
	Suiattle River	373	365 ⁸ (2.0)	170	400	160 (3.2)	2 (0-7)
	Upper Cascade River	326	294 ⁸ (1.5)	170	1,250 ⁶	290 (3.0)	10 (0-50)
	Stillaguamish MU						
	NF Stillaguamish R.	1,227	644 (0.8)	300	550	4,000 (3.4)	37 (8-62)
	SF Stillaguamish R.	151	146 (1.1)	200 ⁶	300	3,600 (3.3)	6 (0-39)
	Snohomish MU						
Central/South Sound	Skykomish River	3,338	1,944 ⁸ (1.3)	1,650	3,500	8,700 (3.4)	35 (15-62)
	Snoqualmie River	1,524	1,088 ⁸ (1.3)	400	1,250 ⁶	5,500 (3.6)	20 (8-35)
	Cedar River	882	816 ⁸ (1.9)	200 ⁶	1,250 ⁶	2,000 (3.1)	24 (10-36)
	Sammamish River	1,159	184 ⁸ (0.7)	200 ⁶	1,250 ⁶	1,000 (3.0)	84 (66-95)
	Duwamish-Green R.	3,591	1,235 ⁸ (1.0)	835	5,523	-	55 (20-79)
	White River ⁹	1,223	515 ⁸ (0.8)	200 ⁶	1,100 ⁷	-	53 (27-87)
	Puyallup River ¹⁰	1,596	747 ⁸ (1.1)	200 ⁶	522 ⁷	5,300 (2.3)	48 (18-76)
Hood Canal	Nisqually River	1,641	526 ⁸ (1.6)	200 ⁶	1,200 ⁷	3,400 (3.0)	69 (53-85)
	Skokomish River	1,223	317 (0.9)	452	1,160	-	67 (7-95)
Strait of Juan de Fuca	Mid-Hood Canal Rivers ¹¹	179		200 ⁶	1,250 ⁶	1,300 (3.0)	48 (5-90)
	Dungeness River	350	103 ⁸ (0.6)	200 ⁶	925 ⁷	1,200 (3.0)	69 (39-96)
	Elwha River ¹²	1,521	116 ⁸	200 ⁶	1,250 ⁶	6,900 (4.6)	90 (82-98)

¹ Includes naturally spawning hatchery fish.

² Source productivity is Abundance and Productivity Tables from NWFSC database; measured as the mean of observed recruits/observed spawners. Sammamish productivity estimate has not been revised to include Issaquah Creek. Source for Recovery Planning productivity target is the final supplement to the Puget Sound Salmon Recovery Plan (NMFS 2006a); measured as recruits/spawner associated with the number of spawners at Maximum Sustained Yield under recovered conditions.

³ Critical natural-origin escapement thresholds under current habitat and environmental conditions (McElhaney et al. 2000; NMFS 2000b).

⁴ Rebuilding natural-origin escapement thresholds under current habitat and environmental conditions (McElhaney et al. 2000; NMFS 2000b).

⁵ Estimates of the fraction of hatchery fish in natural spawning escapements are from the Abundance and Productivity Tables and co-manager postseason reports on the Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2013, WDFW and PSTIT 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2014, 2015, 2016) and the 2010-2014 Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2010a).

⁶ Based on generic VSP guidance (McElhaney et al. 2000; NMFS 2000b).

⁷ Based on alternative habitat assessment.

⁸ Estimates of natural-origin escapement for Nooksack available only for 1999-2015, Skagit springs, Skagit falls and Skokomish available only for 1999-2015; Snohomish for 1999-2001 and 2005-2015; Lake Washington for 2003-2015; White River 2005-2015; Puyallup for 2002-2015; Nisqually for 2005-2015; Dungeness for 2001-2015; Elwha for 2010-2015.

⁹ Captive broodstock program for early run Chinook salmon ended in 2000; estimates of natural spawning escapement include an unknown fraction of naturally spawning hatchery-origin fish from late- and early run hatchery programs in the White and Puyallup River basins.

¹⁰ South Prairie index area provides a more accurate trend in the escapement for the Puyallup River because it is the only area in the Puyallup River for which spawners or redds can be consistently counted (PSIT and WDFW 2010a).

¹¹ The Puget Sound TRT considers Chinook salmon spawning in the Dosewallips, Duckabush, and Hamma Hamma rivers to be subpopulations of the same historically independent population; annual counts in those three streams are variable due to inconsistent visibility during spawning ground surveys. Data on the contribution of hatchery fish is very limited; primarily based on returns to the Hamma Hamma River.

¹² Estimates of natural escapement do not include volitional returns to the hatchery or those fish gaffed or seined from spawning grounds for broodstock collection.

Table 4. Long-term trends in abundance and productivity for Puget Sound Chinook populations. Long-term, reliable data series for natural-origin contribution to escapement are limited in many areas.

Region	Population	Natural Escapement Trend ¹ (1990-2015)		Growth Rate ² (1990-2013)	
		NMFS		Recruitment (Recruits)	Escapement (Spawners)
Georgia Basin	NF Nooksack (early)	1.12	increasing	1.04	1.00
	SF Nooksack (early)	1.03	stable	1.04	1.01
Whidbey/Main Basin	Upper Skagit River (moderately early)	1.02	stable	0.98	1.01
	Lower Sauk River (moderately early)	1.00	stable	0.97	0.98
	Lower Skagit River (late)	1.01	stable	0.97	0.99
	Upper Sauk River (early)	1.04	increasing	0.99	1.03
	Suiattle River (very early)	1.00	stable	0.97	1.00
	Upper Cascade River (moderately early)	1.02	increasing	0.99	1.03
	NF Stillaguamish R. (early)	1.00	stable	0.97	1.00
	SF Stillaguamish R ³ (moderately early)	0.95	declining	0.94	0.97
	Skykomish River (late)	1.00	stable	0.93	1.00
	Snoqualmie River (late)	1.00	stable	0.97	0.99
Central/South Sound	Cedar River (late)	1.04	increasing	1.02	1.04
	Sammamish River ⁴ (late)	1.01	stable	1.04	1.07
	Duwamish-Green R. (late)	0.95	declining	0.95	0.98
	White River ⁵ (early)	1.10	increasing	1.02	1.05
	Puyallup River (late)	0.97	declining	0.93	0.95
	Nisqually River (late)	1.05	increasing	0.93	1.00
Hood Canal	Skokomish River (late)	1.00	stable	0.90	0.96
	Mid-Hood Canal Rivers ³ (late)	1.03	stable	0.95	1.03
Strait of Juan de Fuca	Dungeness River (early)	1.05	stable	1.04	1.08
	Elwha River ³ (late)	1.03	stable	0.91	0.94

¹ Escapement Trend is calculated based on all spawners (i.e., including both natural origin spawners and hatchery-origin fish spawning naturally) to assess the total number of spawners passed through the fishery to the spawning ground. Directions of trends defined by statistical tests.

² Median growth rate (λ) is calculated based on natural-origin production. It is calculated assuming the reproductive success of naturally spawning hatchery fish is equivalent to that of natural-origin fish (for those populations where information on the fraction of hatchery fish in natural spawning abundance is available). Source: Abundance and Productivity Tables from NWFSC database.

³ Estimate of the fraction of hatchery fish in time series is not available for use in λ calculation, so trend represents that in hatchery-origin + natural-origin spawners.

⁴ Median growth rate estimates for Sammamish has not been revised to include escapement in Issaquah Creek.

⁵ Natural spawning escapement includes an unknown % of naturally spawning hatchery-origin fish from late- and early run hatchery programs in the White/Puyallup River basin.

Limiting factors

Limiting factors described in SSPS (2007) and reiterated in NMFS (2017a) include:

- Degraded nearshore and estuarine habitat: Residential and commercial development has reduced the amount of functioning nearshore and estuarine habitat available for salmon rearing and migration. The loss of mudflats, eelgrass meadows, and macroalgae further limits salmon foraging and rearing opportunities in nearshore and estuarine areas.
- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, impaired passage conditions and water quality have been degraded for adult spawning, embryo incubation, and rearing as a result of cumulative impacts of agriculture, forestry, and development. Some improvements have occurred over the last decade for water quality and removal of forest road barriers.
- Anadromous salmonid hatchery programs: Salmon and steelhead released from Puget Sound hatcheries operated for harvest augmentation purposes pose ecological, genetic, and demographic risks to natural-origin Chinook salmon populations. The risk to the species' persistence that may be attributable to hatchery-related effects has decreased since the last Status Review, based on hatchery risk reduction measures that have been implemented, and new scientific information regarding genetic effects noted above (NWFSC 2015). Improvements in hatchery operations associated with on-going ESA review and determination processes are expected to further reduce hatchery-related risks.
- Salmon harvest management: Total fishery exploitation rates have decreased substantially since the late 1990s when compared to years prior to listing (average reduction = -35%, range = -18 to -58%), but weak natural-origin Chinook salmon populations in Puget Sound still require enhanced protective measures to reduce the risk of overharvest. The risk to the species' persistence because of harvest remains the same since the last status review for all three species. Increased harvest from the Canadian WCVI fisheries has impacted most Puget Sound populations. Further, there is greater uncertainty associated with this threat due to shorter term harvest plans and exceedance of management objectives for some Chinook salmon populations essential to recovery.
- Concerns regarding existing regulatory mechanisms, including: lack of documentation or analysis of the effectiveness of land-use regulatory mechanisms and land-use management plans, lack of reporting and enforcement for some regulatory programs, certain Federal, state, and local land and water use decisions continue to occur without the benefit of ESA review. State and local decisions have no Federal nexus to trigger the ESA Section 7 consultation requirement, and thus certain permitting actions allow direct and indirect species take and/or adverse habitat effects.

2.2.1.2 Status of Puget Sound Steelhead

The Puget Sound steelhead Distinct Population Segment (DPS) was listed as threatened on May 11, 2007 (72 Fed. Reg. 26722). The NMFS issued results of a five-year review on May 26, 2016 (81 FR 33469), and concluded that this species should remain listed as threatened. As part of the review, NOAA's Northwest Fisheries Science Center evaluated the viability of the listed species undergoing 5-year reviews and issued a status review update providing updated information and analysis of the biological status of the listed species (NWFSC 2015). The status review

incorporated the findings of the Science Center's report, summarized new information concerning the delineation of the DPS and inclusion of closely related salmonid hatchery programs, and included an evaluation of the listing factors (NMFS 2017a). Where possible, particularly as new material becomes available, the status review information is supplemented with more recent information and other population specific data that may not have been considered during the status review so that NMFS is assured of using the best available information.

The Puget Sound steelhead populations are aggregated into three extant Major Population Groups (MPGs) containing a total of 32 Demographically Independent Populations (DIPs) based on genetic, environmental, and life history characteristics (PSSTRT 2013a). Populations can include summer steelhead only, winter steelhead only, or a combination of summer and winter run timing (e.g., winter run, summer run or summer/winter run). **Figure 2** illustrates the Puget Sound Steelhead DPS, MPGs, and DIPs for Puget Sound steelhead.

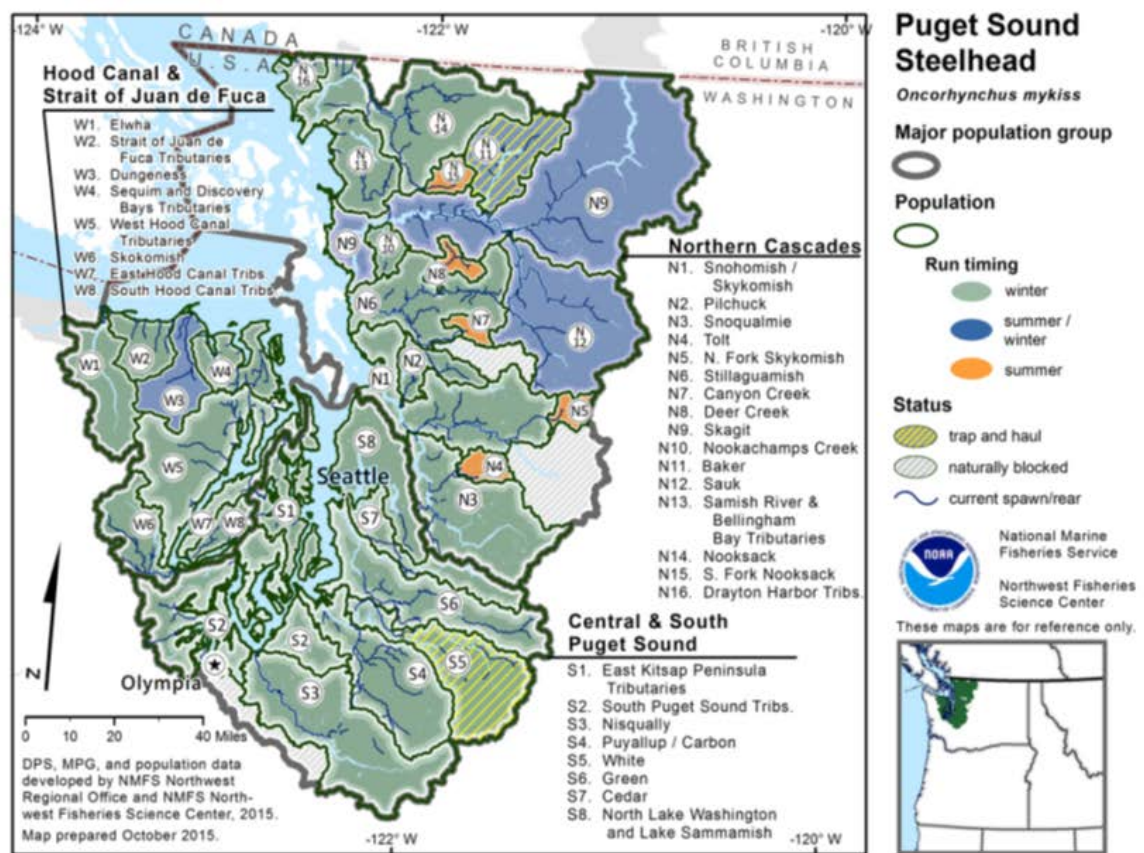


Figure 2. The Puget Sound Steelhead DPS showing MPGs and DIPs. The steelhead MPGs include the Northern Cascades, Central & Sound Puget Sound, and the Hood Canal & Strait of Juan de Fuca.

As part of the early recovery planning process, NMFS convened a technical recovery team to identify historic populations and develop viability criteria for the recovery plan. The Puget Sound Steelhead Technical Recovery Team (PSSTRT) delineated populations (DIPs) and completed a set of population viability analyses (PVAs) for these DIPs and MPGs within the DPS that are summarized in the 5-year status review and the final draft viability criteria reports (NWFSC 2015, PSSTRT 2013a, 2013b). These documents present the biological viability criteria recommended by the PSSTRT. The framework and the analysis it supports do not set targets for delisting or recovery, nor do they explicitly identify specific populations or groups of populations for recovery priority. Rather, the framework and associated analysis are meant to provide a technical foundation for those charged with recovery of listed steelhead in Puget Sound from which they can develop effective recovery plans at the watershed scale, and higher, that are based on biologically meaningful criteria (PSSTRT 2013a). For example, the PSSTRT

developed Major Population Group (MPG) and Distinct Population Segment (DPS) viability criteria for Puget Sound steelhead. For MPGs, the viability criteria includes how many steelhead Demographically Independent Populations (DIPs) must be viable in order for the MPG to be viable (**Table 5**). The DPS is considered viable only if all its component MPGs are viable (PSSTRT 2013a).

Table 5. Number of viable DIPs required for DPS viability in each of the Puget Sound steelhead MPGs.

MPG	Life History Type	Number of DIPs	Number Viable
Northern Cascades	Summer-run	5	2
	Winter-run	11	5
Central and South Puget Sound	Summer-run	0	0
	Winter-run	8	4
Hood Canal & Strait of Juan de Fuca	Summer-run	0	0
	Winter-run	8	4

NMFS is in the process of developing a long-term recovery plan with our Federal, state, tribal, local, and private partners. NMFS is planning to have a draft Puget Sound steelhead recovery plan available for public review in winter 2018 with a final plan completed in 2019. More information on the Puget Sound steelhead recovery planning process can be found online at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/puget_sound/overview_puget_sound_steelhead_recovery_2.html.

Spatial Structure and Diversity

The Puget Sound Steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) populations originating below natural and manmade impassable barriers from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound and the Strait of Georgia. Also, steelhead from six artificial propagation programs: the 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 the Lower Elwha Fish Hatchery Wild Steelhead Recovery Program. (79 Fed. Reg. 20802, April 14, 2014). Steelhead included in the listing are the anadromous form of *O. mykiss* that occur in rivers, below natural and man-made impassable barriers to migration, in northwestern Washington State. Non-anadromous “resident” *O. mykiss* occur within the range of Puget Sound steelhead but are not part of the DPS due to marked differences in physical, physiological, ecological, and behavioral characteristics (Hard et al. 2007).

The Biological Review Team (BRT) considered the major risk factors associated with spatial structure and diversity of Puget Sound steelhead to be: (1) the low abundance of several summer run populations; (2) the sharply diminishing abundance of some winter steelhead populations,

especially in south Puget Sound, Hood Canal, and the Strait of Juan de Fuca; and (3) continued releases of out-of-ESU hatchery fish from Skamania-derived summer run and Chambers Creek-derived winter run stocks (Hard et al. 2007). Loss of diversity and spatial structure were judged to be “moderate” risk factors (Hard et al. 2007).

In 2013, the PSSTRT completed its evaluation of factors that influence the diversity and spatial structure VSP criteria for steelhead in the DPS. For spatial structure, this included the fraction of intrinsic potential rearing available and spawning habitat that is occupied compared to what is needed.⁶ For diversity, these factors included hatchery fish production, contribution of resident fish to anadromous fish production, and run timing of adult steelhead. Quantitative information on spatial structure and connectivity was not available for most Puget Sound steelhead populations, so a Bayesian Network framework was used to assess the influence of these factors on steelhead viability at the population, MPG, and DPS scales (PSSTRT 2013a). The Puget Sound Steelhead Technical Recovery Team concluded that low population viability was widespread throughout the DPS and populations showed evidence of diminished spatial structure and diversity (PSSTRT 2013a). Specifically, population viability associated with spatial structure and diversity was highest in the Northern Cascades MPG and lowest in the Central and South Puget Sound MPG (**Figure 3**). Diversity was generally higher for populations within the Northern Cascades MPG, where more variability in viability was expressed and diversity generally higher, compared to populations in both the Central and South Puget Sound and Hood Canal and Strait of Juan de Fuca MPG, where diversity was depressed and viabilities were generally lower (NWFSC 2015). Most Puget Sound steelhead populations were given intermediate scores for spatial structure and low scores for diversity because of extensive hatchery influence, low breeding population sizes, and freshwater habitat fragmentation or loss (NWFSC 2015).

⁶ Where intrinsic potential is the area of habitat suitable for steelhead rearing and spawning, at least under historical conditions (PSSTRT 2013a or 2013b).

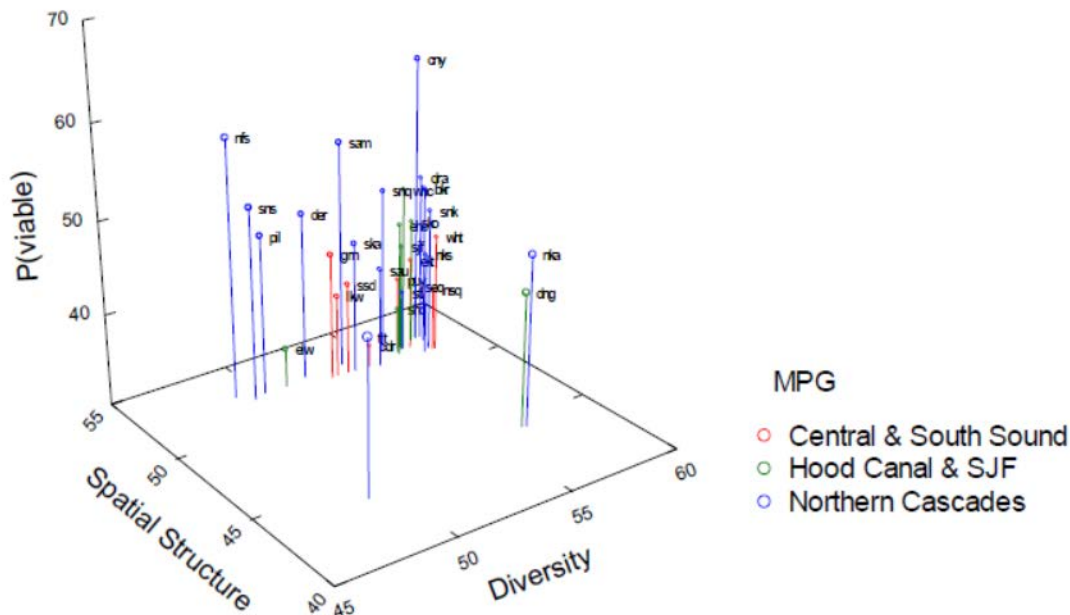


Figure 3. Scatter plot of the probabilities of viability for each of the 32 steelhead populations in the Puget Sound DPS as a function of VSP parameter estimates of influence of diversity and spatial structure on viability (PSSTRT 2013a).

Since the Technical Recovery Team completed its review of Puget Sound steelhead, the only spatial structure and diversity data that have become available have been estimates of the fraction of hatchery fish on the spawning grounds (NWFSC 2015). Hatchery production and release of hatchery smolts of both summer-run and winter-run steelhead have declined in recent years for most geographic areas within the DPS (NWFSC 2015). In addition, the fraction of hatchery steelhead spawning naturally are low for many rivers (NWFSC 2015). In recent years, production and release of hatchery steelhead for winter and summer run types has also declined for most areas of Puget Sound (NWFSC 2015). Steelhead DIPs with the highest estimated proportions of hatchery spawners are the Elwha River, Nisqually River, Puyallup River/Carbon River, and Stillaguamish River winter-run populations. For 17 DIPs across the DPS, the five-year average for the fraction of natural-origin steelhead spawners exceeded 0.75 from 2005 to 2009; this average was near 1.0 for 8 populations, where data were available, from 2010 to 2014 (NWFSC 2015). In some river systems, these estimates are higher than some guidelines recommend (e.g., no more than 5% hatchery-origin spawners on spawning grounds for isolated hatchery programs (HSRG 2009). Overall, the fraction of natural-origin steelhead spawners is 0.9 or greater for the most recent two time periods (i.e., 2005-2009 and 2010-2014) but this fraction could also not be estimated for a substantial number of DIPs especially during the 2010 to 2014 period (**Table 6**) (NWFSC 2015).

Table 6. Puget Sound steelhead 5-year mean fraction of natural-origin spawners¹ for 22 of the 32 DIPs in the DPS for which data are available (NWFSC 2015).

Run Type	DIP	Year				
		1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Winter	Cedar River					
	Green River	0.91	0.95	0.96		
	Nisqually River	0.99	1.00	0.96	0.75	
	N. Lake WA/Lake Sammamish	1.00	1.00	1.00	1.00	
	Puyallup River/Carbon River	0.93	0.89	0.82	0.86	
	White River	1.00	1.00	1.00	1.00	1.00
	Dungeness River	1.00	1.00	0.98	0.99	
	East Hood Canal Tributaries	1.00	1.00	1.00	1.00	1.00
	Elwha River	0.60	0.25			
	Sequim/Discovery Bays Tributaries					
	Skokomish River	1.00	1.00	1.00	1.00	
	South Hood Canal Tributaries	1.00	1.00	1.00	1.00	1.00
	Strait of Juan de Fuca Tributaries	1.00	1.00	1.00	1.00	1.00
	West Hood Canal Tributaries		1.00	1.00	1.00	
	Nooksack River					0.97
	Pilchuck River	1.00	1.00	1.00	1.00	1.00
	Samish River/Bellingham Bay Tributaries	1.00	1.00	1.00	1.00	1.00
	Skagit River	0.94	0.95	0.96	0.95	
	Snohomish/Skykomish Rivers	0.90	0.89	0.82	0.85	
	Snoqualmie River	1.00	1.00	1.00	1.00	1.00
	Stillaguamish River	1.00	0.88	0.75	0.81	
Summer	Tolt River	1.00	1.00	1.00	1.00	1.00

¹ The 5-year estimates represent the sum of all natural-origin spawner estimates divided by the number of estimates; blank cells indicate that no estimate is available for that 5-year range.

Early winter-run fish produced in isolated hatchery programs are derived from Chambers Creek stock in southern Puget Sound, which has been selected for early spawn timing, a trait known to be inheritable in salmonids.⁷ Summer-run fish produced in isolated hatchery programs are derived from the Skamania River summer stock in the lower Columbia River Basin (i.e., from outside the DPS). Thus, the production of hatchery fish of both run types (winter and summer) continue to pose risk to diversity in natural-origin steelhead in the DPS.

More information on Puget Sound steelhead spatial structure and diversity can be found in NMFS's Puget Sound steelhead Technical recovery Team viability report (PSSTRT 2013a) and NMFS's status review update on salmon and steelhead (NWFSC 2015).

Abundance and Productivity

The 2007 BRT considered the major risk factors associated with abundance and productivity to

⁷ The natural Chambers Creek steelhead stock is now extinct.

be: (1) widespread declines in abundance and productivity for most natural steelhead populations in the ESU, including those in Skagit and Snohomish rivers (previously considered to be strongholds); (2) the low abundance of several summer run populations; and (3) the sharply diminishing abundance of some steelhead populations, especially in south Puget Sound, Hood Canal, and the Strait of Juan de Fuca (Hard et al. 2007).

Abundance and productivity estimates have been made available in the NWFSC status review update (NWFSC 2015). Steelhead abundance estimates are available for 7 of the 11 winter-run DIPs and 1 of the 5 summer-run DIPs in the Northern Cascades MPG,⁸ 6 of the 8 winter-run DIPs in the Central and South Puget Sound MPG,⁹ and 8 of the 8 winter-run DIPs in the Hood Canal and Strait of Juan de Fuca MPG.¹⁰ Little or no data is available on summer run populations to evaluate extinction risk or abundance trends. Because of their small population size and the complexity of monitoring fish in headwater holding areas, summer steelhead have not been broadly monitored. Data were available for only one summer-run DIP, the Tolt River steelhead population in the Northern Cascades MPG. Total abundance of steelhead in these populations (**Figure 4**) has shown a generally declining trend over much of the DPS.

⁸ Nooksack River, Samish River/Bellingham Bay Tributaries, Skagit River, Pilchuck River, Snohomish/Skykomish River, Snoqualmie River, and Stillaguamish River winter-run DIPs as well as the Tolt River summer-run DIP.

⁹ Cedar River, Green River, Nisqually River, North Lake Washington/Lake Sammamish, Puyallup River/Carbon River, and White River winter-run DIPs.

¹⁰ Dungeness River, East Hood Canal Tributaries, Elwha River, Sequim/Discovery Bays Tributaries, Skokomish River, South Hood Canal Tributaries, Strait of Juan de Fuca Tributaries, and West Hood Canal Tributaries winter-run DIPs.

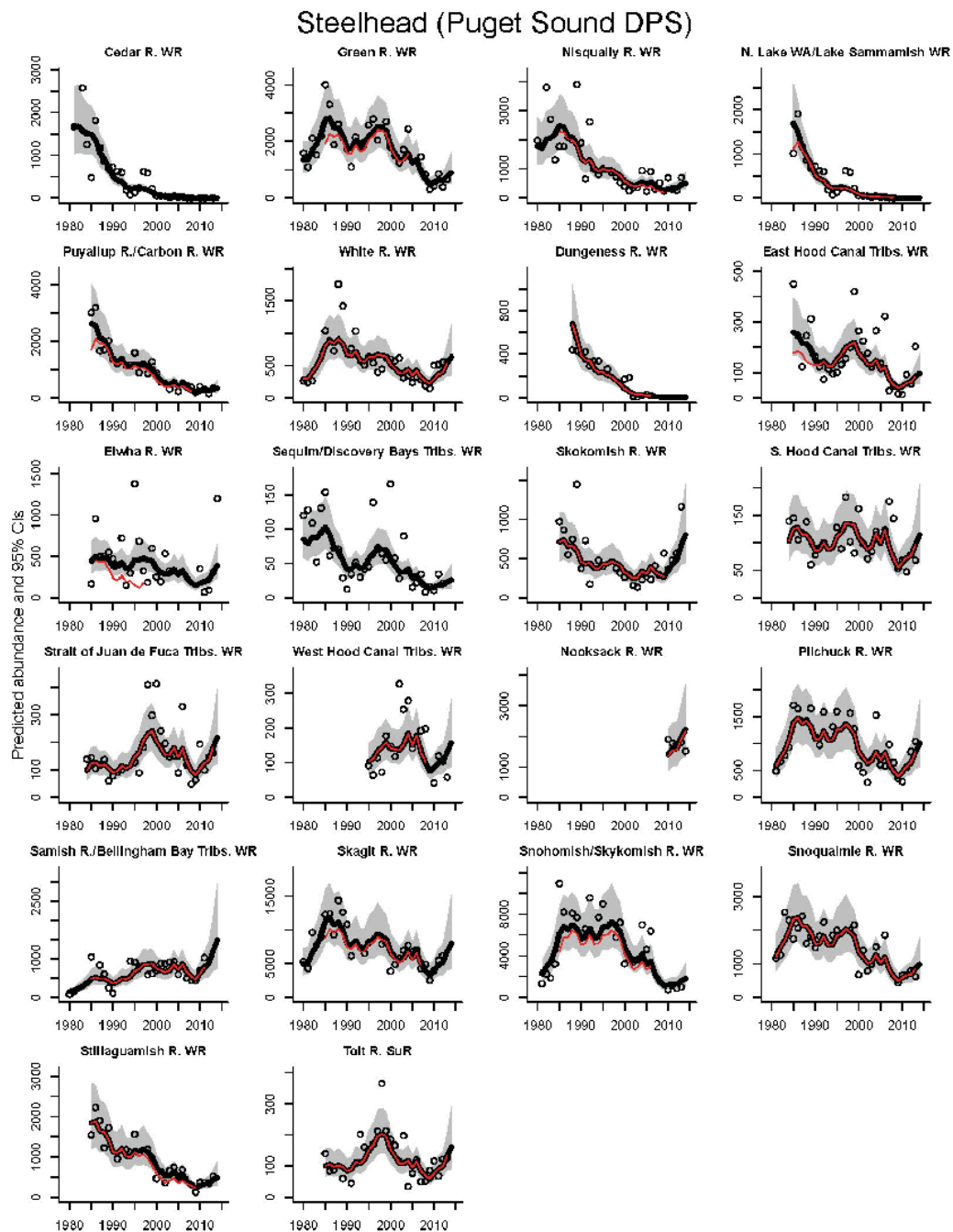


Figure 4. Trends in estimated total (black line) and natural (red line) population spawning abundance of Puget Sound steelhead. The circles represent annual raw spawning abundance data and the gray bands represent the 95% confidence intervals around the estimates.

Since 2009, 10 of the 22 populations indicate small to modest increases in abundance.¹¹ Most steelhead populations remain small. From 2010 to 2014, 8 of the 22 steelhead populations had fewer than 250 natural spawners annually, and 12 of the 22 steelhead populations had fewer than 500 natural spawners (**Table 7**).

Table 7. 5-year geometric mean of raw natural spawner counts for Puget Sound steelhead (raw total spawner counts). This is the raw total spawner count times the fraction natural estimate, if available. A value only in parentheses means that a total spawner count was available but no or only one estimate of natural spawners was available. Percent change between the most recent two 5-year periods is shown on the far right (NWFSC 2015).

MPG	Run	Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Northern Cascades	Winter	Nooksack River	--	--	--	--	1693 (1745)	--
		Pilchuck River	1225 (1225)	1465 (1465)	604 (604)	597 (597)	614 (614)	(3)
		Samish River/Bellingham Bay	316 (316)	717 (717)	852 (852)	534 (534)	846 (846)	(58)
		Skagit River	7189 (7650)	7656 (8059)	5424 (5675)	5547 (4767)	(5123)	(7)
		Snohomish/Skykomish River	6654 (7394)	6382 (7200)	3230 (3980)	4589 (5399)	(930)	(-83)
		Snoqualmie River	1831 (1831)	2056 (2056)	1020 (1020)	944 (944)	680 (680)	(-28)
		Stillaguamish River	1078 (1078)	1024 (1166)	401 (550)	259 (327)	(392)	(20)
	Summer	Tolt River	112 (112)	212 (212)	119 (119)	73 (73)	105 (105)	(44)
Central/South PS	Winter	Cedar River	(321)	(298)	(37)	(12)	(4)	(-67)
		Green River	1566 (1730)	2379 (2505)	1618 (1693)	(716)	(552)	(-23)
		Nisqually River	1201 (1208)	759 (759)	394 (413)	278 (375)	(442)	(18)
		N. Lk WA/Lk Sammamish	321 (321)	298 (298)	37 (37)	12 (12)	--	--
		Puyallup River/Carbon River	1156 (1249)	1003 (1134)	428 (527)	315 (322)	(227)	(-14)
		White River	696 (696)	519 (519)	466 (466)	225 (225)	531 (531)	(136)
Hood Canal/SJF	Winter	Dungeness River	356 (356)	--	38 (38)	24 (25)	--	--
		East Hood Canal Tribs.	110 (110)	176 (176)	202 (202)	62 (62)	60 (60)	(-3)
		Elwha River	206 (358)	127 (508)	(303)	--	(237)	--
		Sequim/Discovery Bays	(30)	(69)	(63)	(17)	(19)	(12)
		Skokomish River	503 (385)	359 (359)	259 (205)	351 (351)	(580)	(65)
		South Hood Canal Tribs.	89 (89)	111 (111)	103 (103)	113 (113)	64 (64)	(-43)
		Strait of Juan de Fuca Tribs.	89 (89)	191 (191)	212 (212)	101 (101)	147 (147)	(46)
		West Hood Canal Tribs.	--	97 (97)	210 (210)	174 (149)	(74)	(-50)

¹¹ Pilchuck River, Samish River/Bellingham Bays Tributaries, Nisqually River, White River, Sequim/Discovery Bay Tributaries, Skokomish River, , and Strait of Juan de Fuca Tributaries winter-run steelhead populations and Tolt River summer-run steelhead population with Skagit River and Stillaguamish River also showing early signs of upward trends..

Steelhead productivity has been variable for most populations since the mid-1980s. In the NWFSC status review update, natural productivity was measured as the intrinsic rate of natural increase (r), which has been well below replacement for at least six of the steelhead DIPs (NWFSC 2015). These six steelhead populations include, the Stillaguamish River winter-run in the Northern Cascade MPG, the North Lake Washington and Lake Sammamish, Puyallup River/Carbon River and Nisqually winter-run populations in the Central and South Puget Sound MPG, and the Dungeness and Elwha winter-run populations in the Hood Canal and Strait of Juan de Fuca MPG. Productivity has fluctuated around replacement for the remainder of Puget Sound steelhead populations, but the majority have predominately been below replacement since around 2000 (NWFSC 2015). Some steelhead populations are also showing signs of productivity that has been above replacement in the last two or three years (**Figure 6**). Steelhead populations with productivity estimates above replacement include the Tolt River summer-run, Pilchuck River winter-run, and Nooksack River winter-run in the Northern Cascades MPG, the White River winter-run in the Central and South Puget Sound MPG, and the East Hood Canal Tributaries and Strait of Juan de Fuca Tributaries winter-run steelhead populations in the Hood Canal and Strait of Juan de Fuca MPG.

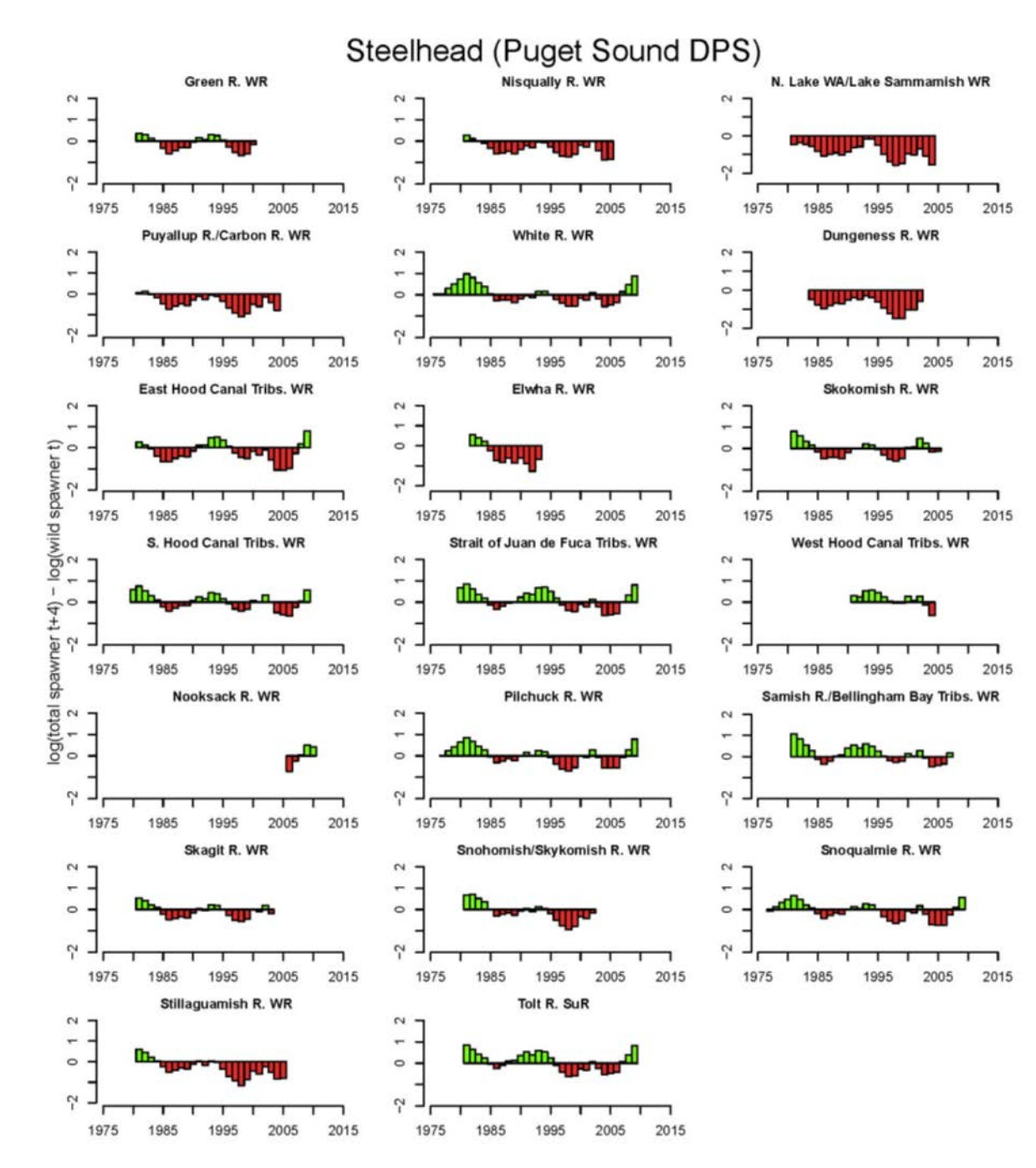


Figure 5. Trends in population productivity of Puget Sound steelhead (NWFSC 2016).

Harvest can also affect the abundance and overall productivity of Puget Sound steelhead. Since the 1970s and 1980s, harvest rates have differed greatly among various watersheds, but all harvest rates on Puget Sound steelhead in the DPS have declined (NWFSC 2015). From the late 1970s to early 1990s, harvest rates on natural-origin steelhead averaged between 10% and 40%, with some populations in central and south Puget Sound¹² at over 60% (**Figure 6**). Harvest rates on natural-origin steelhead vary widely among watersheds, but have declined since the 1970s and 1980s and are now stable and generally less than 5% (NWFSC 2015). Current harvest rates are low enough that they are unlikely to substantially reduce spawner abundance for most steelhead populations in Puget Sound (NWFSC 2015).

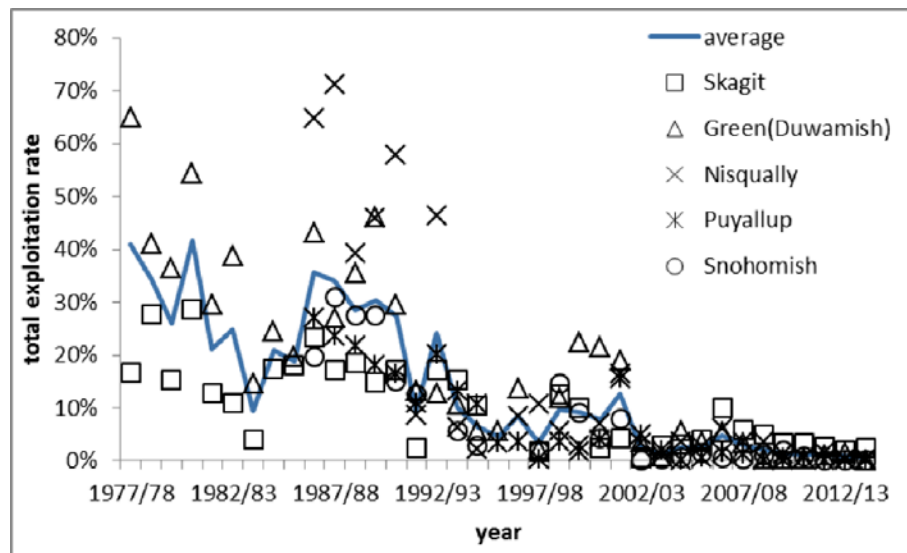


Figure 6. Total harvest rates on natural steelhead in Puget Sound Rivers (WDFW 2010 in NWFSC 2015).

Overall, the status of steelhead based on the best available data on spatial structure, diversity, abundance, and productivity has not changed since the last status review (NWFSC 2015). Recent increases in abundance observed for a few steelhead DIPs have been modest and within the range of variability observed in the past several years and trends in abundance remain predominately negative or flat over the time series examined in the recent status review update (NWFSC 2015). The production of hatchery fish of both run types (winter and summer) continues to pose risk to diversity in natural-origin steelhead in the DPS. Recent increasing estimates of productivity for a few steelhead populations are encouraging but include only one to a few years, thus, the patterns of improvement in productivity are not widespread or considered certain to continue at this time. Total harvest rates are low and are unlikely to increase substantially in the foreseeable future and are low enough that they are unlikely to substantially reduce spawner abundance for most Puget Sound steelhead populations (NWFSC 2015).

¹² Green River and Nisqually River populations.

Although the new 5-year review report has yet to be published, no change in the status or composition of the Puget Sound Steelhead DPS is anticipated.

Limiting factors

NMFS, in its listing document and designation of critical habitat (77 FR 26722, May 11, 2007; 76 FR 1392, January 10, 2011), noted that the factors for decline for Puget Sound steelhead also persist as limiting factors. Information reviewed by NWFSC 2015 did not identify any new key emergent habitat concerns for the Puget Sound steelhead DPS since the 2011 status review.

- In addition to being a factor that contributed to the present decline of Puget Sound steelhead populations, the continued destruction and modification of steelhead habitat is the principal factor limiting the viability of the Puget Sound steelhead DPS into the foreseeable future.
- A reduction in spatial structure for steelhead in the DPS.
- Reduced habitat quality through changes in river hydrology, temperature profile, downstream gravel recruitment, and reduced movement of large woody debris.
- In the lower reaches of many rivers and their tributaries in Puget Sound, urbanization has caused increased flood frequency and peak flows during storms, and reduced groundwater-driven summer flows. Altered stream hydrology has resulted in gravel scour, bank erosion, and sediment deposition.
- Dikes, hardening of banks with riprap, and channelization, which have reduced river braiding and sinuosity, have increased the likelihood of gravel scour and dislocation of rearing juveniles.
- Widespread declines in adult abundance (total run size), despite significant reductions in harvest over the last 25 years. Harvest is not as a significant limiting factor for PS steelhead due to their more limited fisheries.
- Threats to diversity posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania) inconsistent with wild stock diversity throughout the DPS. However, the risk to the species' persistence that may be attributable to hatchery-related effects has decreased since the last Status Review, based on hatchery risk reduction measures that have been implemented, and new scientific information regarding genetic effects noted above (NWFSC 2015). Improvements in hatchery operations associated with on-going ESA review and determination processes are expected to further reduce hatchery-related risks. Further, hatchery releases of PS steelhead have declined.
- Declining diversity in the DPS, including the uncertain, but likely weak, status of summer run fish in the DPS.
- Concerns regarding existing regulatory mechanisms, including: lack of documentation or analysis of the effectiveness of land-use regulatory mechanisms and land-use management plans, lack of reporting and enforcement for some regulatory programs, certain Federal, state, and local land and water use decisions continue to occur without the benefit of ESA review. State and local decisions have no Federal nexus to trigger the ESA Section 7 consultation requirement, and thus certain permitting actions allow direct and indirect species take and/or adverse habitat effects.

2.2.1.3 Status of Puget Sound/Georgia Basin Rockfish

We describe the status of each rockfish species with nomenclature referring to specific areas of the Puget Sound. The Puget Sound is the second largest estuary in the United States, located in northwest Washington State and covering an area of about 900 square miles (2,330 square km), including 2,500 miles (4,000 km) of shoreline. Puget Sound is part of a larger inland waterway, the Georgia Basin, situated between southern Vancouver Island, British Columbia, Canada and the mainland coast of Washington State. We subdivide the Puget Sound into five interconnected basins because of the presence of shallow sills: (1) the San Juan/Strait of Juan de Fuca Basin (also referred to as “North Sound”), (2) Main Basin, (3) Whidbey Basin, (4) South Sound, and (5) Hood Canal. We use the term “Puget Sound proper” to refer to all of these basins except the San Juan/Strait of Juan de Fuca Basin.

The Puget Sound/Georgia Basin DPSs of yelloweye rockfish is listed under the ESA as threatened and bocaccio are listed as endangered (75 Fed. Reg. 22276, April 28, 2010). On January 23, 2017 we issued a final rule to remove the Puget Sound/Georgia Basin canary rockfish (*Sebastes pinniger*) Distinct Population Segment (DPS) from the Federal List of Threatened and Endangered Species and remove its critical habitat designation. We also revised the yelloweye rockfish DPS area further north in the waters of Canada in Johnstone Strait. We proposed these actions based on newly obtained samples and genetic analysis. For canary rockfish the genetic information demonstrated that the Puget Sound/Georgia Basin population does not meet the DPS criteria and therefore does not qualify for listing under the Endangered Species Act (ESA). The final rule was effective March 24, 2017.

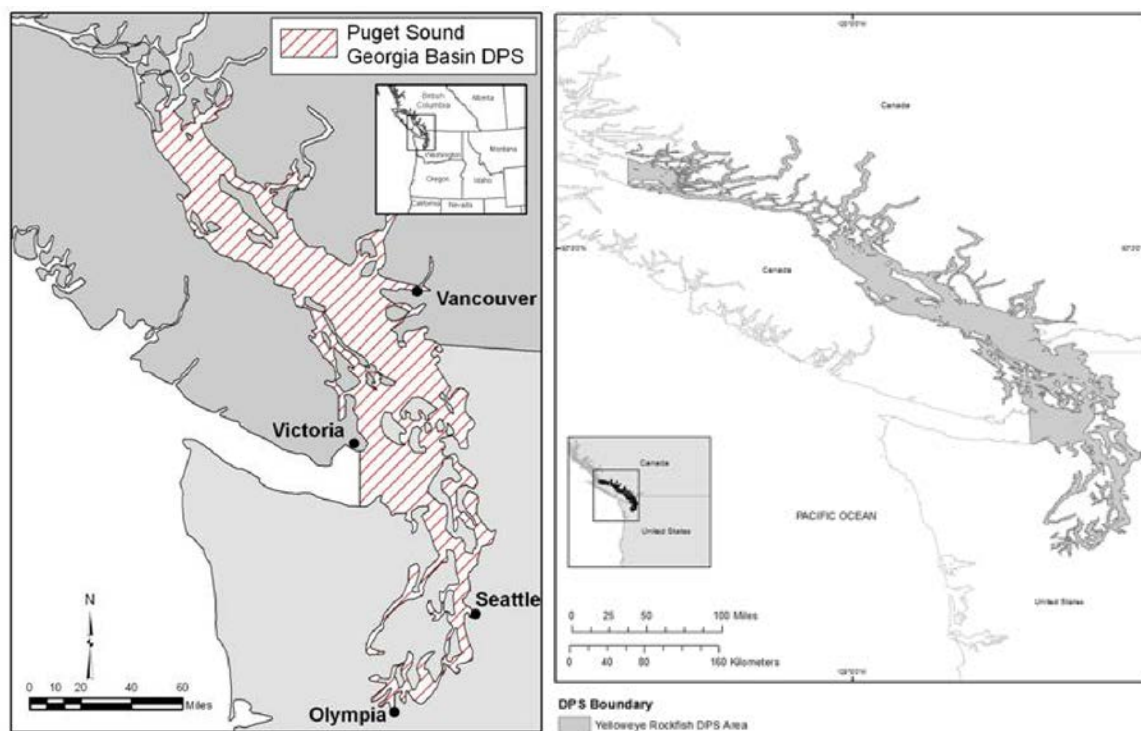


Figure 7. Bocaccio DPS (left) and yelloweye rockfish DPS (right).

The life histories of yelloweye rockfish and bocaccio include a larval/pelagic juvenile stage followed by a nearshore juvenile stage, and sub-adult and adult stages. Much of the life history and habitat use for each species is similar, with important differences noted below.

Rockfish fertilize their eggs internally and the young are extruded as larvae. Yelloweye rockfish, and bocaccio produce from several thousand to over a million eggs (Love et al. 2002). Larvae can make small local movements to pursue food immediately after birth, but are likely initially passively distributed with prevailing currents until they are large enough to progress toward preferred habitats. Larvae are observed under free-floating algae, seagrass, and detached kelp (Love et al. 2002; Shaffer et al. 1995), but are also distributed throughout the water column (Weis 2004). Unique oceanographic conditions within Puget Sound proper 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. 2010b).

When bocaccio reach sizes of 1 to 3.5 inches (3 to 9 centimeters (cm)) (approximately 3 to 6 months old), they 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). Areas with floating and submerged kelp species support the highest densities of most juvenile rockfish (Carr 1983; Halderson and Richards 1987; Hayden-Spear 2006; Matthews 1989). Unlike bocaccio, juvenile yelloweye rockfish do not typically occupy intertidal waters (Love et al. 1991; Studebaker et al. 2009), but settle in 98 to 131 feet (30 to 40 m) of water near the upper depth range of adults (Yamanaka and Lacko 2001).

Sub-adult and adult yelloweye rockfish, and 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, each species has been documented in areas of high relief rocky and non-rocky substrates such as sand, mud, and other unconsolidated sediments (Miller and Borton 1980; Washington 1977). Yelloweye rockfish remain near the bottom and have small home ranges, while some bocaccio have larger home ranges, move long distances, and spend time suspended in the water column (Love et al. 2002). Adults of each species are most commonly found between 131 to 820 feet (40 to 250 m) (Love et al. 2002; Orr et al. 2000).

Yelloweye rockfish are one of the longest-lived of the rockfishes, with some individuals reaching more than 100 years of age. They reach 50% maturity at sizes around 16 to 20 inches (40 to 50 cm) and ages of 15 to 20 years (Rosenthal et al. 1982; Yamanaka and Kronlund 1997). The maximum age of bocaccio is unknown, but may exceed 50 years, and they are first reproductively mature near age 6 (FishBase 2010).

In the following section, we summarize the condition of yelloweye rockfish and bocaccio at the DPS level according to the following demographic viability criteria: abundance and productivity, spatial structure/connectivity, and diversity. These viability criteria are outlined in McElhaney et al. (2000) and reflect concepts that are well founded in conservation biology and are generally applicable to a wide variety of species. These criteria describe demographic risks that

individually and collectively provide strong indicators of extinction risk (Drake et al. 2010b). There are several common risk factors detailed below at the introduction of each of the viability criteria for yelloweye and bocaccio. Information on species and habitat limiting factors can affect abundance, spatial structure and diversity, and are described.

Abundance and Productivity

There is no single reliable historic or contemporary population estimate for the yelloweye rockfish or bocaccio within the Puget Sound/Georgia Basin DPSs (Drake et al. 2010b). Despite this limitation, there is clear evidence each species' abundance has declined dramatically (Drake et al. 2010b). The total rockfish population in the Puget Sound region is estimated to have declined around 3% per year for the past several decades, which corresponds to an approximate 70% decline from 1965 to 2007 (Drake et al. 2010b). A survey designed to provide abundance and demographic information in Puget Sound for listed rockfish was completed in early 2017. The study, supported by NMFS and conducted by WDFW, assessed listed rockfish habitats by Remotely Operated Vehicle (ROV) in Hood Canal, the South Sound and Central Sound. The survey was designed to provide abundance estimates for listed rockfish in three habitat strata based on high, medium, and low probability of presence, and analysis of data is underway.

Catches of yelloweye rockfish, and bocaccio have declined as a proportion of the overall rockfish catch (Drake et al. 2010b; Palsson et al. 2009). Yelloweye rockfish were 2.4% of the harvest in North Sound during the 1960s, occurred in 2.1% of the harvest during the 1980s, but then decreased to an average of 1% from 1996 to 2002 (Palsson et al. 2009). In Puget Sound proper, yelloweye rockfish were 4.4% of the harvest during the 1960s, only 0.4% during the 1980s, and 1.4% from 1996 to 2002 (Palsson et al. 2009).

Bocaccio consisted of 8 to 9% of the overall rockfish catch in the late 1970s and declined in frequency, relative to other species of rockfish, from the 1970s to the 1990s (Drake et al. 2010b). From 1975 to 1979, bocaccio averaged 4.6% of the catch. From 1980 to 1989, they were 0.2% of the 8,430 rockfish identified (Palsson et al. 2009). In the 1990s and early 2000s bocaccio were not observed by WDFW in the dockside surveys of the recreational catches (Drake et al. 2010). In 2008 and 2009, some fish were reported by recreational anglers in the Main Basin (WDFW 2011a).

Fishery-independent estimates of population abundance come from spatially and temporally limited research trawls, drop camera surveys, and underwater ROV surveys conducted by WDFW. These population estimates included in **Table 8** should be interpreted in the context of the sampling design and gear. The trawl surveys were conducted on the bottom to assess marine fish abundance for a variety of species. These trawls generally sample over non-rocky substrates where yelloweye rockfish and bocaccio are less likely to occur compared to steep-sloped, rocky habitat (Drake et al. 2010b). The drop camera surveys sampled habitats less than 120 feet (36.6 m), which is potential habitat for juveniles, but less likely habitat for adults of the two listed species. Similarly, because juvenile yelloweye rockfish are less dependent on rearing in shallow nearshore environments, the likelihood of documenting them with drop camera surveys in water shallower than 120 feet (36.6 m) is less than for bocaccio.

The WDFW ROV surveys were conducted exclusively within the rocky habitats of the San Juan Basin in 2008, and represent the best available abundance estimates to date for one basin of the DPS for each species because of their survey area, number of transects, and stratification methods. Rocky habitats have been mapped within the San Juan Basin, which allows a randomized survey of these areas to assess species assemblages and collect data for abundance estimates. WDFW conducted 200 transects and stratified each rocky habitat survey as either “shallower than” or “deeper than” 120 feet (36.6 m). The total area surveyed within each stratum was calculated using the average transect width multiplied by the transect length. The mean density of yelloweye rockfish and bocaccio was calculated by dividing the species counts within each stratum by the area surveyed. Population estimates for each species were calculated by multiplying the species density estimates by the total survey area within each stratum (Pacunski et al. 2013). Because WDFW did not survey non-rocky habitats of the San Juan Basin with the ROV, these estimates do not account for listed rockfish in non-rocky habitat in 2008. WDFW expanded the survey data to estimate total abundance in the San Juan Basin (**Table 8**). From the midwater trawl and drop camera surveys, WDFW has reported population estimates in the North Sound and Puget Sound proper (**Table 8**).

Though the bottom trawl and drop camera surveys did not detect bocaccio in Puget Sound proper, they have been historically present there, observed in recent ROV surveys and genetic study and reported caught in recent recreational fisheries. The lack of detected bocaccio from these previous sampling efforts (listed in Table 8) in Puget Sound proper is likely due to the following factors: (1) populations of each species are depleted; (2) the general lack of rocky benthic areas in Puget Sound proper may lead to densities of each species that are naturally less than the San Juan Basin; and (3) the study design or effort may not have been sufficiently powerful to detect each species. Though yelloweye rockfish were detected in Puget Sound proper with bottom trawl surveys, we do not consider the WDFW estimate of 600 fish to be a complete estimate, for the same reasons given above. Thus, there are no reliable abundance estimates of yelloweye rockfish and bocaccio within Puget Sound proper.

Table 8. WDFW population estimates for yelloweye rockfish and bocaccio.

WDFW Survey Method	Yelloweye Population Estimate		Percent Standard Error (or Variance)	
	North Sound	Puget Sound proper		
Bottom Trawl	Not detected	600	NA	400 (variance)
Drop Camera	Not detected	Not detected	NA	NA
Remotely Operated Vehicle	47,407 (San Juan Basin)		25	
WDFW Survey Method	Bocaccio Population Estimate		Percent Standard Error	
	North Sound	Puget Sound proper		
Bottom Trawl	Not detected	Not detected	NA	NA
Drop Camera	Not detected	Not detected	NA	NA
Remotely Operated Vehicle	4,606 (San Juan Basin)		100	

Productivity is the measurement of a population's growth rate through all or a portion of its life cycle. Life history traits of yelloweye rockfish and bocaccio suggest generally low levels of inherent productivity because they are long-lived, mature slowly, and have sporadic episodes of successful reproduction (Drake et al. 2010b; Tolimieri and Levin 2005). Overfishing can have dramatic impacts on the size or age structure of the population, with effects that can influence ongoing productivity. When the size and age of females decline, there are negative impacts to reproductive success. These impacts, termed maternal effects, are evident in a number of traits. Larger and older females of various rockfish species have a higher weight-specific fecundity (number of larvae per unit of female weight) (Bobko and Berkeley 2004; Boehlert et al. 1982; Sogard et al. 2008). A consistent maternal effect in rockfishes relates to the timing of parturition. The timing of larval birth 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 and in yelloweye rockfish in Puget Sound (Washington et al. 1978). Several studies of rockfish species have shown that larger or older females release larvae earlier in the season compared to smaller or younger females (Nichol and Pikitch 1994; Sogard et al. 2008). 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).

Contaminants such as polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and chlorinated pesticides appear in rockfish collected in urban areas (Palsson et al. 2009). While the highest levels of contamination occur in urban areas, toxins can be found in the tissues of fish throughout Puget Sound (West et al. 2001). Although few studies have investigated the effects of toxins on rockfish ecology or physiology, other fish in the Puget Sound region that have been studied do show a substantial impact, including reproductive

dysfunction of some sole species (Landahl et al. 1997). Reproductive function of rockfish is also likely affected by contaminants (Palsson et al. 2009) and other life history stages may be affected as well (Drake et al. 2010b).

Future climate-induced changes to rockfish habitat could alter their productivity (Drake et al. 2010b). Harvey (2005) created a generic bioenergetic model for rockfish, showing that their 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). Recruitment of all species of rockfish 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. 2010b), although the consequences of climate change to rockfish productivity during the course of the proposed actions will likely be small.

Yelloweye Rockfish Abundance and Productivity

Yelloweye rockfish within the Puget Sound/Georgia Basin (in U.S. waters) are very likely the most abundant within the San Juan Basin. Though there is no reliable population census (ROV or otherwise) within the basins of Puget Sound proper, the San Juan Basin has the most suitable rocky benthic habitat (Palsson et al. 2009) and historically was the area of greatest numbers of angler catches (Moulton and Miller 1987; Olander 1991). Productivity for yelloweye rockfish is influenced by long generation times that reflect intrinsically low annual reproductive success. Natural mortality rates have been estimated from 2 to 4.6% (Yamanaka and Kronlund 1997; Wallace 2007). Productivity may also be particularly impacted by Allee effects, which occur as adults are removed by fishing, and the density and proximity of mature fish decreases. Adult yelloweye rockfish typically occupy relatively small ranges (Love et al. 2002) and it is unknown the extent they may move to find suitable mates.

Bocaccio Abundance and Productivity

Bocaccio in the Puget Sound/Georgia Basin were historically most common within the South Sound and Main Basin (Drake et al. 2010b). Though bocaccio were never a predominant segment of the multi-species rockfish abundance within the Puget Sound/Georgia Basin (Drake et al. 2010b), their present-day abundance is likely a fraction of their pre-contemporary fishery abundance. Bocaccio abundance may be very low in significant segments of the Puget Sound/Georgia Basin. Productivity is driven by high fecundity and episodic recruitment events, largely correlated with environmental conditions. Thus, bocaccio populations do not follow consistent growth trajectories and sporadic recruitment drives population structure (Drake et al. 2010b). Natural annual mortality is approximately 8% (Palsson et al. 2009). Tolimieri and Levin (2005) found that the bocaccio population growth rate is around 1.01, indicating a very low intrinsic growth rate for this species. Demographically, this species demonstrates some of the highest recruitment variability among rockfish species, with many years of failed recruitment being the norm (Tolimieri and Levin 2005). Given their severely reduced abundance, Allee

effects may be particularly acute for bocaccio, even considering the propensity of some individuals to move long distances and potentially find mates.

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

Spatial Structure and Connectivity

Spatial structure consists of a population's geographical distribution and the processes that generate that distribution (McElhaney et al. 2000). 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). Prior to contemporary fishery removals, each of the major basins in the range of the DPSs likely hosted relatively large populations of yelloweye rockfish and bocaccio (Moulton and Miller 1987; Washington 1977; Washington et al. 1978). This distribution allowed each species to utilize the full suite of available habitats to maximize their abundance and demographic characteristics, thereby enhancing their resilience (Hamilton 2008). This distribution also enabled each species to potentially exploit ephemerally good habitat conditions, or in turn receive protection from smaller-scale and negative environmental fluctuations. These types of fluctuations may change prey abundance for various life stages and/or may change environmental characteristics that influence the number of annual recruits. Spatial distribution also provides a measure of protection from larger scale anthropogenic changes that damage habitat suitability, such as oil spills or hypoxia that can occur within one basin, but not necessarily the other basins. Rockfish population resilience is sensitive to changes in connectivity among various groups of fish (Hamilton 2008). Hydrologic connectivity of the basins of the Puget Sound is naturally restricted by relatively shallow sills located at Deception Pass, Admiralty Inlet, the Tacoma Narrows, and in Hood Canal (Burns 1985). The Victoria Sill bisects the Strait of Juan de Fuca and runs from east of Port Angeles north to Victoria, and regulates water exchange (Drake et al. 2010b). These sills regulate water exchange from one basin to the next, and thus likely moderate the movement of rockfish larvae (Drake et al. 2010b). When localized depletion of rockfish occurs, it can reduce stock resiliency (Hamilton 2008; Hilborn et al. 2003). The effects of localized depletions of rockfish are likely exacerbated by the natural hydrologic constrictions within Puget Sound.

Yelloweye Rockfish Spatial Structure and Connectivity

Yelloweye rockfish spatial structure and connectivity is threatened by the reduction of fish within each basin. This reduction is most acute within the basins of Puget Sound proper. Yelloweye rockfish are probably most abundant within the San Juan Basin, but the likelihood of juvenile recruitment from this basin to the adjacent basins of Puget Sound proper is naturally low because of the generally retentive circulation patterns that occur within each of the major basins of Puget Sound proper. Combined with limited adult movement, yelloweye rockfish population viability may be highly influenced by the probable localized loss of populations within the DPS, which decreases spatial structure and connectivity.

Bocaccio Spatial Structure and Connectivity

Most bocaccio may have been historically spatially limited to several basins. They were historically most abundant in the Main Basin and South Sound (Drake et al. 2010b) with no documented occurrences in the San Juan Basin until 2008 (Pacunski et al. 2013). Positive signs for spatial structure and connectivity come from the propensity of some adults and pelagic juveniles to migrate long distances, which could re-establish aggregations of fish in formerly occupied habitat (Drake et al. 2010b). The apparent reduction of populations of bocaccio in the Main Basin and South Sound represents a further reduction in the historically spatially limited distribution of bocaccio, and adds significant risk to the viability of the DPS.

In summary, spatial structure and connectivity for each species have been adversely impacted, mostly by fishery removals. These impacts to species viability are likely most acute for yelloweye rockfish because of their sedentary nature as adults.

Diversity

Characteristics of diversity for rockfish include fecundity, timing of the release of larvae and their condition, morphology, age at reproductive maturity, physiology, and molecular genetic characteristics. In spatially and temporally varying environments, there are three general reasons why diversity is important for species and population viability: (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.

Yelloweye Rockfish Diversity

Yelloweye rockfish size and age distributions have been truncated (**Figure 8**). Recreationally caught yelloweye rockfish in the 1970s spanned a broad range of sizes. By the 2000s, there was some evidence of fewer older fish in the population (Drake et al. 2010b). No adult yelloweye rockfish have been observed within the WDFW ROV surveys and all observed fish in 2008 in the San Juan Basin were less than 8 inches long (20 cm) (Pacunski et al 2013), though adult yelloweye were caught in the genetic research and observed in Puget Sound Proper ROV surveys. The reduction of adult fish over the last several decades has shifted the reproductive burden to younger and smaller fish. This shift could alter the timing and condition of larval release, which may be mismatched with habitat conditions within the range of the DPS, potentially reducing the viability of offspring (Drake et al. 2010b).

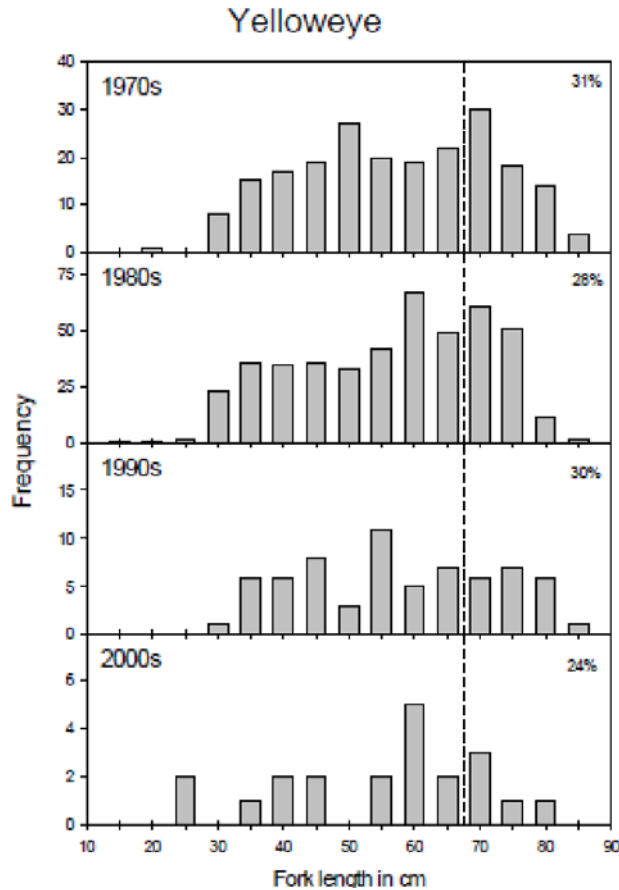


Figure 8. Yelloweye rockfish length frequency distributions (cm) binned within four decades. The vertical line depicts the size at which about 30% of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for lat

The recently completed genetic study provide new insights of yelloweye population structure and reveal significant genetic differentiation between the inland (DPS) and coastal samples. These new data are consistent with and further support the existence of a population of Puget Sound/Georgia Basin yelloweye rockfish that is discrete from coastal populations (Ford 2015; NMFS 2016b). In addition, yelloweye rockfish from Hood Canal were genetically differentiated from other Puget Sound/Georgia Basin fish (cluster in the upper right of **Figure 9**), indicating a previously unknown degree of population differentiation within the DPS (Ford 2015; NMFS 2016b). Other genetic analysis has found that yelloweye rockfish in the Georgia Basin had the lowest molecular genetic diversity of a collection of samples along the coast (Siegle et al. 2013). Although the adaptive significance of such microsatellite diversity is unclear, it may suggest low effective population size, increased drift, and thus lower genetic diversity in the Puget Sound/Georgia Basin DPS.

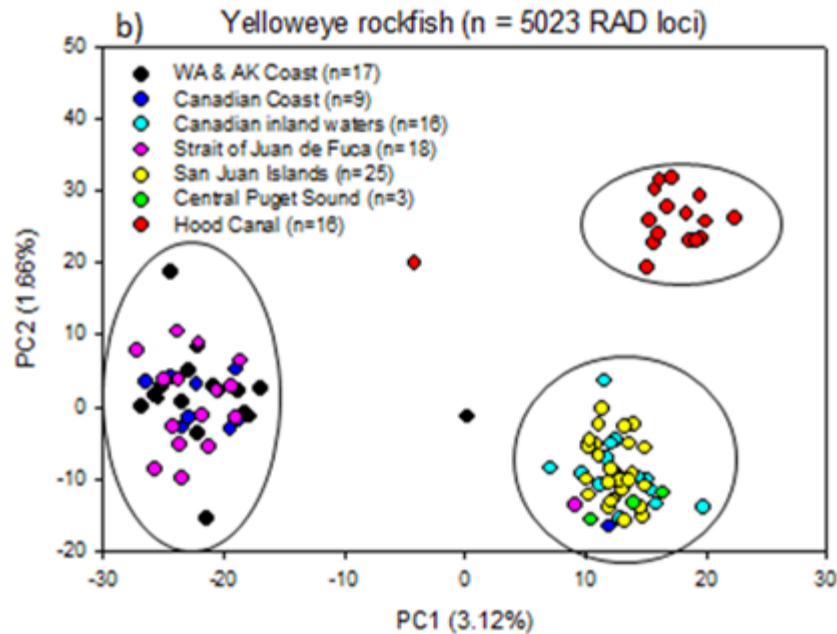


Figure 9. Three clusters of yelloweye rockfish based on a principal components analysis of the genetic variation between individuals outside the DPS (left circle) and inside the DPS (right circles) (NMFS 2016b).

Bocaccio Diversity

Size-frequency distributions for bocaccio in the 1970s indicate a wide range of sizes, with recreationally caught individuals from 9.8 to 33.5 inches (25 to 85 cm) (**Figure 10**). This broad size distribution suggests a spread of ages, with some successful recruitment over many years. A similar range of sizes is also evident in the 1980s catch data. The temporal trend in size distributions for bocaccio also suggests size truncation of the population, with larger fish becoming less common over time. By the decade of the 2000s, no size distribution data for bocaccio were available. Bocaccio in the Puget Sound/Georgia Basin may have physiological or behavioral adaptations because of the unique habitat conditions in the range of the DPS. The potential loss of diversity in the bocaccio DPS, in combination with their relatively low productivity, may result in a mismatch with habitat conditions and further reduce population viability (Drake et al. 2010b).

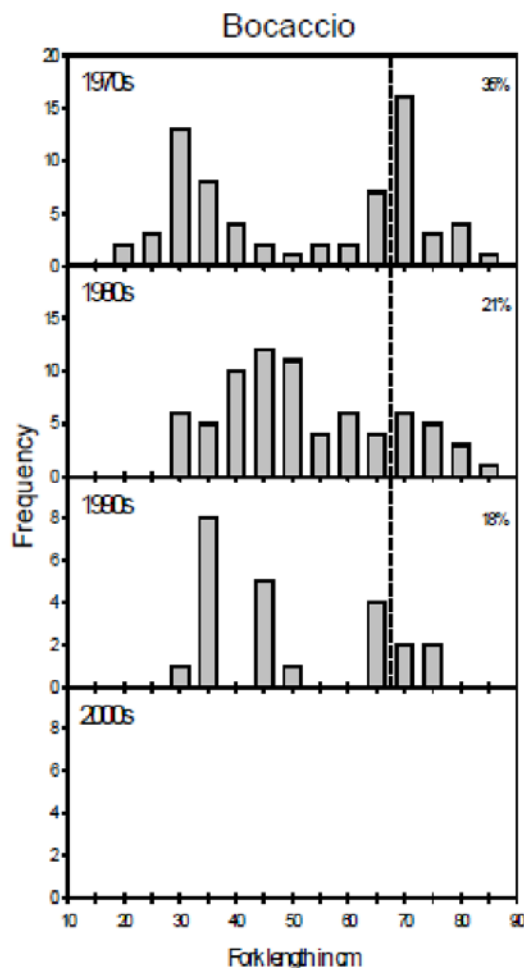


Figure 10. Bocaccio length frequency distributions (cm) binned within four decades. The vertical line depicts the size at which about 30% of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for later decades (figure from Drake et al. 2010b).

During the genetic survey, scientists also tried to collect bocaccio tissue. Because of their rarity, genetic analysis for bocaccio included only two samples from within the DPS area (NMFS 2016b); this is not sufficient information to change the prior status review determination (Ford 2015; NMFS 2016b) and researchers are attempting to gather additional biological samples.

In summary, diversity for each species has likely been adversely impacted by fishery removals. In turn, the ability of each fish to utilize habitats within the action area may be compromised.

Limiting factors

Climate change and other ecosystem effects

As reviewed in ISAB (2007), average annual Northwest air temperatures have increased by approximately 1.8°F (1°C) since 1900, which is nearly twice that for the previous 100 years, indicating an increasing rate of change. Summer temperatures, under the A1B emissions scenario

(a “medium” warming scenario), are expected to increase 3°F (1.7°C) by the 2020s and 8.5°F (4.7°C) by 2080 relative to the 1980s in the Pacific Northwest (Mantua et al. 2010). This change in surface temperature has already modified, and is likely to continue to modify, marine habitats of listed rockfish. There is still a great deal of uncertainty associated with predicting specific changes in timing, location, and magnitude of future climate change.

As described in ISAB (2007), climate change effects that have, and will continue to, influence the habitat, include increased ocean temperature, increased stratification of the water column, and intensity and timing changes of coastal upwelling. These continuing changes will alter primary and secondary productivity, marine community structures, and in turn may alter listed rockfish growth, productivity, survival, and habitat usage. Increased concentration of CO₂ (termed Ocean Acidification, or OA) reduces carbonate availability for shell-forming invertebrates. OA will adversely affect calcification, or the precipitation of dissolved ions into solid calcium carbonate structures, for a number of marine organisms, which could alter trophic functions and the availability of prey (Feely et al. 2010). Further research is needed to understand the implications OA may have on trophic functions in Puget Sound to understand how they may affect rockfish. Thus far, studies conducted in other areas have shown that the effects of OA will be variable (Ries et al. 2009) and species-specific (Miller et al. 2009).

There have been very few studies to date on the direct effect OA may have on rockfish. In a laboratory setting OA has been documented to affect rockfish behavior (Hamilton et al. 2014). Fish behavior changed significantly after juvenile Californian rockfish (*Sebastes diploproa*) spent one week in seawater with the OA conditions that are projected for the next century in the California shore. Researchers characterized the behavior as “anxiety” as the fish spent more time in unlighted environments compared to the control group. Research conducted to understand adaptive responses to OA on other marine organisms has shown that although some organisms may be able to adjust to OA to some extent, these adaptations may reduce the organism’s overall fitness or survival (Wood et al. 2008). More research is needed to further understand rockfish-specific responses and possible adaptations to OA.

There are natural biological and physical functions in regions of Puget Sound, especially in Hood Canal and South Sound, that cause the water to be corrosive and hypoxic, such as restricted circulation and mixing, respiration, and strong stratification (Newton et al. 2002; Feely et al. 2010). However, these natural conditions, typically driven by climate forcing, are exacerbated by anthropogenic sources such as OA, nutrient enrichment, and land-use changes (Feely et al. 2010). By the next century, OA will increasingly reduce pH and saturation states in Puget Sound (Feely et al. 2010). Areas in Puget Sound susceptible to naturally occurring hypoxic and corrosive conditions are also the same areas where low seawater pH occurs, compounding the conditions of these areas (Feely et al. 2010).

Commercial and Recreational Bycatch

Listed rockfish are caught in some recreational and commercial fisheries in the Puget Sound. This bycatch is described in section 2.4.3.1.

Other Limiting Factors

The yelloweye rockfish DPS abundance is much less than it was historically. The fish face several threats, including bycatch in some commercial and recreational fisheries, non-native species introductions, and habitat degradation. NMFS has determined that this DPS is likely to be in danger of extinction in the foreseeable future throughout all of its range.

The bocaccio DPS exists at very low abundance and observations are rare. Their low intrinsic productivity, combined with continuing threats from bycatch in commercial and recreational harvest, non-native species introductions, loss and degradation of habitat, and chemical contamination, increase the extinction risk. NMFS has determined that this DPS is currently in danger of extinction throughout all of its range.

In summary, despite some limitations on our knowledge of past abundance and specific current viability parameters, characterizing the viability of yelloweye rockfish and bocaccio includes their severely reduced abundance from historic times, which in turn hinders productivity and diversity. Spatial structure for each species has also likely been compromised because of the relative lack of mature fish of each species distributed throughout their historic range within the DPSs (Drake et al. 2010b).

2.2.1.4 Status of 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). In December 2016, NMFS finalized a 5-year status review under the ESA, which provided an update on the status of the Southern Residents and the progress toward meeting the recovery criteria identified in the recovery plan. The recommended classification in the 5-year review is for Southern Resident killer whales to remain the same: Endangered

(http://www.westcoast.fisheries.noaa.gov/publications/status_reviews/marine_mammals/kw-review-2016.pdf). Limiting factors described in the final recovery plan for Southern Resident killer whales include quantity of prey (subsequent data collection and analysis indicated a strong preference for Chinook salmon) (NMFS 2008f, Hanson et al. 2010, NWFSC unpubl. data). As described above (in Section 1.1, Background), we are incorporating the previous analyses by reference (and therefore the status, environmental baseline, and effects), as supplemented by the information presented here. The previous opinions (NMFS 2011a, NMFS 2014a, NMFS 2015b, NMFS 2016a) incorporated the best available information at the time for the relevant sections, and here we supplement with new information available subsequent to the 2016 biological opinion.

Updates to Abundance, Productivity, and Trends

NMFS has continued to fund the Center for Whale Research to conduct the 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, two whales died (a post-reproductive female from L pod and a young adult male from L pod), and five whales were born (3 from J pod, one of which later died, and 2 from L pod). As of March 2017, five individuals from J pod

died, bringing the number of whales to 78. There is representation in all three pods, J (24 whales), K (19 whales), and L (35 whales). There are currently 4 reproductively mature males in J, 8 in K, and 10 in L pod between the ages of 10 and 42 years old. Of the 78 individuals in the population, 22 of them are reproductive age males and 27 are reproductive age females.

Based on an updated pedigree from new genetic data (NWFSC unpubl.), most of the offspring in recent years were sired by two fathers. Because a small number of males were identified as the fathers of many offspring, a smaller number may be sufficient to support population growth than was previously thought (Ford et al. 2011, NWFSC unpublished data). In addition many offspring were the result of matings within the same pod raising questions and concerns about inbreeding effects. Research into the relationship between genetic diversity, effective breeding population size, and health is currently underway to determine how this metric can inform us about extinction risk and recovery (NWFSC unpublished data).

The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the work on population viability analyses conducted for the 2004 Status Review for Southern Resident Killer Whales and the science panel review (Krahn et al. 2004; Hilborn et al. 2012; Ward et al. 2103). Following from that work, the data now suggests a downward trend in population growth projected over the next 50 years, in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016. The population trend projection is most pessimistic if future fecundity rates are assumed to be similar to those in 2016, and less steep but still declining if an average fecundity rate over the last five years is used for the projections (**Figure 11**). The projection using 2011 through 2016 fecundity data shows some stability and even a slight increase over the next decade. As the model projects out over a longer time frame (50 years) there is increased uncertainty around the estimates, however, if all of the parameters in the model remain the same the overall trend shows a decline in later years.

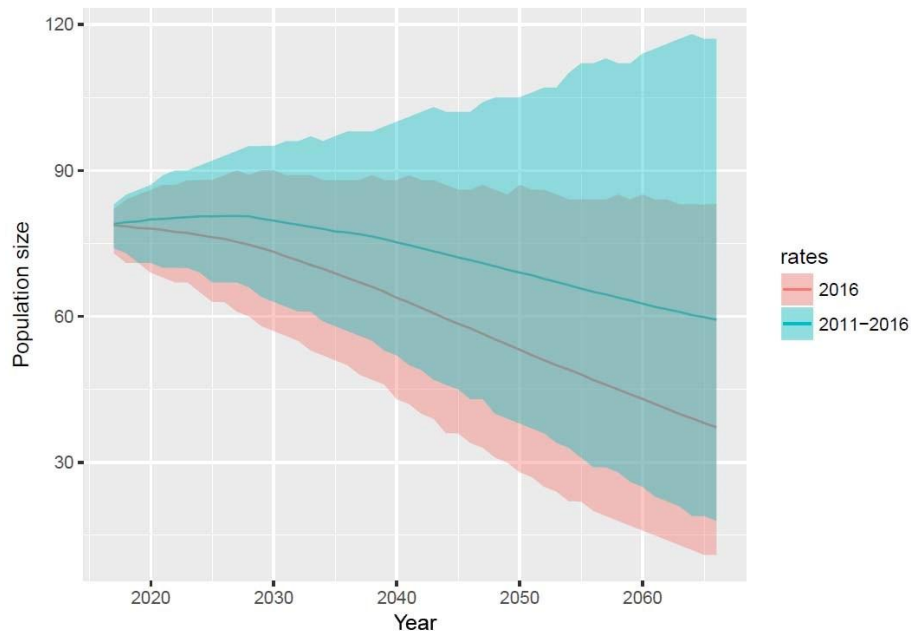


Figure 11. Southern Resident killer whale population size projections from 2016 to 2066 using 2 scenarios: (1) projections using demographic rates held at 2016 levels, and (2) projections using demographic rates from 2011 to 2016. The pink line represents the projection assuming future rates are similar to those in 2016, whereas the blue represents the scenario with future rates being similar to 2011 to 2016.

Updates to Range and Distribution

As part of an effort to help understand where Southern Residents go in the winter, and thus their winter habitat use, NWFSC researchers in collaboration with Cascadia Research Collective researchers conducted a satellite tagging project. Between 2012 and 2016, the NWFSC deployed eight satellite tags on individual Southern Residents to track their movement during the winter months. The researchers that worked on the satellite tagging project will use the location data from the satellite tags deployed on Southern Residents to find out more about their winter migration and the extent of their geographic range. Analysis of the satellite tag data is currently underway and will inform designation of coastal critical habitat for the whales.

Updates to Limiting Factors

As described in the previous biological opinions (NMFS 2011a, NMFS 2014a, NMFS 2015b, NMFS 2016a), several factors identified in the final recovery plan for Southern Residents may be limiting recovery. These factors are quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting together to impact the whales. Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, all of the threats identified are potential limiting factors in their population dynamics (NMFS 2008f).

Following issuance of the 2011 biological opinion (NMFS 2011a), NMFS implemented

conservation measures that included convening an independent science panel to critically evaluate the effects of salmon fisheries on the abundance of Chinook salmon available to Southern Residents. Overall, the panel concluded that the impact of reduced Chinook salmon harvest on future availability of Chinook salmon to Southern Residents is not clear, and cautioned against overreliance on correlative studies or implicating any particular fishery (Hilborn et al. 2012). In the 2014 biological opinion, we summarized the panel's findings, new findings following the panel process, and future needs to characterize uncertainty and to reduce bias (NMFS 2014a). In the 2015 opinion, additional information on differences in demographic rates between the Northern and Southern Residents (Vélez-Espino et al. 2014a), and the relative role of Chinook salmon abundance on the population growth and viability of the Southern Residents (Vélez-Espino et al. 2014b), had become available and was summarized (NMFS 2015b). In the 2016 biological opinions, we noted that the Southern Resident killer whale population had experienced an increase in reproductive females since the beginning of the annual censuses in the 1970s. However, even with the recent uptick in births for the SRKW population, there was weak evidence of a decline in fecundity rates through time for reproductive females. We also noted there had been a general decline in post-reproductive females and highlighted the concern of having a decline in this life stage because of their relative importance to improve fitness of their offspring and transfer ecological knowledge (Brent et al. 2015, Franks et al. 2016, NMFS 2016a).

NMFS has also been developing a risk assessment framework relating Chinook salmon abundance to Southern Resident killer whale population dynamics that will help evaluate the impacts of actions that affect salmon abundance and availability on the whales. At this time, development of the framework is on a coast-wide scale and intended for broad applicability across actions that impact salmon. NMFS' work to develop the risk assessment for this purpose currently remains ongoing.

Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. As described in NMFS 2011a, scale and tissue sampling in inland waters from May to September indicate that Southern Residents' diet consists of a high percentage of ChinookChinook (Hanson et al. 2010). DNA quantification methods also can be used to estimate the proportion of diet from fecal samples (i.e., Deagle et al. 2005). As described in the 2016 biological opinion, Ford et al. (2016) confirmed the importance of Chinook salmon to the killer whales in the summer months using DNA sequencing from whale feces. They estimated 79.5% of the sequences were Chinook salmon, which was similar to the proportion found in the Hanson et al. (2010) surface prey remains analysis. They also found evidence of prey shifting at the end of summer towards coho salmon, contributing to up to 40% of the whales' diet. Chum, sockeye, and steelhead made up relatively small contributions to the sequences (less than 3% each).

As described in the previous biological opinions (NMFS 2011a, 2014a, 2015c, 2016b), Chinook salmon contain higher levels of some persistent pollutants than other salmon species, but only limited information is available for pollutant levels of Chinook in inland waters (i.e., Krahn et al. 2007, O'Neill and West 2009, Veldhoen et al. 2010, Mongillo et al. 2016). Killer whales are

exposed to persistent pollutants primarily through their diet. These harmful pollutants are stored in blubber, and can later be released and become redistributed to other tissues when the whales metabolize the blubber in response to food shortages or reduced acquisition of food energy that could occur for a variety of other reasons, or could occur during gestation or lactation. High levels of these pollutants have been measured in blubber biopsy samples from Southern Residents (Ross et al. 2000, Krahn et al. 2007, 2009), and more recently these pollutants were measured in scat samples collected from the whales providing another potential opportunity to evaluate exposure of these pollutants in the whales (Lundin et al. 2015). More recently, Lundin et al. (2016) characterized circulating toxicants in Southern Residents by prey availability, age and sex class, and reproductive class by measuring toxicants from the scat. Their results were similar to previous work (adult females that have produced offspring tend to have lower persistent pollutant levels, whereas in males the toxicants increase with age). Correlating toxicant levels in the scat revealed higher levels of the more persistent toxicants when prey abundance was predicted to be lower. This, they suggest, is potentially from metabolizing lipid stores for energy, however, it could reflect a change in prey or feeding across different Chinook stocks. High levels of persistent pollutants have the potential to affect the whales' endocrine and immune systems and reproductive fitness (Krahn et al. 2002, Mongillo et al. 2016).

As a part of their Killer Whale Research and Conservation Program, the National Fish and Wildlife Foundation awarded \$590,000 (over \$1.4 million including matching funds) in grants to research partners in 2015. Over half of that funding awarded was consistent with projects identified as priority actions from a 2015 Health Workshop (http://www.westcoast.fisheries.noaa.gov/publications/protected_species/marine_mammals/killer_whales/srkw_healthpriority_dec2015.pdf). In particular, UC Davis was awarded funds for the development of a standardized health assessment protocol and health index as well as the creation of a comprehensive database for killer whale health records. Representatives from The SeaDoc Society, NOAA Fisheries, and the National Marine Mammal Foundation, along with other partner organizations, held a workshop in March 2017 to review the nutritional condition of the killer whales and review the status of the health database and to develop the protocol to assess health. These tools will be used to identify spatial and temporal trends in whale health, assess group and individual fitness, guide research activities, and review killer whale strandings protocols.

As described in NMFS 2011, vessel activities may affect foraging efficiency, communication, and/or energy expenditure through the physical presence of the vessels, underwater sound created by the vessels, or both. In 2011, NMFS announced final regulations to protect killer whales in Washington State from the effects of various vessel activities (76 FR 20870). The final rule includes two elements: 1) a prohibition on approaching killer whales within 200 yards, and 2) a prohibition on parking in the path of the whales.

Many studies provided evidence for the vessel regulations and new studies continue to improve our understanding. Previously, researchers found that whales spend more time traveling and less time foraging when vessels are nearby, indicating that they should maintain a greater distance from the whales in inland waters, which serve as important foraging areas (Lusseau et al. 2009).

Results from more recent behavioral studies can help vessel operators understand potential risks and contribute to mitigation of vessel impacts (Noren and Hauser 2016). In addition to proximity to the vessels, a NWFSC study using suction cup digital acoustic tags (DTAGs) study found that speed of nearby vessels is an important indicator of the level of noise received by the whales at a given distance (Houghton et al. 2015). Although the regulations codified in 2011 do not include a restriction on speed, the Be Whale Wise guidelines recommend a slow zone up to 400 meters away from the whales at all times. Other recent studies have identified that noise from large ships extends into frequencies used by Southern Residents for echolocation. This means vessels not targeting the whale can still cause disturbance and impair the whales' ability to find food, should they continue foraging when vessels are present (Veirs et al. 2015). The NWFSC is continuing DTAG data analysis funded by NFWF to better understand how vessel-generated noise influences the subsurface behavior of Southern Residents, especially foraging behaviors (NFWF 2015). In 2013 and 2016, WDFW received NMFS endangered species grants to support enforcement efforts. The regulations are currently being evaluated for their effectiveness in advancing the recovery of the Southern Residents and results of the review are expected in 2017.

2.2.2 Status of Critical Habitat

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

For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each listed species they support¹³; the conservation rankings are high, medium, or low. To determine the conservation value of each watershed to species viability, NMFS' critical habitat analytical review teams (CHARTs; NMFS 2005a) evaluated the quantity and quality of habitat features (for example, spawning gravels, wood and water condition, side channels), the relationship of the area compared to other areas within the species' range, and the significance to the species of the population occupying that area. Thus, even a location that has poor quality of habitat could be ranked with a high conservation value if it were essential due to factors such as limited availability (e.g., one of a very few spawning areas), a unique contribution to the population it served (e.g., a population at the extreme end of geographic distribution), or the fact that it serves another important role (e.g., obligate area for migration to upstream spawning areas).

2.2.2.1 Puget Sound Chinook

Critical habitat for the Puget Sound Chinook ESU was designated on September 2, 2005 (70 FR 52630). It includes estuarine areas and specific river reaches associated with the following

¹³ The conservation value of a site depends upon "(1) the importance of the populations associated with a site to the ESU [or DPS] conservation, and (2) the contribution of that site to the conservation of the population through demonstrated or potential productivity of the area" (NOAA Fisheries 2005).

subbasins: Strait of Georgia, Nooksack, Upper Skagit, Sauk, Lower Skagit, Stillaguamish, Skykomish, Snoqualmie, Snohomish, Lake Washington, Duwamish, Puyallup, Nisqually, Deschutes, Skokomish, Hood Canal, Kitsap, and Dungeness/Elwha (70 FR 52630). The designation also includes some nearshore areas extending from extreme high water out to a depth of 30 meters and adjacent to watersheds occupied by the 22 populations because of their importance to rearing and migration for Chinook salmon and their prey, but does not otherwise include offshore marine areas. There are 61 watersheds within the range of this ESU. Twelve watersheds received a low rating, nine received a medium rating, and 40 received a high rating of conservation value to the ESU (NMFS 2005a). Nineteen nearshore marine areas also received a rating of high conservation value. Of the 4,597 miles of stream and nearshore habitat eligible for designation, 3,852 miles are designated critical habitat while the remaining 745 miles were excluded because they are lands controlled by the military, overlap with Indian lands, or the benefits of exclusion outweighed the benefits of designation (70 FR 52630).

Physical or biological factors involve those sites and habitat components that support one or more life stages, including general categories of: (1) water quantity, quality, and forage to support spawning, rearing, individual growth, and maturation; (2) areas free of obstruction and excessive predation; and (3) the type and amount of structure and rugosity that supports juvenile growth and mobility.

Major management activities affecting PBFs are forestry, grazing, agriculture, channel/bank modifications, road building/maintenance, urbanization, sand and gravel mining, dams, irrigation impoundments and withdrawals, river, estuary and ocean traffic, wetland loss, and forage fish/species harvest. NMFS has completed several section 7 consultations on large scale habitat projects affecting listed species in Puget Sound. Among these are the Washington State Forest Practices Habitat Conservation Plan (NMFS 2006b), and consultations on Washington State Water Quality Standards (NMFS 2008b), the National Flood Insurance Program (NMFS 2008c), the Washington State Department of Transportation Preservation, Improvement and Maintenance Activities (NMFS 2013a), and the Elwha River Fish Restoration Plan (Ward et al. 2008). These documents provide a more detailed overview of the status of critical habitat in Puget Sound and are incorporated by reference here. Effects of these activities on habitat, including primarily critical habitat, are also addressed in Section 2.3.1 and 2.4.1.

2.2.2.2 Puget Sound Steelhead

Critical habitat for the Puget Sound Steelhead DPS was proposed for designation on January 14, 2013 (78 Fed. Reg. 2726). On February 12, 2016, NMFS announced the final critical habitat designation for Puget Sound steelhead along with the critical habitat designation for Lower Columbia River coho salmon (81 FR 9252, February 24, 2016). The specific areas designated for Puget Sound steelhead include approximately 2,031 miles of freshwater and estuarine habitat in Puget Sound, Washington. NMFS excluded areas where the conservation benefit to the species was relatively low compared to the economic impacts of inclusion. Approximately 138 stream miles were excluded from the designation based on this criterion. Approximately 1,361 stream miles covered by four habitat conservation plans and approximately 70 stream miles on tribal lands were also excluded because the benefits of exclusion outweighed the benefits of

designation.

There are 72 HUC5 watersheds occupied by Puget Sound steelhead within the range of this DPS. NMFS also designated approximately 90 stream miles of critical habitat on the Kitsap Peninsula that were originally proposed for exclusion, but, after considering public comments, determined that the benefits of exclusion did not outweigh the benefits of designation. The final designation also includes areas in the upper Elwha River where the recent removal of two dams now provides access to areas that were previously unoccupied by Puget Sound steelhead at the time of listing but are essential to the conservation of the DPS.

Puget Sound steelhead also occupy marine waters in Puget Sound and vast areas of the Pacific Ocean where they forage during their juvenile and subadult life phases before returning to spawn in their natal streams (NMFS 2012a). The NMFS (NMFS 2012b), NMFS could not identify “specific areas” within the marine and ocean range that meet the definition of critical habitat. Instead, NMFS considered the adjacent marine areas in Puget Sound when designating steelhead freshwater and estuarine critical habitat. Critical habitat information can be found online at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/steelhead/puget_sound/puget_sound_steelhead_proposed_critical_habitat_supporting_information.html.

Physical or biological factors for Puget Sound steelhead involve those sites and habitat components that support one or more life stages, including general categories of: (1) water quantity, quality, and forage to support spawning, rearing, individual growth, and maturation; (2) areas free of obstruction and excessive predation; and (3) the type and amount of structure and complexity that supports juvenile growth and mobility.

Major management activities affecting PBFs are forestry, grazing, agriculture, channel/bank modifications, road building/maintenance, urbanization, sand and gravel mining, dams, irrigation impoundments and withdrawals, river, estuary and ocean traffic, wetland loss, and forage fish/species harvest. NMFS has completed several section 7 consultations on large scale habitat projects affecting listed species in Puget Sound. Among these are the Washington State Forest Practices Habitat Conservation Plan (NMFS 2006b), and consultations on Washington State Water Quality Standards (NMFS 2008b), the National Flood Plain Insurance Program (NMFS 2008c), the Washington State Department of Transportation Preservation, Improvement and Maintenance Activities (NMFS 2013a), and the Elwha River Fish Restoration Plan (Ward et al. 2008). In 2012, the Puget Sound Action Plan was also developed and can be found online at: http://www.westcoast.fisheries.noaa.gov/habitat/conservation/puget_sound_action_plan.html. Several federal agencies (e.g., EPA, NOAA Fisheries, the Corps of Engineers, NRCS, USGS, FEMA, and USFWS) are collaborating on an enhanced approach to implement the Puget Sound Action Plan. These documents provide a more detailed overview of the status of critical habitat in Puget Sound and are incorporated by reference here. Effects of these activities on habitat, including primarily critical habitat, are also addressed in Section 2.3.1 and 2.4.1.

2.2.2.3 Puget Sound/Georgia Basin Rockfish

Critical habitat was designated for listed rockfish in 2014 under section 4(a)(3)(A) of the ESA

(79 FR 68041, November 13, 2014). The specific areas designated for bocaccio includes approximately 1,083.11 square miles (1,743.10 sq. km) of deep water (< 98.4 feet [30 m]) and nearshore (> 98.4 feet [30 m]) marine habitat in Puget Sound. The specific areas designated for yelloweye rockfish include 438.45 square miles (705.62 sq. km) of deepwater marine habitat in Puget Sound, all of which overlap with areas designated for bocaccio. Section 3(5)(A) of the ESA defines critical habitat as “(i) the specific areas within the geographical area occupied by the species, at the time it is listed . . . on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed . . . upon a determination by the Secretary that such areas are essential for the conservation of the species.”

Critical habitat is not designated in areas outside of U.S. jurisdiction; therefore, although waters in Canada are part of the DPSs’ ranges for each species, critical habitat was not designated in that area. We also excluded 13 of the 14 Department of Defense Restricted Areas, Operating Areas, and Danger Zones and waters adjacent to tribal lands from the critical habitat designation.

Based on the best available scientific information regarding natural history and habitat needs, we developed a list of physical and biological features essential to the conservation of adult and juvenile yelloweye rockfish and bocaccio, and relevant to determining whether proposed specific areas are consistent with the above regulations and the ESA section (3)(5)(A) definition of “critical habitat.” The physical or biological features essential to the conservation of yelloweye rockfish and bocaccio fall into major categories reflecting key life history phases.

Adult bocaccio, and adult and juvenile yelloweye rockfish: We designated sites deeper than 98 feet (30 m) that possess (or are adjacent to) areas of complex bathymetry. These features are essential to conservation because they support growth, survival, reproduction, and feeding opportunities by providing the structure to avoid predation, seek food, and persist for decades. Several attributes of these sites affect the quality of the area and are useful in considering the conservation value of the feature in determining whether the feature may require special management considerations or protection, and in evaluating the effects of a proposed action in a section 7 consultation if the specific area containing the site is designated as critical habitat. These attributes include: (1) quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; (2) water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities; and (3) structure and rugosity to support feeding opportunities and predator avoidance.

Juvenile bocaccio only: Juvenile settlement sites located in the nearshore with substrates such as sand, rock, and/or cobble compositions that also support kelp. These features are essential for conservation because they enable forage opportunities and refuge from predators, and enable behavioral and physiological changes needed for juveniles to occupy deeper adult habitats. Several attributes of these sites affect the quality of the area and are useful in considering the conservation value of the feature in determining whether the feature may require special management considerations or protection, and in evaluating the effects of a proposed actions in a

section 7 consultation if the specific area containing the site is designated as critical habitat. These attributes include: (1) quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; and (2) water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

Regulations for designating critical habitat at 50 CFR 424.12(b) state that the agencies shall consider physical and biological features essential to the conservation of a given species that “may require special management considerations or protection.” Joint NMFS and USFWS regulations at 50 CFR 424.02(j) define “special management considerations or protection” to mean “any methods or procedures useful in protecting physical and biological features of the environment for the conservation of listed species.” We identified a number of activities that may affect the physical and biological features essential to yelloweye rockfish and bocaccio such that special management considerations or protection may be required. Major categories of such activities include: (1) nearshore development and in-water construction (e.g., beach armoring, pier construction, jetty or harbor construction, pile driving construction, residential and commercial construction); (2) dredging and disposal of dredged material; (3) pollution and runoff; (4) underwater construction and operation of alternative energy hydrokinetic projects (tidal or wave energy projects) and cable laying; (5) kelp harvest; (6) fisheries; (7) non-indigenous species introduction and management; (8) artificial habitat creation; (9) research activities; (10) aquaculture, and (11) activities that lead to global climate change.

Overall, the status of critical habitat in the nearshore is impacted in many areas by the degradation from coastal development and pollution. The status of deep water critical habitat is impacted by remaining derelict fishing gear, and degraded water quality among other factors. The input of pollutants affect water quality, sediment quality, and food resources in the nearshore and deep water areas of critical habitat.

2.2.2.4 Southern Resident Killer Whale

Here we incorporate by reference the status of Southern Resident killer whale critical habitat description from the 2011 biological opinion (NMFS 2011a) and provide updated information. Critical habitat was designated in 2006 (71 Fed. Reg. 69054, November 29, 2006). 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, NMFS announced a 12-month finding to revise the critical habitat designation for the Southern Residents and will proceed with a revision to critical habitat and develop a proposed rule for publication in 2017 (80 Fed. Reg. 9682, February 24, 2015).

Water Quality: Water quality in Puget Sound, in general, is degraded as described in the Puget Sound Partnership Recommendations and subsequent Action Agenda (Puget Sound Partnership 2016). For example, some toxics in Puget Sound persist and build up in marine organisms including Southern Residents and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. The primary concern for direct effects on whales from water quality is oil spills, although oil spills can also have long-lasting impacts on other habitat features.

Prey Quantity, Quality, and Availability: Most wild salmon stocks throughout the Northwest are at fractions of their historic levels. Beginning in the early 1990s, 28 ESUs and DPSs of salmon and steelhead in Washington, Oregon, Idaho, and California were listed as threatened or endangered under the ESA. Historically, overfishing, habitat losses, and hatchery practices were major causes of decline. Poor ocean conditions over the past two decades have reduced populations already weakened by the degradation and loss of freshwater and estuary habitat, fishing, hydropower system management, and hatchery practices. While wild salmon stocks have declined in many areas, hatchery production has been generally strong.

Contaminants and pollution also affect the quality of Southern Resident killer whale prey in Puget Sound. Chemical contamination of prey is a potential threat to Southern Resident killer whale critical habitat, despite the enactment of modern pollution controls in recent decades, which were successful in reducing, but not eliminating, the presence of many contaminants in the environment. The size of Chinook salmon is also an important aspect of prey quality (i.e., Southern Residents primarily consume large Chinook), and any reduction in Chinook salmon size is therefore a threat to their critical habitat. In addition, vessels and sound may reduce the effective zone of echolocation and reduce availability of fish for the whales in their critical habitat (Holt 2008).

Passage: Southern Residents are highly mobile and use a variety of areas for foraging and other activities, as well as for traveling between these areas. Human activities can interfere with movements of the whales and affect their passage. In particular, vessels may present obstacles to whale passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior (review in NMFS 2011c).

2.3 Action Area

“Action area” means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For the purposes of this opinion, the action area (**Figure 12**) includes all marine and freshwater fishing areas in Puget Sound and the western Strait of Juan de Fuca to Cape Flattery within the United States; and certain high seas and territorial waters westward from the U.S. coast between 48 and 49 degrees N. latitude during the period of Fraser Panel control (a detailed description of U.S. Panel Area waters can be found at 50 CFR 300.91, Definitions). Within this area, U.S. Fraser Panel fisheries occur in the Strait of Juan de Fuca region (treaty Indian drift net fisheries) Catch Reporting Areas 4B, 5, and 6C, and in the San Juan Islands region (treaty Indian drift net, set net, and purse seine fisheries; and non-treaty drift net, reef net, and purse seine fisheries) Catch Reporting Areas 6, 6A (treaty only), 7, and 7A. To assess the effects of the proposed actions on the Southern

Resident killer whale DPS, we considered the geographic area of overlap in the marine distribution of Chinook salmon affected by the action, and the range of Southern Resident killer whales. The marine range of the salmonids overlaps with the core area of the whales' range in inland marine waters from the southern Strait of Georgia (below Vancouver and Nanaimo B.C.) to southern Puget Sound and the Strait of Juan de Fuca.

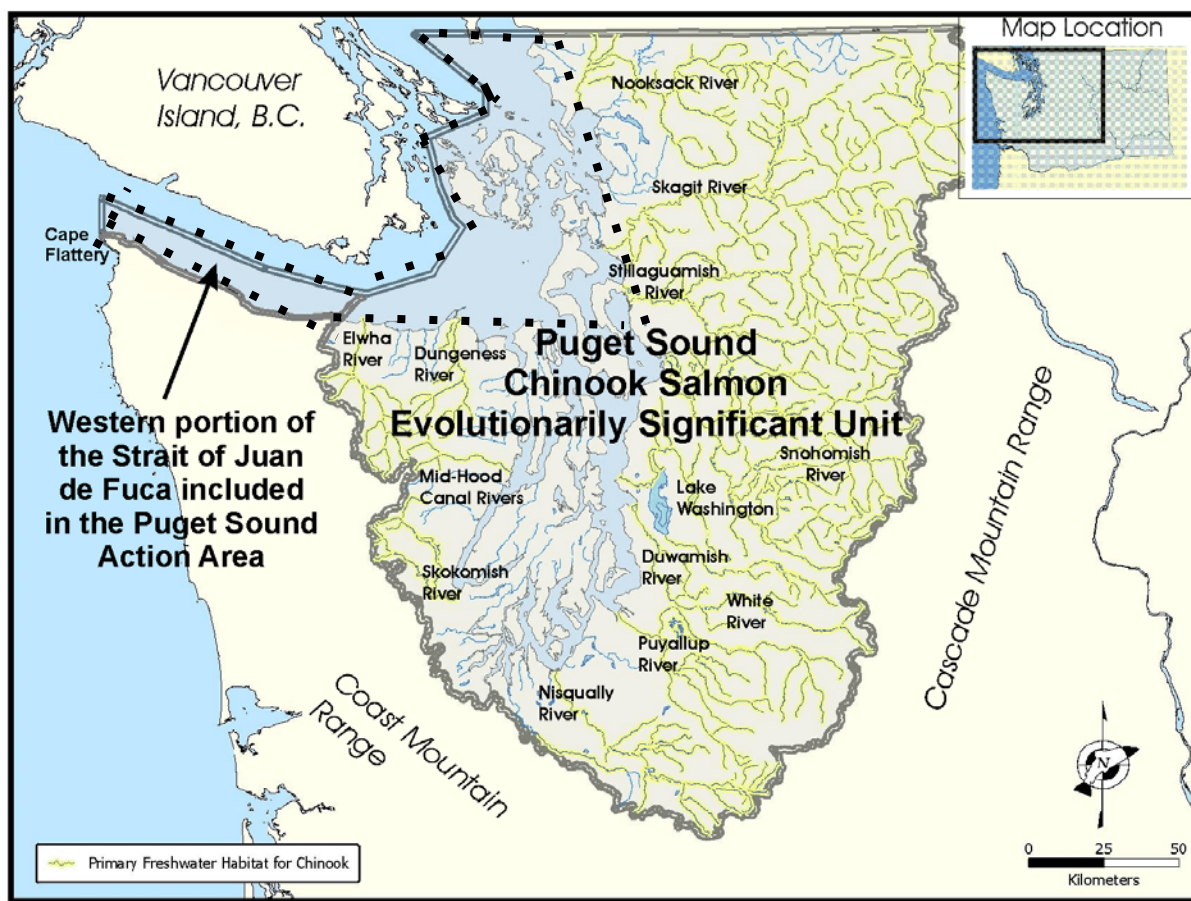


Figure 12. Puget Sound Action Area, which includes the Puget Sound Chinook ESU and the western portion of the Strait of Juan de Fuca in the United States. Dashed area denotes waters in U.S. Fraser Panel jurisdiction.

2.4 Environmental Baseline

The “environmental baseline” includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02). The environmental baseline for the species affected by the proposed actions includes the effects of many activities that occur across the broad expanse of the action area considered in this opinion. The status of the species described in Section 2.2 of the biological opinion is a consequence of those effects.

NMFS recognizes the unique status of treaty Indian fisheries and their relation to the environmental baseline. Implementation of treaty Indian fishing rights involves, among other things, application of the sharing principles of *United States v. Washington*, annual calculation of allowable harvest levels and exploitation rates, the application of the “conservation necessity principle” articulated in *United States v. Washington* to the regulation of treaty Indian fisheries, and an understanding of the interaction between treaty rights and the ESA on non-treaty allocations. Exploitation rate calculations and harvest levels to which the sharing principles apply, in turn, are dependent upon various biological parameters, including the estimated run sizes for the particular year, the mix of stocks present, the allowable fisheries and the anticipated fishing effort. The treaty fishing right itself exists and must be accounted for in the environmental baseline, although the precise quantification of treaty Indian fishing rights during a particular fishing season cannot be established by a rigid formula.

If, after completing this ESA consultation, circumstances change or unexpected consequences arise that necessitate additional Federal action to avoid jeopardy determinations for ESA listed species, such action will be taken in accordance with standards, principles, and guidelines established under *United States v. Washington*, Secretarial Order 3206, and other applicable laws and policies. The conservation principles of *United States v. Washington* will guide the determination of appropriate fishery responses if additional harvest constraints become necessary. Consistent with the September 23, 2004 Memorandum for the Heads of Executive Departments and Agencies pertaining to Government-to-Government Relationship with Tribal Governments and Executive Order 13175, Departmental and agency consultation policies guiding their implementation, and administrative guidelines developed to implement Secretarial Order 3206, these responses are to be developed through government-to-government discourse involving both technical and policy representatives of the West Coast Region and affected Indian tribes prior to finalizing a proposed course of action.

2.4.1 Puget Sound Chinook and Steelhead

NMFS has convened recovery planning efforts across the Pacific Northwest to identify what actions are needed to recover listed salmon and steelhead. A recovery plan for the Puget Sound Chinook ESU was completed in 2007. This plan is made up of two documents: a locally developed recovery plan and a NMFS-developed supplement ([Puget Sound Salmon Recovery Plan](http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/PS-Recovery-Plan.cfm) (SSPS 2007) <http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/PS-Recovery-Plan.cfm> and [Final Supplement to the Shared Strategy’s Puget Sound Salmon Recovery Plan](http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/upload/PS-Supplement.pdf) (NMFS 2006c) <http://www.nwr.noaa.gov/Salmon-Recovery-Planning/Recovery-Domains/Puget-Sound/upload/PS-Supplement.pdf>). In 2014, a Puget Sound Steelhead Recovery Team was established and recovery planning for Puget Sound steelhead is underway. NMFS anticipates to have a draft Puget Sound steelhead recovery plan available for public review in 2018 with a final plan completed in 2019. More information on the recovery planning process and draft documents for public comment are available at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/puget_sound/overview_puget_sound_steelhead_recovery_2.html. NMFS expects that both Federal and State steelhead recovery and management efforts will provide new

tools and data and technical analyses to further refine Puget Sound steelhead population structure and viability, if needed, and better define the role of individual populations at the watershed level and in the DPS. Future consultations will incorporate information from the recovery planning process as it becomes available.

Climate change and other ecosystem effects

Changes in climate and ocean conditions happen on several different time scales and have had a profound influence on distributions and abundances of marine and anadromous fishes. Evidence suggests that marine survival among salmonids fluctuates in response to 20 to 30-year cycles of climatic conditions and ocean productivity. The fluctuations in salmon survival that occur with these changes in climate conditions can also affect species that depend on salmon for prey such as Southern Resident killer whales. More detailed discussions about the likely effects of large-scale environmental variation on salmonids, including climate change, are found in Section 2.2.1 of this opinion, and biological opinions on the 2008 Pacific Salmon Treaty Agreement (NMFS 2008d) and the Pacific Coast Salmon Plan effects on Lower Columbia River Chinook (NMFS 2012c). The University of Washington Climate Impacts Group summarized the current state of knowledge of climate change and anticipated trends on Puget Sound and its environs including those that would affect salmon (Mauger et al. 2015). Warmer streams, ocean acidification, lower summer stream flows, and higher winter stream flows are projected to negatively affect salmon. The persistence of cold water “refugia” within rivers and the diversity among salmon populations will be critical in helping salmon populations adapt to future climate conditions. Similar types of effects on salmon may occur in the marine ecosystem including warmer water temperatures, loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (Mauger et al. 2015).

Harvest

Salmon and steelhead fisheries

In the past, fisheries in Puget Sound were generally not managed in a manner appropriate for the conservation of naturally spawning Chinook salmon populations. Fisheries exploitation rates were in most cases too high—even in light of the declining pre-harvest productivity of natural Chinook salmon stocks. In response, over the past several decades, the co-managers implemented strategies to manage fisheries to reduce harvest impacts and to implement harvest objectives that are consistent with the underlying productivity of the natural populations. Time and area closures, and selective gear types are implemented to reduce catches of weak stocks and to reduce Chinook salmon and steelhead bycatch in fisheries targeting other salmon species. Other regulations, such as size limits, bag limits, mark-selective fisheries and requirements for the use of barbless hooks in all recreational fisheries are also used to achieve these objectives while providing harvest opportunities. Exploitation rates for most of the Puget Sound Chinook management units have been reduced substantially since the late 1990s compared to years prior to listing (average reduction = -35%, range = -18 to -58%). The effect of these overall reductions in harvest has been to improve the baseline condition and help to alleviate the effect of harvest as a limiting factor. Since 2010, the state and Tribal fishery co-managers managed Chinook mortality in Puget Sound salmon and Tribal steelhead fisheries to meet the conservation and

allocation objectives described in the jointly-developed 2010-2014 Puget Sound Chinook Harvest RMP (PSIT and WDFW 2010a), and as amended in 2014 (Grayum and Anderson 2014, Redhorse 2014), 2015 and 2016 (Grayum and Unsworth 2015, Shaw 2015, Shaw 2016). The 2010-2014 Puget Sound Chinook Harvest RMP was adopted as the harvest component of the Puget Sound Salmon Recovery Plan which includes the Puget Sound Chinook ESU (NMFS 2011a). Recent year exploitation rates are summarized in **Table 9**.

Forty percent or more of the harvest of most Puget Sound Chinook stocks occurs in salmon fisheries outside the Action Area, primarily in Canadian waters (**Table 9**). These fisheries are managed under the terms of the Pacific Salmon Treaty Agreement and the Pacific Fisheries Management Council. The effects of these fisheries were assessed in previous biological opinions (NMFS 2004a; 2008e).

Table 9. Average 2008 to 2014 total and southern U.S. (SUS) exploitation rates (ER) for Puget Sound Chinook management units (see Table 3 for correspondence to populations).

Management Unit	% of total ER in AK/CAN fisheries	SUS Exploitation Rate (PFMC and PS fisheries)	Total Exploitation Rate	Total ER Pre-listing (1992-1998)
Nooksack early	77%	9%	40%	48%
Skagit spring	49%	10%	21%	23%
Skagit summer/fall	57%	21%	47%	44%
Stillaguamish	69%	7%	24%	34%
Snohomish	65%	7%	19%	39%
Lake Washington	48%	15%	29%	42%
Duwamish-Green River	41%	23%	37%	48%
White River	32%	16%	23%	28%
Puyallup River	27%	39%	53%	58%
Nisqually River	18%	48%	58% *	74%
Skokomish River	21%	45%	57% *	39%
Mid-Hood Canal rivers	55%	10%	22%	31%
Dungeness River	72%	5%	20%	12%
Elwha River	77%	4%	19%	17%

*Beginning in 2010, the Skokomish Chinook Management Unit was managed for 50% and the Nisqually Chinook Management Unit was managed for a stepped harvest rate of 65% (2010-11) – 56% (2012-2013) – 52% (2014-2015), 50% (2016).

Steelhead are caught in marine areas and in river systems throughout Puget Sound. NMFS observed that previous harvest management practices likely contributed to the historical decline of Puget Sound steelhead, but concluded in the Federal Register Notice for the listing determination (72 FR 26732, May 11, 2007) that the elimination of the direct harvest of wild steelhead in the mid-1990s has largely addressed this threat. The recent NWFSC status review update concluded that current harvest rates on natural-origin steelhead continue to decline and are unlikely to substantially reduce spawner abundance of most Puget Sound steelhead populations (NWFSC 2015).

In marine areas, the majority of fisheries target salmon species other than steelhead. However, Puget Sound treaty marine salmon fisheries encounter listed summer and winter steelhead. An annual average of 126 (hatchery and wild combined) (range 7 – 266) summer and winter steelhead were landed incidentally in treaty marine fisheries (commercial and ceremonial and subsistence) from all Puget Sound marine areas combined during the 2001/2002 to 2006/2007 time period (NMFS 2010b). An annual average of 72 (hatchery and wild combined) (range 9 – 252) summer and winter steelhead were landed incidentally in treaty marine fisheries from all Puget Sound marine areas combined during the 2008/2009 to 2015/2016 time period (NMFS 2017b). Catch in tribal commercial and ceremonial and subsistence marine fisheries continues to be low. Not all tribal catch is sampled for marks so these estimates represent catch of ESA-listed steelhead, unlisted hatchery steelhead, and hatchery and natural-origin fish from Canada (Beattie 2014).

In marine non-treaty salmon commercial fisheries retention of steelhead is prohibited (RCW 77.12.760 1993). Encounters of steelhead in non-treaty commercial fisheries targeting other salmon species in marine areas of Puget Sound are rare. In an observer study by WDFW to estimate the incidental catch rate of steelhead in non-treaty commercial salmon fisheries, 20 steelhead were encountered in 5,058 net sets over an 18 year period (i.e., 1991 to 2008) (i.e., 1 fish annually (Jording 2010). Over the most recent eight year period from 2009 to 2016, 32 steelhead were encountered in 2,959 net sets estimated at 4 steelhead per year (Henry 2017). Over the 24 year observer time period from 1991 to 2015, 52 steelhead were encountered in 7,781 net sets averaging 2 steelhead encounters annually (Henry 2016) indicating that encounters of steelhead in non-treaty commercial salmon fisheries remain uncommon. Incidental catch of steelhead is not sampled for marks in order to return the bycatch to the water as quickly as possible (Henry 2014). As a consequence, the catch estimates include catch of ESA-listed steelhead, unlisted hatchery steelhead, and hatchery and natural-origin fish from Canada.

In marine non-treaty recreational fisheries, an annual average of 198 (range 102 – 352) hatchery summer and winter steelhead were landed incidentally from all Puget Sound marine areas combined during the 2001/2002 to 2006/2007 time period (Leland 2010). An annual average of 100 (range 22 – 213) hatchery summer and winter steelhead were landed incidentally in non-treaty marine recreational fisheries from all Puget Sound marine areas combined during the 2008/2009 to 2015/2016 time period (Kraig 2017). The catch of steelhead in recreational fisheries has therefore declined by 49.5% in recent years. There is some additional mortality associated with the catch-and-release of unmarked steelhead in the recreational fishery. However, the mortality rate associated with catch-and-release is 10%, so the additional mortality is assumed to be low.

In summary, at the time of listing, during the 2001/02 to 2006/07 seasons, an average of 325 steelhead were caught in marine treaty and non-treaty commercial, ceremonial and subsistence (C&S), and recreational fisheries (i.e., 126 treaty marine; 1 non-treaty commercial; 198 non-treaty recreational). An average of 176 steelhead were caught in marine treaty and non-treaty commercial, ceremonial and subsistence, and recreational fisheries (i.e., 72 treaty marine; 4 non-treaty commercial; 100 non-treaty recreational) for the most recent time period (2007/2008 to

2015/2016) (**Table 10**). The fish caught include ESA-listed steelhead, unlisted hatchery steelhead, and hatchery and natural-origin fish from Canada. Overall, the average treaty and non-treaty catch in marine area fisheries has declined by 46% compared with the earlier period.

Table 10. Marine area catch on steelhead from 2001/02 to 2006/07 and 2007/08 to 2015/16 time periods.

Time Period	Marine Catch			
	Treaty commercial & C&S	Non-Treaty Commercial	Non-Treaty Recreational	Total
2001/02 to 2006/07	126	1	198	325
2007/08 to 2015/16	72	4	100	176

In Puget Sound freshwater areas, the non-treaty harvest of steelhead occurs in recreational hook-and-line fisheries targeting adipose fin-clipped hatchery summer run and winter run steelhead. Washington State prohibits the retention of natural-origin steelhead (those without a clipped adipose fin) in recreational fisheries as well. Treaty fisheries retain both natural-origin and hatchery steelhead. The treaty freshwater fisheries for winter steelhead target primarily hatchery steelhead by fishing during the early winter months when hatchery steelhead are returning to spawn and natural-origin steelhead are at low abundance. Fisheries capture natural-origin summer run steelhead incidentally while targeting other salmon species, but are presumed to have limited impact because the fisheries start well after the summer spawning period, and are located primarily in lower and mid-mainstem rivers where natural-origin summer steelhead (if present) are believed not to hold for an extended period (PSIT and WDFW 2010b). However, some natural-origin late winter and summer run steelhead, including winter run kelts (repeat spawners), are intercepted in Skagit River salmon and steelhead marine and freshwater fisheries. A small number of natural-origin summer steelhead are also encountered in Nooksack River spring Chinook salmon fisheries.

Available data on escapement of summer, winter, and summer/winter steelhead stocks in Puget Sound are limited. Complete long-term time series of escapement and catch to complete run reconstruction are available for none of the six Puget Sound summer run populations, four out of the twenty-two winter run populations, and one out of the three summer/winter run populations (Marshall 2014). Data are currently insufficient to provide a full run reconstruction of natural-origin steelhead populations needed to assess harvest rates for any of the summer run steelhead populations or most summer/winter and winter run populations. Given the circumstances, NMFS used the available data for the five Puget Sound winter and summer/winter steelhead populations to calculate terminal harvest rates on natural-origin steelhead. NMFS calculated that the harvest rate on a subset of watersheds for natural-origin steelhead averaged 4.2% annually in Puget Sound fisheries during the 2001/2002 to 2006/2007 time period (NMFS 2010b) (**Table 11**). Average harvest rates on the same subset of watersheds for natural-origin steelhead demonstrated a reduction to 1.6% in Puget Sound fisheries during the 2007/2008 to 2015/2016 time period (**Table 11**). These estimates include sources of non-landed mortality such as hooking mortality

and net dropout, 10% and 2% respectively. Overall, the average harvest rate for these five indicator populations declined by 62% in recent years (i.e., 4.2% to 1.6% harvest rate = 61.9% decline).

Table 11. Tribal and non-tribal terminal harvest rate (HR) percentages on natural-origin steelhead for a subset of Puget Sound winter steelhead populations for which catch and run size information are available (NMFS 2015b; WDFW and PSIT 2017).

Year	Skagit	Snohomish	Green	Puyallup	Nisqually ^a
2001-02	4.2	8.0	19.1	15.7	N/A
2002-03	0.8	0.5	3.5	5.2	N/A
2003-04	2.8	1.0	0.8	2.2	1.1
2004-05	3.8	1.0	5.8	0.2	3.5
2005-06	4.2	2.3	3.7	0.8	2.7
2006-07	10.0	N/A ^b	5.5	1.7	5.9
Avg HRs 2001-07	4.3	2.6	6.4	4.3	3.3
Total Avg HR	4.2% total average harvest rate across populations from 2001-02 to 2006-07				
2007-08	5.90	0.40	3.50	1.00	3.70
2008-09	4.90	1.10	0.30	0.00	3.70
2009-10	3.30	2.10	0.40	0.00	1.20
2010-11	3.40	1.50	1.60	0.60	1.80
2011-12	2.90	0.90	2.00	0.40	2.50
2012-13	2.30	1.10	2.38	0.70	1.10
2013-14	2.60	0.89	1.09	0.56	1.33
2014-15	1.25	1.00	1.05	0.54	0.89
2015-16	1.12	0.09	0.92	0.06	0.2
Avg HRs 2007-16	3.1	1.1	1.5	0.4	1.8
Total Avg HR	1.6% total average harvest rate across all populations from 2007-08 to 2015-16				
Total average HR 2001-02 to 2015-16	2.88				

^a Escapement methodology for the Nisqually River was adjusted in 2004; previous estimates are not comparable.

^b Catch estimate not available in 2006-07 for Snohomish River.

As mentioned above, NMFS concluded in the final steelhead listing determination that previous harvest management practices likely contributed to the historical decline of Puget Sound steelhead, but that the elimination of the directed harvest of wild steelhead in the mid-1990s largely addressed the threat of decline to the listed DPS posed by harvest and the NWFSC's recent status review update confirmed continued declines in natural-origin steelhead harvest rates are not likely to substantially affect steelhead spawner abundance in the DPS (NWFSC 2015).

Halibut Fisheries

Commercial and recreational halibut fisheries occur in the Strait of Juan de Fuca and San Juan Island areas of Puget Sound. In a recent biological opinion, NMFS concluded that salmon are not likely to be caught incidentally in the commercial or tribal halibut fisheries when using halibut

gear (NMFS 2017c). The total estimated non-retention mortality of Chinook salmon in Puget Sound recreational halibut fisheries is extremely low, averaging two Chinook salmon per year. Of these, the estimated catch of listed fish (hatchery and wild) is about one Puget Sound Chinook per year. Given the very low level of impacts and the fact that the fishery occurs in mixed stock areas, different populations within the ESUs are likely affected each year. No steelhead have been observed in the fishery.

Puget Sound bottomfish and shrimp trawl fisheries

Recreational fishers targeting bottom fish and the shrimp trawl fishery in Puget Sound can incidentally catch listed Puget Sound Chinook. In 2012 NMFS issued an incidental take permit to the WDFW for listed species caught in these two fisheries, including Puget Sound Chinook salmon (NMFS 2012d). The permit will be in effect for 5 years and authorizes the total incidental take of up to 92 Puget Sound Chinook salmon annually. Some of these fish will be released. Some released fish are expected to survive; thus, of the total takes, we authorized a subset of lethal take of up to 50 Chinook salmon annually.

Hatcheries

Hatcheries can provide benefits by reducing demographic risks and preserving genetic traits for populations at low abundance in degraded habitats; providing harvest opportunity is an important contributor to upholding the meaningful exercise of treaty rights for the Northwest tribes. Hatchery-origin fish may also pose risk through genetic, ecological, or harvest effects. Seven factors may pose positive, negligible, or negative effects to population viability of naturally-produced salmon and steelhead. These factors are:

- (1) the hatchery program does or does not remove fish from the natural population and use them for hatchery broodstock,
- (2) hatchery fish and the progeny of naturally spawning hatchery fish on spawning grounds and encounters with natural-origin and hatchery fish at adult collection facilities,
- (3) hatchery fish and the progeny of naturally spawning hatchery fish in juvenile rearing areas,
- (4) hatchery fish and the progeny of naturally spawning hatchery fish in the migration corridor, estuary, and ocean,
- (5) research, monitoring, and evaluation that exists because of the hatchery program,
- (6) the operation, maintenance, and construction of hatchery facilities that exist because of the hatchery program, and
- (7) fisheries that exist because of the hatchery program, including terminal fisheries intended to reduce the escapement of hatchery-origin fish to spawning grounds.

Beginning in the 1990s, state and tribal co-managers took steps to reduce risks identified for Puget Sound hatchery programs as better information became available (PSTT and WDFW 2004), in response to reviews of hatchery programs (e.g., Busack and Currens 1995, HSRG 2000, HSRG 2002), and as part of the region-wide Puget Sound salmon recovery planning effort (SSPS 2007). The intent of hatchery reform is to reduce negative effects of artificial propagation on natural populations while retaining proven production and potential conservation benefits. The goals of conservation programs are to restore and maintain natural populations. Hatchery

programs in the Pacific Northwest are phasing out use of dissimilar broodstocks, such as out-of-basin or out-of-ESU stocks, replacing them with fish derived from, or more compatible with, locally adapted populations. Producing fish that are better suited for survival in the wild is now an explicit objective of many salmon hatchery programs. Hatchery programs are also incorporating improved production techniques, such as NATURES-type rearing protocols¹⁴ and limits on the duration of conservation hatchery programs. The changes proposed are to ensure that existing natural salmonid populations are preserved, and that hatchery-induced genetic and ecological effects on natural populations are minimized.

About one-third of the hatchery programs in Puget Sound incorporate natural-origin Chinook salmon as broodstock for supportive breeding (conservation) or harvest augmentation purposes. Use of natural-origin fish as broodstock for conservation programs is intended to impart viability benefits to the total, aggregate population by bolstering total and naturally spawning fish abundance, preserving remaining diversity, or improving population spatial structure by extending natural spawning into unused areas. Integration of natural-origin fish for harvest augmentation programs is intended to reduce genetic diversity reduction risks by producing fish that are no more than moderately diverged from the associated, donor natural population. Incorporating natural-origin fish as broodstock for harvest programs produces hatchery fish that are genetically similar to natural-origin fish, reducing risks to the natural population that may result from unintended straying and spawning by unharvested hatchery-origin adults in natural spawning areas. To allow monitoring and evaluation of the performance and effects of programs incorporating natural-origin fish as broodstock, all juvenile fish are marked prior to release with CWTs or with a clipped adipose fin so that they can be differentiated and accounted for separately from juvenile and returning adult natural-origin fish.

Chinook salmon stocks are artificially propagated through 41 programs in Puget Sound. Currently, the majority of Chinook salmon hatchery programs produce fall-run (also called summer/fall) stocks for fisheries harvest augmentation purposes. Supplementation programs implemented as conservation measures to recover early returning Chinook salmon operate in the White (Appleby and Keown 1994), Dungeness (Smith and Sele 1995), and North Fork Nooksack rivers, and for summer Chinook salmon on the North Fork Stillaguamish and Elwha Rivers (Fuss and Ashbrook 1995; Myers et al. 1998). Supplementation or re-introduction programs are in operation for early Chinook in the South Fork Nooksack River, fall Chinook in the South Fork Stillaguamish River (Tynan 2010) and spring and late-fall Chinook in the Skokomish River (Redhorse 2014, Speaks 2017).

There are currently 13 hatchery programs in Puget Sound that propagate steelhead. Currently there are five steelhead supplementation programs operating for natural-origin winter run steelhead conservation purposes in Puget Sound. Fish produced through the five conservation

¹⁴ A fundamental assumption is that improved rearing technology will reduce environmentally induced physiological and behavioral deficiencies presently associated with cultured salmonids. NATURES-type rearing protocols includes a combination of underwater feed-delivery systems, submerged structure, overhead shade cover, and gravel substrates, which have been demonstrated in most studies to improve instream survival of Chinook salmon (*O. tshawytscha*) smolts during seaward migrations.

programs are designated as part of the listed Puget Sound Steelhead DPS, and are protected with their associated natural-origin counterparts from take (79 FR 20802, April 14, 2014). In the Central/Southern Cascade MPG, two conservation programs operate to rebuild the native Green River winter-run steelhead population, and one program is implemented to recover the native White River winter-run population. The other two conservation programs have operated to conserve steelhead populations that are part of the Hood Canal and Strait of Juan de Fuca MPG. The Hood Canal Steelhead Supplementation Program functioned to rebuild native stock winter-run steelhead abundances in the Dewatto, Duckabush, and South Fork Skokomish river watersheds. That program has been terminated with the last adult fish produced returning in 2019. The Elwha River Native Steelhead program preserves and assists in the recolonization of native Elwha River winter-run steelhead. Listed hatchery-origin steelhead from the integrated programs listed above produce fish that are similar to the natural-origin steelhead populations, are designed for conservation of the ESA-listed populations, and allow for natural spawning of hatchery-origin fish. One new steelhead program has been proposed for the DPS. The Fish Restoration Facility winter-run steelhead program propagates winter-run steelhead native to the Green River to mitigate for lost natural-origin steelhead abundance and harvest levels associated with the placement and operation of Howard Hanson Dam (Jones 2015).

Five other hatchery programs in the Puget Sound region produce early winter-run steelhead (EWS) that are not considered part of the Puget Sound Steelhead DPS - Dungeness River Hatchery, Kendall Creek Hatchery, Whitehorse Ponds, Snohomish/Skykomish River (Wallace River Hatchery and Reiter Ponds Hatchery), and Tokul Creek Hatchery. After a two year hiatus in response to a settlement agreement between WDFW and an environmental group, smolt releases from these programs were reinitiated in 2016 after their approval by NMFS under ESA 4(d) rule, limit 6 for effects on ESA-listed steelhead and Chinook salmon (NMFS 2016d, 2016f). Three other harvest augmentation programs propagate non-listed early summer-run steelhead (ESS) derived from Columbia River, Skamania stock. These summer-run steelhead programs have yet to receive ESA approval from NMFS. The EWS and ESS stocks reared and released as smolts through the eight programs are considered more than moderately diverged from any natural-origin steelhead stocks in the region and were therefore excluded from the Puget Sound Steelhead DPS. Gene flow from naturally spawning fish produced by the eight hatchery programs may pose genetic risks to natural-origin steelhead (NMFS 2016c). However, in evaluating and approving the EWS programs for effects on listed fish (NMFS 2016d; 2016f), and based on analyses of genetic data provided by WDFW (Warheit 2014), NMFS determined that gene flow levels for the five EWS programs were very low and unlikely to pose substantial genetic diversity reduction risks to natural-origin winter-run steelhead populations. Of particular importance to this harvest evaluation is that EWS have been artificially selected to return and spawn in peak abundance as adults earlier in the winter than the associated natural-origin Puget Sound winter-run steelhead populations in the watersheds where the hatchery fish are released. This timing difference, in addition to other factors, including hatchery risk reduction management measures that reduce natural spawning and natural spawning success by EWS act to reduce gene flow and associated genetic risks to natural-origin steelhead. The temporal separation between EWS and natural-origin steelhead adult return and spawn timing provides

protection to the later-returning natural-origin steelhead populations in harvest areas when and where fisheries directed at EWS occur (Crawford 1979)."

On April 15, 2016, NMFS announced the release of a FEIS (NMFS 2016c) and signed a Record of Decision (ROD). The FEIS and 4(d) assessment reviewed five HGMPs for early winter steelhead hatchery programs submitted by the co-managers for review and approval under section 4(d) of the ESA. As mentioned above, the HGMPs describe five early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins. NMFS subsequently approved the programs as consistent with ESA requirements (Turner 2016a, Turner 2016b).

As described in Section 2.2.1.2, NWFSC (2015) noted that hatchery steelhead releases in Puget Sound have declined in most areas. The Puget Sound Early Winter Steelhead FEIS indicated that steelhead hatchery releases decreased from about 2,468,000 annually (NMFS 2014b) to about 1,504,750 annually (Appendix A in NMFS 2016c). Hatchery programs propagating unlisted winter steelhead account for the majority of hatchery-origin steelhead smolt releases (531,600) for a total of 841,600 unlisted smolts released annually (including 310,000 summer steelhead) in the Puget Sound DPS (Appendix A in NMFS 2016c).

Habitat

Human activities have degraded extensive areas of salmon spawning and rearing habitat in Puget Sound. Most devastating to the long term viability of salmon has been the modification of the fundamental natural processes which allowed habitat to form and recover from disturbances such as floods, landslides, and droughts. Among the physical and chemical processes basic to habitat formation and salmon persistence are floods and droughts, sediment transport, heat and light, nutrient cycling, water chemistry, woody debris recruitment and floodplain structure (SSPS 2007).

Development activities have limited access to historical spawning grounds and altered downstream flow and thermal conditions. Watershed development and associated urbanization throughout the Puget Sound, Hood Canal, and Strait of Juan de Fuca regions have resulted in direct loss of riparian vegetation and soils, significantly altered hydrologic and erosion rates and processes by creating impermeable surfaces (roads, buildings, parking lots, sidewalks etc.), and polluting waterways, raised water temperatures, decreased large woody debris recruitment, decreased gravel recruitment, reduced river pools and spawning areas, and dredged and filled estuarine rearing areas (Bishop and Morgan 1996). Hardening of nearshore bank areas with riprap or other material has altered marine shorelines; changing sediment transport patterns and reducing important juvenile habitat (SSPS 2005a). The development of land for agricultural purposes has resulted in reductions in river braiding, sinuosity, and side channels through the construction of dikes, hardening of banks with riprap, and channelization of the river mainstems (EDPU 2005, SSPS 2005a). Poor forest practices in upper watersheds have resulted in bank destabilization, excessive sedimentation and removal of riparian and other shade vegetation important for water quality, temperature regulation and other aspects of salmon rearing and spawning habitat (SSPS 2005a, SSPS 2007). There are

substantial habitat blockages by dams in the Skagit and Skokomish River basins, in the Elwha until 2013, and minor blockages, including impassable culverts, throughout the region. Historically, low flows resulting from operation of the Cushman dams and habitat degradation of freshwater and estuarine habitat have adversely affected the Skokomish population. A settlement agreement in 2008 between the Skokomish Tribe and Tacoma Power, the dam operator, resulted in a plan to restore normative flows to the river, improve habitat, and restore an early Chinook life history in the river using supplementation. Significant work is occurring to stabilize river channels, restore riparian forests, improve adult access to the South Fork Skokomish, and improve and restore estuarine habitat through land acquisition, levee breaching and similar projects (Skokomish and WDFW 2010, Redhorse 2014). In general, habitat has been degraded from its pristine condition, and this trend is likely to continue with further population growth and resultant urbanization in the Puget Sound region.

Habitat utilization by steelhead in the Puget Sound area has been dramatically affected by large dams and other manmade barriers in a number of drainages, including the Nooksack, Skagit, White, Nisqually, Skokomish, and Elwha¹⁵ river basins (Appendix B in NMFS 2012a). In addition to limiting habitat accessibility, dams affect habitat quality through changes in river hydrology, altered temperature profile, reduced downstream gravel recruitment, and the reduced recruitment of large woody debris. Such changes can have significant negative impacts on salmonids (e.g., increased water temperatures resulting in decreased disease resistance) (Spence et al. 1996, McCullough 1999).

Many upper tributaries in the Puget Sound region have been affected by poor forestry practices, while many of the lower reaches of rivers and their tributaries have been altered by agriculture and urban development (Appendix B in NMFS 2012a). Urbanization has caused direct loss of riparian vegetation and soils, significantly altered hydrologic and erosional rates and processes (e.g., by creating impermeable surfaces such as roads, buildings, parking lots, sidewalks etc.), and polluted waterways with stormwater and point-source discharges (Appendix B in NMFS 2012a). The loss of wetland and riparian habitat has dramatically changed the hydrology of many streams, with increases in flood frequency and peak low during storm events and decreases in groundwater driven summer flows (Moscrip and Montgomery 1997, Booth et al. 2002, May et al. 2003). River braiding and sinuosity have been reduced in Puget Sound through the construction of dikes, hardening of banks with riprap, and channelization of the mainstem (NMFS 2012a). Constriction of river flows, particularly during high flow events, increases the likelihood of gravel scour and the dislocation of rearing juveniles. The loss of side-channel habitats has also reduced important areas for spawning, juvenile rearing, and overwintering habitats. Estuarine areas have been dredged and filled, resulting in the loss of important juvenile rearing areas (NMFS 2012a). In addition to being a factor that contributed to the present decline of Puget Sound steelhead populations, the continued destruction and modification of steelhead habitat is the principal factor limiting the viability of the Puget Sound steelhead DPS into the foreseeable future (72 Fed. Reg. 26722, May 11, 2007). Because of their limited distribution in upper tributaries, summer run steelhead may be at higher risk than winter run steelhead from

¹⁵ The Elwha dams have been removed, which has significantly changed the Elwha River's hydrology and now allows for steelhead and salmon access to miles of historical habitat upstream.

habitat degradation in larger, more complex watersheds (Appendix B in NMFS 2012a).

NMFS has completed several section 7 consultations on large scale projects affecting listed species in Puget Sound. Among these are the Washington State Forest Practices Habitat Conservation Plan (NMFS 2006b), and consultations on Washington State Water Quality Standards (NMFS 2008b), Washington State Department of Transportation Preservation, Improvement, and Maintenance Activities (NMFS 2013a), the National Flood Insurance Program (NMFS 2008c), and the Elwha River Fish Restoration Plan (Ward et al. 2008). These documents considered the effects of the proposed actions that would occur up to the next 50 years on the ESA listed salmon and steelhead species in the Puget Sound basin. Information on the status of these species, the environmental baseline, and the effects of the proposed actions are reviewed in detail. The environmental baselines in these documents consider the effects from timber, agriculture and irrigation practices, urbanization, hatcheries and tributary habitat, estuary, and large scale environmental variation. These biological opinions and HCPs, in addition to the watershed specific information in the Puget Sound Salmon Recovery Plan mentioned above, provide a current and comprehensive overview of baseline habitat conditions in Puget Sound and are incorporated here by reference.

2.4.2 Puget Sound/Georgia Basin Rockfish

The Puget Sound and Georgia Basin comprise the southern arm of an inland sea located on the Pacific Coast of North America that is directly connected to the Pacific Ocean. Most of the water exchange in Puget Sound proper is through Admiralty Inlet near Port Townsend, and the configuration of sills and deep basins results in the partial recirculation of water masses and the retention of contaminants, sediment, and biota (Rice 2007). Tidal action, freshwater inflow, and ocean currents interact to circulate and exchange salty marine water at depth from the Strait of Juan de Fuca, and less dense fresh water from the surrounding watersheds at the surface produce a net seaward flow of water at the surface (Rice 2007).

Listed rockfish are linked to numerous other fish species in Puget Sound through the food web. Groundfish (often referred to as demersal fish, or bottom fish), make up the majority of the estimated 253 species of fish within Puget Sound (Pietsch and Orr 2015) and comprise the largest number of species in the action area. Groundfish collectively occupy habitats ranging from intertidal zones to the deepest waters of the region.

Most of the benthic deepwater (e.g., deeper than 90 feet) habitats of Puget Sound proper consist of unconsolidated sediments such as sand, mud, and cobbles. The vast majority of the rocky-bottom areas of Puget Sound occur within the San Juan Basin, with the remaining portions spread among the rest of Puget Sound proper (Palsson et al. 2009). Depths in the Puget Sound extend to over 920 feet (280 meters).

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 includes 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 (NRC 2010).

Over the last century, human activities have introduced a variety of toxins into the Georgia Basin at levels that may affect adult and juvenile rockfish habitat and/or the prey that support them. Toxic pollutants in Puget Sound include oil and grease, polychlorinated biphenyls (PCBs), phthalates, PBDEs, and heavy metals that include zinc, copper, and lead. Several urban embayments in Puget Sound have high levels of heavy metals and organic compounds (Palsson et al. 2009). About 32% of the sediments in the Puget Sound region are considered to be moderately or highly contaminated (Puget Sound Action Team 2007), though some areas are undergoing clean-up operations that have improved benthic habitats (Puget Sound Partnership 2010).

Washington State has a variety of marine protected areas managed by 11 Federal, state, and local agencies (Van Cleve et al. 2009, Smith et al. 2012), though some of these areas are outside of the range of the rockfish DPSs. The WDFW has established 25 marine reserves within the DPSs’ range, and 16 host rockfish (Palsson et al. 2009), though most of these reserves are within waters shallower than those typically used by adult yelloweye rockfish or bocaccio. The WDFW reserves total 2,120.7 acres of intertidal and subtidal habitat. The total percentage of the Puget Sound region within reserve status is unknown, though Van Cleve et al. (2009) estimate that one percent of the subtidal habitats of Puget Sound are designated as a reserve. Compared to fished areas, studies have found higher fish densities, sizes, or reproductive activity in the assessed WDFW marine reserves (Eisenhardt 2001, 2002; Palsson 1998, 2004; Palsson and Pacunski 1995). These reserves were established over several decades with unique and somewhat unrelated ecological goals, and encompass relatively small areas (average of 23 acres).

We cannot quantify the effects of degraded habitat on the ESA-listed rockfish because these effects are poorly understood. However, there is sufficient evidence to indicate that ESA-listed rockfish productivity may be negatively impacted from the habitat structure and water quality stressors discussed above (Drake et al. 2010b).

We discuss fisheries management pertinent to listed rockfish that is part of the environmental baseline in the Puget Sound area as a context for the fisheries take evaluated within previous section 7 consultations. In addition, we briefly summarize fisheries management in Canadian waters of the DPSs, as it is relevant to 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 listed rockfish DPSs' range to Cape Flattery. The WDFW extended the closure west of the rockfish DPSs' range 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, 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, and 25 bocaccio annually (consultation number F/NWR/2012/1984). Recreational and commercial halibut fishermen can incidentally catch listed rockfish. Recently we assessed the bycatch associated with the halibut fishery in Puget Sound for the 2017 fishing season. We estimated that up to 335 yelloweye rockfish and 15 bocaccio would be caught in the 2017 fishing season (consultation number 2017/F/WCR/6480).

Fisheries management in British Columbia, Canada (also partially overlapping with the DPSs' range) 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.¹⁶ 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 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).

2.4.3 Southern Resident Killer Whales

Here we incorporate by reference the environmental baseline section description from the 2011, 2014, 2015, and 2016 biological opinions for Southern Resident killer whales (NMFS 2011a, NMFS 2014, 2015, 2016). Below we provide updated information relevant to the Environmental Baseline.

Previous Harvest Actions

In the past harvest opinions (NMFS 2011a, NMFS 2014a, NMFS 2015b, 2016), we characterized the short-term and long-term effects on Southern Residents from prey reduction caused by harvest. We considered the short-term direct effects to whales resulting from reductions in Chinook abundance that occur during a specified year, and the long-term indirect effects to whales that could result if harvest affected viability of the salmon stock over time by decreasing the number of fish that escape to spawn. (In the present opinion we also consider the long-term effects to whales resulting from reductions in Chinook abundance during the specified years of fishing.) These past analyses suggested that in the short term, prey reductions were small relative to remaining prey available to the whales. In the long term, harvest actions have met the conservation objectives of harvested stocks, were not likely to appreciably reduce the survival or recovery of listed Chinook salmon, and were therefore not likely to jeopardize the continued existence of listed Chinook salmon. The harvest biological opinions referenced above concluded that the harvest actions cause prey reductions in a given year, and were likely to adversely affect but were not likely to jeopardize the continued existence of ESA-listed Chinook salmon or Southern Residents.

¹⁶ 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>)

2.4.4 Scientific Research

The listed salmon, steelhead, and rockfish species in this opinion are the subject of scientific research and monitoring activities. Most biological opinions issued by NMFS have conditions requiring specific monitoring, evaluation, and research projects to gather information to aid the preservation and recovery of listed species. The impacts of these research activities pose both benefits and risks. Research on the listed species in the Action Area is currently provided coverage under Section 7 of the ESA or the 4(d) research Limit 7, or included in the estimates of fishery mortality discussed in the Effects of the Proposed Action in this opinion.

For the year 2012 and beyond, NMFS has issued several section 10(a)(1)(A) scientific research permits allowing lethal and non-lethal take of listed species (**Table 12**). In a separate process, NMFS also has completed the review of the state and tribal scientific salmon and research programs under ESA section 4(d) Limit 7. **Table 12** displays the total take for the ongoing research authorized under ESA sections 4(d) and 10(a)(1)(A) for the listed Puget Sound Chinook salmon ESU, the Puget Sound steelhead DPS and Puget Sound/Georgia Basin rockfish species DPS.

Table 12. Annual take allotments for research on listed species in 2013-2017 (Dennis 2017).

Species	Life Stage	Production/Origin	Total Take	Lethal Take
Puget Sound Chinook	Juvenile	Natural	438,512	11,336
		Listed hatchery intact adipose	129,752	5,268
		Listed hatchery clipped adipose	121,581	12,210
	Adult	Natural	971	49
		Listed hatchery intact adipose	298	11
		Listed hatchery clipped adipose	2,623	917
Puget Sound steelhead	Juvenile	Natural	71,414	1,393
		Listed hatchery intact adipose	1,211	14
		Listed hatchery clipped adipose	6,226	131
	Adult	Natural	1,484	31
		Listed hatchery intact adipose	4	
		Listed hatchery clipped adipose	38	6
PS/GB Bocaccio	Adult	Natural	58	27
PS/GB Yelloweye Rockfish	Adult	Natural	116	48

Actual take levels associated with these activities are almost certain to be substantially lower than the permitted levels. There are three reasons for this. First, most researchers do not handle the full number of individual fish they are allowed. Our research tracking system reveals that researchers, on average, end up taking about 37% of the number of fish they estimate needing. Second, the estimates of mortality for each proposed study are purposefully inflated (the amount depends upon the species) to account for potential accidental deaths, and it is therefore very likely that fewer fish (in some cases many fewer), especially juveniles, than the researchers are allotted would be killed during any given research project. Finally, researchers within the same

watershed are encouraged to collaborate on studies (i.e., share fish samples and biological data among permit holders) so that overall impacts to listed species are reduced.

2.5 Effects of the Action on Species and Designated Critical Habitat

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

2.5.1 Puget Sound Chinook

2.5.1.1 Assessment Approach

In assessing the effects of the proposed harvest actions on the Puget Sound Chinook salmon ESU, NMFS first analyzes the effects on individual salmon populations within the ESU using quantitative analyses where possible (i.e., where a sufficiently reliable time series of data is available) and more qualitative considerations where necessary. Risk to the survival and recovery of the ESU is then determined by next assessing the distribution of risk across the populations within each major geographic region and then accounts for the relative role of each population to the viability of the ESU.

The Viable Risk Assessment Procedure (VRAP) provides estimates of the maximum population-specific exploitation rates (called Rebuilding Exploitation Rates or RERs) that are thought to be consistent with survival and recovery of that population based on the assumptions made in deriving the rates for individual populations (Appendix A). In deriving the RERs, NMFS accounts for and makes conservative assumptions regarding management error, environmental uncertainty, and parameter variability. NMFS has established RERs for 11 individual populations within the ESU and for the Nooksack Management Unit. The RERs are converted to FRAM-based (Fishery Regulation and Assessment Model) equivalents (**Table 13**) for the purposes of assessing proposed harvest actions, since FRAM is the analytical tool used by NMFS and the co-managers to assess proposed fishery actions. Surrogate standards are identified for those populations where data are currently insufficient or NMFS has not completed population-specific analyses to establish RERs. Surrogates are based on similarities in population size, life history, productivity, watershed size, and hatchery contribution with other populations in the ESU for which RERs have been derived. We also consider the results of independent analyses conducted using other methods (e.g., analysis of MSY in the Nisqually Chinook Stock Management Plan (2011) for the Nisqually Chinook population).

Although component populations contribute fundamentally to the structure and diversity of the ESU, it is the ESU, not an individual population, which is the listed species under the ESA. NMFS uses the FRAM-equivalent RERs, and the critical and rebuilding escapement thresholds¹⁷

¹⁷ After taking into account uncertainty, the critical threshold is defined as a point below which: (1) compensatory processes are likely to reduce the population below replacement; (2) the population is at risk from inbreeding

in addition to other relevant information and the guidance described below to assist it in evaluating the effects of the proposed actions on survival and recovery of the populations within the ESU.¹⁸ The rates that would result from the proposed fisheries are compared to the relevant RERs. Generally speaking, where estimated impacts of the proposed fisheries are less than or equal to the RERs, NMFS considers the fisheries to present a low risk to that population (NMFS 2004b). However, the RERs for individual populations are not jeopardy standards.

Table 13. Rebuilding Exploitation Rates by Puget Sound Chinook population. Surrogate RERs are italicized.

Region	Management Unit	Population	Rebuilding Exploitation Rate	FRAM-based Rebuilding Exploitation Rate
Strait of Georgia	Nooksack Early	N.F. Nooksack S.F. Nooksack	21%	17%
Whidbey/Main Basin	Skagit Spring	Upper Sauk River Suiattle River Upper Cascade	46% 50%	23% 24% 23-24%
	Skagit Summer/Fall	Upper Skagit River Lower Skagit River Lower Sauk River	54% 36% 33%	45% 30% 28%
	Stillaguamish	N.F. Stillaguamish River S.F. Stillaguamish River	24% 28%	16% 18%
	Snohomish	Skykomish River Snoqualmie	24%	18% 18%
South Sound	Lake Washington	Sammamish ^a Cedar ^a	62%	17% 23%
	Green-Duwamish	Duwamish-Green		48%
	White	White ^b		17%
	Puyallup	Puyallup ^c		29-48%
	Nisqually	Nisqually ^d		29%
Hood Canal	Mid-Hood Canal Skokomish	Mid-Hood Canal ^e Skokomish	36%	17-18% 29%

depression or fixation of deleterious mutations; or (3) productivity variation due to demographic stochasticity becomes a substantial source of risk (NMFS 2000b). The rebuilding threshold is defined as the escapement that will achieve Maximum Sustained Yield (MSY) under current environmental and habitat conditions (NMFS 2000b). Thresholds were based on population-specific data where available.

¹⁸ For most populations, the rebuilding thresholds are well below the escapement levels associated with recovery, but achieving these goals under current conditions is a necessary step to eventual recovery when habitat and other conditions are more favorable. Therefore, NMFS has evaluated the future performance of populations in the ESU under recent productivity conditions; i.e., assuming that the impact of hatchery and habitat management actions remain as they are now.

Strait of Juan de Fuca	Dungeness Elwha	Dungeness ^b Elwha ^b		17% 17%
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^a Uses Upper Sauk River RER as a surrogate for the Cedar (23%) and the Nooksack RER as a surrogate for the Sammamish (17%) given similarity of current abundance and escapement trends, and watershed size.

^b Uses Nooksack early Chinook as surrogate (17%).

^c Uses the Skokomish (29%) as surrogate.

^d Uses range including Skokomish (29%) and Green Rivers fall Chinook as surrogates

^e Uses range including Nooksack early Chinook (17%) and South Fork Stillaguamish (18%) as surrogates.

The risk to the ESU associated with an individual population not meeting its RER must be considered within the broader context of other information such as guidance on the number, distribution, and life-history representation of populations within the regions and across the ESU; the role of associated hatchery programs; observed population status, and trend; and the effect of further constraints on the proposed actions. Derivation of an RER is based on conservative assumptions regarding environmental conditions, and uncertainty in management performance and population dynamics based on observed patterns over a 25 year period (Appendix A). The objectives of the RER are to achieve escapement levels consistent with the rebuilding threshold and minimize escapements below the critical threshold over a given time frame. The VRAP model identifies the RER that meets specific probabilities based on these assumptions when compared with the same conditions and no harvest. The RER analyses are updated periodically to incorporate the most recent information, and assumptions are made conservatively (e.g., assuming low marine survival) to protect against overly optimistic future projections of population performance. However, the observed data may indicate that the population status or environmental conditions are actually better than the conservative assumptions anticipated in the RER derivation. For example, the observed information may indicate that marine survival is better than assumed or that a population's escapement has achieved its rebuilding threshold under exploitation rates higher than the RER. Therefore, it is important to consider the anticipated exploitation rates and escapements relative to the RERs and thresholds, and the observed information on population status, environmental conditions, and exploitation rate patterns. A population will be identified in this opinion as having an increased level of risk¹⁹ when the expected escapement of that population does not meet its critical threshold or its RER. We will then examine the effects of the proposed actions on the status of the populations and the degree to which the effects contribute that that status.²⁰

Populations are also at increased risk if actual exploitation rates exceed exploitation rate ceilings that are part of the proposed actions. In most cases for most management units actual exploitation rates are routinely at or below the specified objectives. As explained in Appendix A, incorporation of uncertainty is reflected in the variability in exploitation rates observed in the simulations. That is, the derivation of RERs assume that observed exploitation rates will vary over time (above and below the RER) as a result of these uncertainties even if fisheries are

¹⁹ When compared to a population otherwise at or above its critical threshold.

²⁰ NMFS has used RERs as part of its assessment of proposed harvest actions on the Puget Sound Chinook ESU in biological opinions and application of take limits under the ESA 4(d) Rule since 1999 (NMFS 1999; 2005b; 2008e; 2010b, NMFS 2014a, NMFS 2015b, NMFS 2016).

managed as closely as possible to meet the RERs. Therefore, management error is such that it is reasonable to expect that management objectives will be exceeded on occasion. However, consistent overages may reflect bias in management procedures and assumptions that need to be corrected. Because of the significant amount of analysis and staff resources required and the lag in availability of some of the information (e.g., two years to finalize sport fishery catch), exploitation rates are assessed every three years. The most recent information is available through 2014 based on work completed in late 2016 (**Table 14**).

The co-managers routinely assess the performance of fishery management regimes and the technical tools and information that are used (e.g., abundance forecasts, management models, input parameters). Assessments typically review past performance, by comparing preseason and post season estimates of exploitation rate, factors that contributed to the observed overages, and identify remedial actions designed to address any identified problems. The most recent in depth assessment was conducted in 2015 for four populations (Skagit summer/falls, Puyallup, Nisqually and Skokomish)(Graham and Unsworth 2015) with an assessment of the efficacy of the actions taken in 2016 (Adicks 2016). The update of the FRAM model in late 2016 provided another opportunity for a high level overview of management performance. The update of the FRAM model itself was designed to address identified problems and improve management

Table 14. Estimated exploitation rates compared with the applicable management objective for each Puget Sound Chinook Management Unit. Rates exceeding the objective are **bolded***

Region	Management Unit	2010		2011		2012		2013		2014	
		Actual	Objective	Actual	Objective	Actual	Objective	Actual	Objective	Actual	Objective
Georgia Basin	Nooksack early	4%	7% SUS	5%	8%	6%	7%	9%	7%	8%	7%
Whidbey/ Main Basin	Skagit spring	20%	38%	30%	38%	24%	38%	22%	38%	24%	38%
	Skagit summer/fall	40%	50%	65%	50%	36%	50%	41%	50%	47%	50%
	Stillaguamish	12%	25%	26%	25%	16%	25%	13%	25%	24%	25%
	Snohomish	14%	21%	14%	15% SUS*	15%	21%	21%	21%	24%	21%
Central/ South Sound	Lake Washington	10%	20% SUS	21%	20% SUS	18%	20% SUS	16%	20% SUS	17%	20% SUS
	Duwamish-Green R	8%	15%/5800	13%	15%/5800	13%	15%/5800	13%	15%/5800	13%	15%/5800
	White River	16%	20% SUS	13%	20% SUS	14%	20% SUS	7%	20% SUS	21%	20% SUS
	Puyallup River	59%	50%	56%	50%	68%	50%	62%	50%	64%	50%
	Nisqually River	65%	65%	59%	65%	57%	56%	51%	56%	60%	52%
Hood Canal	Mid-Hood Canal R.	8%	12% PTSUS	11%	12% PTSUS	13%	12% PTSUS	10%	12% PTSUS	11%	12% PTSUS
	Skokomish River	52%	50%	57%	50%	60%	50%	49%	50%	59%	50%
Strait of Juan de Fuca	Dungeness River	4%	10% SUS	4%	10% SUS	3%	10% SUS	3%	10% SUS	4%	6% SUS
	Elwha River	4%	10% SUS	4%	10% SUS	3%	10% SUS	3%	10% SUS	4%	10% SUS

*For management units like the Skagit summer/fall and Snohomish that cannot meet their total exploitation rate objectives because 50% or more of the harvest occurs in northern fisheries, the harvest plan provides that a SUS objective may also be applicable.

* Rates are based on the old base period for FRAM since it was used at the time to shape fisheries to meet the objectives. The co-managers have recently updated the FRAM base period and are reviewing objectives. For example, the Nooksack objective was recently updated to 10% SUS from the previous 7% SUS.

performance. The results of the update and other sources of fishery information indicated that the Skokomish and Puyallup populations continue to exceed their exploitation rate ceiling despite meaningful actions taken by the co-managers over the last several years to bring exploitation rates under the ceilings. Consequently, as part of the proposed actions, the co-managers will assess management actions affecting achievement of objectives specified by the Puget Sound Chinook Harvest Plan for these populations, review available information, explore likely fishery management and other causative factors contributing to failures to achieve management objectives and address any bias found in the review. Specific circumstances for these areas are discussed in more detail in the Effects on the Species section for each of the relevant regions.

The Supplement to the Puget Sound Recovery Plan provides general guidelines for assessing recovery efforts across individual populations within Puget Sound and determining whether they are sufficient for delisting and recovery of the ESU (Ruckelshaus et al. 2002, NMFS 2006c). As described in Section 2.2.1.1, an ESU-wide recovery scenario should include two to four viable Chinook salmon populations in each of the five geographic regions identified within Puget Sound, depending on the historical biological characteristics and acceptable risk levels for populations within each region (Ruckelshaus et al. 2002, NMFS 2006c). Unlike other ESUs (e.g., Lower Columbia River (NMFS 2013b)), however, the Puget Sound Recovery Plan and PSTRT guidance did not define the role of each population to the survival and recovery of the ESU which is important in assessing the distribution of risk from specific proposed actions in such a complex ESU. Therefore, NMFS developed the Population Recovery Approach (PRA; see Section 2.2.1.1) to use as further guidance in its consultations. Guidance from the PSTRT, the Supplement, and the PRA provide the framework to assess risk to the Puget Sound Chinook salmon ESU. The distribution of risk across populations based on the weight of information available in the context of this framework is then used in making the jeopardy determination for the ESU as a whole. For a more detailed explanation of the technical approach see NMFS (2000b, 2004b, 2011a).

In addition to the biological information, NMFS' federal trust responsibilities to treaty Indian tribes are also considered in NMFS' conclusions. In recognition of treaty right stewardship, NMFS, as a matter of policy, has sought not to entirely eliminate tribal harvest (Secretarial Order 3206). Instead, NMFS' approach is to accept some fisheries impacts that may result in increased risk to the listed species, if consistent with the ESA's requirements, in order to provide limited tribal fishery opportunity. This approach recognizes that the treaty tribes have a right and priority to conduct their fisheries within the limits of conservation constraints (Garcia 1998). Because of the Federal government's trust responsibility to the tribes, NMFS is committed to considering the tribal co-managers' judgment and expertise regarding conservation of trust resources. However, the opinion of the tribal co-managers and their immediate interest in fishing must be balanced with NMFS' responsibilities under the ESA. The discussion in the following section summarizes the results of the impact analysis of the proposed actions across populations within each of the five major bio-geographical regions in the ESU.

2.5.1.2 Effects on the Species

Effects of the Proposed Actions on listed species occur through implementation of the proposed

Puget Sound salmon fisheries and associated research as described earlier (see sections 1.2 and 1.3). Escapements and exploitation rates expected to result from these fisheries during May 1, 2017 through April 30, 2018 are summarized in **Table 15**. Exploitation rates are reported by management units and escapements by populations based on the information that the FRAM model provides. Impacts in PFMC and PST fisheries are included in actions previously consulted on by NMFS (2004a, 2008e) and are therefore part of the Environmental Baseline (see Section 2.3.1). However, the harvest objectives proposed by the co-managers to manage Puget Sound Chinook take into account impacts in these other fisheries (Speaks 2017). Thus, **Table 15** represents the sum of fishing-related mortality anticipated under the proposed actions together with that evaluated under the existing PFMC and PST consultations.

Also included in **Table 15** are the RERs and critical and rebuilding thresholds discussed above that NMFS uses as some of the benchmarks to evaluate the effects of the proposed actions on survival and recovery of populations within the ESU. For management units comprised of multiple populations, **Table 15** provides the range of RERs associated with the populations within that management unit. For example, the range of RERs summarized for the Skagit Spring Management Unit represents the Suiattle (38%) and the Upper Sauk (41%).²¹ All of the population specific RERs are shown in **Table 13**.

NMFS' critical and rebuilding escapement thresholds represent natural-origin spawners (**Table 15**). However, long-term time series of data on the contribution of natural-origin fish to escapement are limited for all Puget Sound populations; particularly those historically dominated by hatchery production. The co-managers are refining abundance forecasts and modeling tools like the FRAM as better information becomes available. Several historically hatchery-dominated populations are transitioning to natural-origin management and, for others, hatchery production will continue to contribute significantly to escapement depending on their role in ESU recovery.

²¹ Data were insufficient to develop a RER for the Upper Cascade population; the third population in the Skagit Spring Management Unit.

Table 15. FRAM adult equivalent exploitation rates in 2017 ocean and Puget Sound fisheries and escapements expected after these fisheries occur for Puget Sound management units compared with their RERs and escapement thresholds (surrogates in *italics*). Outcomes expected to exceed RERs or fall below critical escapement thresholds are **bolded**.

Region	Management Unit	Ocean (PST, PFMC)	Puget Sound	Ocean + Puget Sound	RER or RER surrogate	
Georgia Basin	Nooksack early	23.5%	7.3%	30.9%	17%	
Whidbey/ Main Basin	Skagit spring	7.5%	15.5%	22.9%	23-24%	
	Skagit summer/fall	23.3%	13.0%	36.3%	28-45%	
	Stillaguamish	11.2%	11.1%	22.4%	16-18%	
	Snohomish	8.7%	5.8%	14.5%	18%	
Central/South Sound	Lake Washington	15.7%	15.1%	30.8%	17-23%	
	Duwamish-Green R	15.7%	25.8%	41.4%	48%	
	White River	5.9%	16.0%	21.9%	17%	
	Puyallup River	15.7%	33.9%	49.5%	29-48%	
	Nisqually River	14.5%	32.5%	47.0%	29%	
Hood Canal	Mid-Hood Canal R.	16.2%	5.1%	21.3%	17-18%	
	Skokomish River	16.1%	31.2%	47.5%	29%	
Strait of Juan de Fuca	Dungeness River	16.0%	4.7%	20.7%	17%	
	Elwha River	16.5%	5.0%	21.5%	17%	
Escapement			Natural (HOR+NOR)	NOR	Critical	Rebuilding
Georgia Basin	Nooksack Management Unit			227		500
	NF Nooksack (early)			177	200	-
	SF Nooksack (early)			49²	200	-
Whidbey/ Main Basin	Upper Skagit River (moderately early)		11,827	11,440	967	7,454
	Lower Sauk River (moderately early)		666	666	200	681
	Lower Skagit River (late)		2,506	2,506	251	2,182
	Upper Sauk River (early)		1,389	1,389	130	330
	Suiattle River (very early)		653	653	170	400
	Upper Cascade River (moderately early)		346	346	170	1,250
	NF Stillaguamish R. (early)		611	176	300	550
	SF Stillaguamish R. (moderately early)		157	45	200	300
	Skykomish River (late)			2,689	1,650	3,500
Central/South Sound	Snoqualmie River (late)			619	400	1,250
	Cedar River (late)		1,080	960	200	1,250
	Sammamish River (late)		1,559	162¹	200	1,250
	Duwamish-Green R. (late)		5,847	1,386	835	5,523
	White River (early)		1,489	786	200	1,100
	Puyallup River (late)		1,092	616	200	522
	Nisqually River (late)		1,128	332	200	1,200
Hood Canal	Mid-Hood Canal Rivers (late)		330	171¹	200	1,250
	Skokomish River (late)		1,330	377	452	1,160
Strait of Juan de Fuca	Dungeness River		364	95	200	925
	Elwha River		2,621	152	200	1,250

Source: Chin2017_ BiOp.xlsm (J. Carey, pers. comm., April, 2017). Model output escapements adjusted to reflect natural-origin (NOR) or natural (hatchery-origin (HOR)+NOR) escapement as closely as possible using FRAM 2017 inputs, preseason forecasts or postseason data from previous years.

¹Information not available to directly assess 2017 natural origin escapement. Previous postseason reports indicate NOR Chinook contribute approximately 52% (Mid-Hood Canal) to natural escapement since 2004. Sammamish

escapement based on 2006-2015 contribution to Lake Washington natural-origin escapement.

² Represents NOR spawners of South Fork Nooksack origin. North Fork Nooksack spawners stray into the South Fork but the progeny of the spawners is genetically distinct from each other.

Consequently, the preseason expectations of natural-origin escapements compared to the escapement thresholds in **Table 15** were derived from several sources and represent a variety of different levels of hatchery contribution depending on the available information. NMFS expects the treatment of escapements to become more refined over time as information improves, as decisions are made regarding the treatment of hatchery- and natural-origin fish in an individual watershed, and as the role of individual populations in ESU recovery becomes better defined.

Test, research, update, and evaluation fisheries that inform fishery management decisions are included as part of the fishery-related mortality reflected in **Table 15** and included in the estimates of exploitation rates discussed in the following paragraphs. Several other related studies are included as part of the proposed actions evaluated in the subsequent discussion. These activities are therefore part of the actions addressed in this opinion. Other research activities informing Puget Sound salmon fishery management are permitted under section 7 of the ESA or Limit 7 of the 4(d) Rule and are part of the Environmental Baseline.

Georgia Basin: There are two populations within the Strait of Georgia Basin: the North Fork Nooksack River and the South Fork Nooksack River early Chinook salmon populations (**Figure 1**). Both are classified as PRA Tier 1 populations and both are essential to recovery of the Puget Sound Chinook ESU (NMFS 2006a). The two populations form the Nooksack Early Management Unit. Both populations are expected to be affected by the proposed actions in the action area described in Section 1.4.

Natural-origin average escapement for the North Fork Nooksack is near its critical escapement threshold and the South Fork Nooksack population is below its critical escapement threshold (**Table 3**), indicating additional risk to both populations in this Region. When hatchery-origin spawners are included, average spawning escapement for the North Fork Nooksack population is significantly higher. Hatchery contribution to natural escapement from the conservation program at the Kendall Creek Hatchery on the North Fork Nooksack is significant (North Fork average NOR=205, North Fork average NOR+HOR=1,804; **Table 3**) and the hatchery fish retain the native profile of North Fork Nooksack early Chinook.

Managers have implemented two conservation hatchery programs in the Region. Both programs are essential to recovery of each of the populations in this Region and thus to the ESU. Each program has met its hatchery's egg-take objectives in recent years with few exceptions, and is expected to do so again in 2017 and for the foreseeable future (WDFW 2014a, Lummi Nation 2015), thus ensuring that what remains of the genetic legacy is preserved and can be used to advance recovery. The Kendall Creek program is intended to assist in recovery of the North Fork Nooksack population by contributing to spawning escapement, thus increasing escapements and potentially productivity in order to buffer risks while necessary improvements in habitat occur. An aggressive captive brood stock program to enhance returns of native South Fork Nooksack Chinook began in 2007. The first substantial number of adults to contribute to escapement began

returning in 2015 (Chapman 2013, 2016). Preliminary information indicates 2016 returns from the program were greater than 2015 with greater potential contribution to spawning (B. Apgar-Kurtz, pers. com., April 21, 2017). A record number of redds were observed in the South Fork sub-basin compared with previous years and 33% of the sampled carcasses for which data are available had CWTs from the South Fork captive brood program²². As observed in 2015, most of the recovered carcasses were male (7 of the 47 CWTs recovered were female) and based on returns to the hatchery, over 80 percent of the males appeared to be age 2. However, large, obviously older males were observed more frequently in 2016 than 2015 based on the length frequency of the males sampled. This is only the fourth year of expected returns since the program began releasing juveniles from the program with the 2010 brood year so we expect a greater number of returning adults contributing to escapement and more diverse age structure as more brood years return and the program becomes established.

Productivity (recruits/parent spawners) is 0.4 for the North Fork and 1.0 for the South Fork (**Table 3**). This analyses indicates a relative lack of response in terms of natural-origin production given the much higher total natural escapements described in the above paragraph. Trends in total escapement are increasing or stable for the North Fork and South Fork Nooksack populations, respectively (**Table 4**). The growth rates for natural-origin escapement and natural-origin recruitment are both positive but low (**Table 4**). This indicates that sufficient fish are escaping the fisheries to maintain or increase the number of spawners relative to the parent generation, providing some stabilizing influence for abundance and reducing demographic risks. The combination of these factors suggests that natural-origin productivity and abundance will not increase much beyond existing levels unless constraints limiting marine, freshwater, and estuary survival for the Nooksack early populations are alleviated (NMFS 2005c and 2008b, PSIT and WDFW 2010a). Exploitation rates during 2008-2014 averaged 40% (total) and 9% (southern U.S. (SUS)) (**Table 9**), higher than the RER but below the SUS exploitation rate ceiling in place during that time²³. Seventy-seven percent of the harvest occurred in Alaska and Canadian fisheries (**Table 9**).

The anticipated total exploitation rate resulting from the PFMC, PSC fisheries and proposed actions is 30.9 percent, well above the RER for the management unit of 17 percent, although the exploitation rate in the proposed action area alone (Puget Sound) is expected to be very low, i.e., 7.3 percent (**Table 15**). Under the proposed actions, both populations are anticipated to be below their critical thresholds (**Table 15**), which is cause for concern, but total natural escapements are anticipated to remain higher than the critical thresholds in 2017 given recent year hatchery-origin contribution rates (see **Table 3** for comparison of natural spawning escapement and natural-origin spawning escapement). Spring Chinook harvest restraints in the Strait of Juan de Fuca, northern Puget Sound, and the Nooksack River have been in place since the late 1980s. Net, troll, and recreational fisheries in Puget Sound are regulated to minimize incidental Chinook mortality

²² Preliminary, Nooksack Natural Resources and WDFW spawning ground data are not included.

²³ The Nooksack management unit was managed for an objective of 7% exploitation rate in southern U.S. fisheries until 2017 when the new FRAM was implemented. A comparison of exploitation rate estimates under the old and new FRAM indicated the previous objective of 7% was equivalent to a rate of 11% under the new base period. In light of the new information, in 2017, the co-managers revised their objective to 10% to be conservative.

while maintaining fishing opportunity on other species such as sockeye and summer/fall Chinook. There have been no directed commercial fisheries on Nooksack spring Chinook in Bellingham Bay or the Nooksack River since the late 1970s. Incidental harvest in fisheries directed at fall Chinook in Bellingham Bay and the lower Nooksack River was reduced in the late 1980s by severely reducing July fisheries. Commercial fisheries in Bellingham Bay that target fall Chinook have been delayed until August for tribal fishermen and mid-August for non-treaty fishermen. Since 1997, there were limited ceremonial and subsistence fisheries in the lower river in May and early July. Beginning in 2008, the July fishery was discontinued entirely, and a portion of the ceremonial and subsistence fishery was shifted to the lower North Fork as additional conservation measures to further limit the potential harvest of the South Fork early Chinook population (PSIT and WDFW 2010a). For the last several years, selective gear and natural-origin Chinook non-retention were implemented in the largest component of the fishery. These protective measures are proposed to continue in 2017 as part of the proposed actions (Speaks 2017). Any proposed extension of the in-river ceremonial and subsistence (C&S) fishery in 2017 beyond June 15 would rely on inseason monitoring and an assessment of impacts to the populations (Unsworth and Parker 2017, Speaks 2017). In 2017, 69% of the harvest of Nooksack early Chinook in Puget Sound fisheries is expected to occur in tribal fisheries; primarily in C&S fisheries (FRAM Chin2017). If the proposed actions were not to occur in 2017, we estimate that an additional 13 and 4 natural-origin spawners would return to the North and South Fork Nooksack early Chinook escapements, respectively.

In summary, the status of the populations given their role in recovery of the ESU is cause for significant concern and so the effects of the harvest resulting from the proposed actions on the populations must be carefully considered. The vast majority of harvest occurs in fisheries north of the southern U.S. border, including Canadian fisheries which are outside U.S. jurisdiction. Under the proposed actions, the exploitation rate on Nooksack early Chinook within the action area is expected to be low (7.3%). The managers propose actions to minimize impacts to Nooksack early Chinook and past patterns indicate exploitation rates under the proposed actions are likely to be lower than anticipated (**Table 9** and **Table 14**). Most of the harvest of Nooksack early Chinook in SUS fisheries is expected to occur in tribal fisheries; primarily in C&S fisheries. Information suggests that past harvest constraints have had limited effect on increasing escapement of returning natural-origin fish, when compared with the return of hatchery-origin fish, and further harvest reductions in 2017 Puget Sound fisheries would not accrue meaningful benefits for either Nooksack population. The Kendall Creek hatchery program retains the native profile of the North Fork Nooksack early Chinook. The South Fork Nooksack Chinook captive broodstock program is designed to retain and enhance the native profile of that population. Both programs are key components in recovery of the Nooksack early Chinook populations and the supplemental spawners from these programs should buffer demographic and genetic risks while improvements in habitat occur although the contribution of the South Fork program is untested. Therefore, any substantive constraints to fisheries occurring in 2017 would likely come at the expense of tribal fisheries and would not provide substantive benefits to either population by providing sufficient additional spawners to significantly change its status or trends from what would occur without the fisheries.

Whidbey/Main Basin: The ten Chinook salmon populations in the Whidbey/Main Basin region are genetically unique and indigenous to Puget Sound. These areas are managed primarily for natural-origin production. The six Skagit Chinook populations are in PRA Tier 1, the Stillaguamish and Skykomish populations are in PRA Tier 2, and the Snoqualmie population is in PRA Tier 3 (**Figure 2**). NMFS has determined that the Suiattle and one each of the early (Upper Sauk, North Fork Stillaguamish), moderately early (Upper Skagit, Lower Sauk, Upper Cascade, South Fork Stillaguamish), and late (Lower Skagit, Skykomish, Snoqualmie) life history types will need to be viable for the Puget Sound Chinook ESU to recover (NMFS 2006a). The ten populations comprise four management units: Skagit Spring (Suiattle, Upper Cascade and Upper Sauk), Skagit Summer/Fall (Upper Skagit, Lower Skagit and Lower Sauk), Snohomish (Skykomish and Snoqualmie) and Stillaguamish (North Fork Stillaguamish and South Fork Stillaguamish). Hatchery contribution to natural escapement is extremely low in the Skagit system and moderate in the Snohomish and Stillaguamish systems (**Table 3**). All populations in the region are expected to be affected by the proposed actions.

Natural-origin average escapement is above rebuilding thresholds for three populations (Upper Skagit summer, Upper Sauk and North Fork Stillaguamish), below the critical threshold for the South Fork Stillaguamish, and in between for the remaining populations (**Table 3**). Observed productivity is 1.1 or more for nine of the 10 populations (**Table 3**) while longer term trends indicate declining trends in recruitment for all the populations (**Table 4**). With the exception of the South Fork Stillaguamish, long term trends in total natural escapement are stable or increasing. Growth rates for natural-origin escapements are increasing for six of the 10 populations and all are higher than the growth rate for recruitment (**Table 4**). This indicates that sufficient fish are escaping the fisheries to maintain or increase the number of spawners from the parent generation; providing some stabilizing influence for abundance and reducing demographic risks. The critical abundance status, low productivity, and declining escapement and growth trends for the South Fork Stillaguamish population indicate additional concern for this population. Average observed exploitation rates during 2008-2014 ranged between 19 and 47 percent (total) and 7 to 21 percent (SUS)(**Table 9**). About 50 percent or more of the harvest occurred in Alaska and Canadian fisheries.

The NMFS had previously identified the Skagit summer/fall management unit as exceeding its exploitation rate objective in odd-numbered years between 2007 and 2012. The co-managers took steps to improve preseason forecasts, evaluate in-season management tools and shape fisheries to reduce Chinook encounters. Exploitation rates were also re-evaluated using an updated FRAM model in 2017. Exploitation rates for the Skagit summer/fall management unit have been well below the objective since 2011 (**Table 14**). Other management units in the region have been below their objectives in all or all but one year in the series.

Under the proposed actions, eight of the 10 populations in the region are expected to exceed their critical thresholds and four to exceed their rebuilding thresholds (**Table 15**) in 2017. The South Fork Stillaguamish population is expected to remain below its critical threshold and the North Fork Stillaguamish population will fall below its critical threshold. Including the effects of the proposed actions, total exploitation rates for two of the four management units (Skagit spring (3

populations), Snohomish (two populations)) and the Upper Skagit population are below the RERs for the populations in those watersheds (**Table 15**). Therefore, NMFS considers the proposed actions to present a low risk to those populations. The exploitation rates in 2017 Puget Sound fisheries are expected to be low across the four management units (5.8%-15.5%)(**Table 15**). If the proposed actions were not to occur in 2017, we estimate that an additional 4 and 15 natural-origin spawners would return to the South Fork and North Fork Stillaguamish Rivers, respectively, and would not provide substantive benefits by providing sufficient additional spawners to significantly change their status or trends from what would occur without the fisheries.

In summary, the effects of the proposed actions in 2017 will meet the recovery plan guidance for two to four populations representing the range of life histories displayed in the region at low risk, including those specifically identified as needed for recovery of the Puget Sound Chinook ESU. The Whidbey/Main Basin Region is a stronghold of Chinook production in the ESU. Most populations in the region are doing relatively well relative to abundance criteria and RERs given current habitat conditions, representing a diversity of healthy populations in the region as a whole. The stable escapement trend and, in particular, the relatively robust status of the populations compared with their thresholds should mitigate any increased risk as a result of exceeding the RER for two of the three Skagit summer/fall populations. The continued critical status and trends for the South Fork Stillaguamish is a cause for concern. However, the moderately early life history type exhibited by the South Fork Stillaguamish population is represented by two other healthier populations in the region which are expected to be below their RERs.

Central/South Sound: There are six populations within the Central/South Sound Region (**Figure 1**). Most are genetically similar, likely reflecting the extensive influence of transplanted hatchery releases, primarily from the Duwamish-Green River population. Except for the White River, Chinook populations in this region exhibit a fall type life history and were historically managed primarily to achieve hatchery production objectives. The White River spring and Nisqually Chinook salmon population are in PRA Tier 1. The Duwamish-Green population is in PRA Tier 2, and the Cedar, Sammamish, and Puyallup populations are in Tier 3. The six populations constitute five management units: Lake Washington (Cedar and Sammamish), Duwamish-Green, White, Puyallup, and Nisqually. Hatchery contribution to spawning escapement is moderate to high for the populations within this region (**Table 3**). NMFS determined the Nisqually and White River populations must be at low extinction risk to recover the ESU (NMFS 2006a). The Nisqually population will need to transition to natural-origin management over time, as it is considered essential to recovery of the ESU. All populations in the region are expected to be affected by the proposed actions.

The basins in the Central/South Sound region are the most urbanized and some of the most degraded in the ESU (SPSS 2007). The lower reaches of all these system flow through lowland areas that have been developed for agricultural, residential, urban, or industrial use. Much of the watersheds or migration corridors for five of the six populations in the region are within the cities of Tacoma or Seattle or their metropolitan environments (Sammamish, Cedar, Duwamish-

Green, Puyallup and White). Natural production is limited by stream flows, physical barriers, poor water quality, elimination of intertidal and other estuarine nursery areas, and limited spawning and rearing habitat related to timber harvest and residential, industrial, and commercial development. The indigenous population in all but the Duwamish-Green River and White Rivers have been extirpated and the objective is to recover the populations using the individuals that best approximate the genetic legacy of the original population, reduce the effects of the factors that have limited their production, and provide the opportunity for them to readapt to the existing conditions. Managers have implemented a conservation hatchery program for the White River population. The program is essential to recovery of the population and thus to the ESU. The program regularly has met its hatchery's egg-take objectives and is expected to do so again in 2017, thus ensuring that what remains of the genetic legacy is preserved and used to advance recovery.

Except for the Sammamish population, current average natural-origin escapements are well above their critical thresholds, and average escapement in the Puyallup River exceeds its rebuilding threshold (**Table 3**). Recent spawner-recruit analysis indicates the upper threshold for the White River population may be closer to 400 rather than 1,100 (J. Schaffler, pers. com., February 24, 2017). In which case, the average natural-origin escapement of the White River population would be exceeding its rebuilding threshold (**Table 3**). These recent results suggest the need to reconsider escapement thresholds shown in **Table 3**. Productivity is 1.0 or more for four of the six populations (**Table 3**). Total escapement trends are stable or increasing for all populations within the region except for the Green River and Puyallup, which are declining (**Table 4**). Growth rates for recruits and escapement are positive for the Cedar, Sammamish and White River and stable for the Nisqually. Trends are negative for the Duwamish-Green and Puyallup populations (**Table 4**). As with populations in other Puget Sound regions, the growth rates for escapement are higher than growth rates for recruitment. The fact that growth rates for escapement (i.e., fish through the fishery) are greater than growth rates for return (i.e., abundance before fishing) indicates some stabilizing influence on escapement from past reductions in fishing-related mortality. The combination of declining growth rates and a declining trend in escapement (total and NOR) suggests that the Duwamish-Green and Puyallup populations are at higher risk for survival and recovery than other populations in the region, at least over the longer term. However, natural-origin spawning escapement is well above the rebuilding threshold for the Puyallup population at this time and it is a Tier 3 population in terms of its role of recovery for the ESU (**Table 3**).

Natural-origin spawning escapements in 2017 are expected to be between the critical and rebuilding thresholds for all of the populations except for the Sammamish which is expected to be below its critical threshold (**Table 15**). The additional contribution of hatchery spawners to natural escapement for most of these populations (**Table 15**) should mitigate demographic risk. The genetic risks related to the hatchery contributions are less clear, but except for the Duwamish-Green and White Rivers, the indigenous populations were extirpated and are being rebuilt using extant stock of Green River origin. In response to recent declines in escapements due to poor freshwater survival and unanticipated changes in spawning distribution, managers managed fisheries that impact the Green River population very conservatively (Unsworth and

Grayum 2016), i.e., no Chinook directed fisheries, limited pre-terminal fisheries, and later start dates for fisheries directed on other species (Bowhay and Warren 2016, Unsworth and Grayum 2016). In 2017, projected escapement is much higher than in recent years (i.e., above 5,800) and the total exploitation rate is expected to be below its RER (**Table 15**) indicating the risk to the population from the proposed actions is low.

Average observed exploitation rates during 2008-2014 ranged between 23 and 58% (total) and 15 to 48% (SUS)(**Table 9**), above the RERs for four of the five management units (**Table 13**). Overall, a larger proportion of the harvest of these populations occurs in SUS fisheries than for populations in other regions of Puget Sound; 18 to 48% of the harvest occurred in Alaska and Canadian fisheries depending on the population (**Table 9**).

Exploitation rate objectives for the Puyallup and Nisqually populations were exceeded in most or all years since exploitation rate objectives were adopted in 2003 (Puyallup) and 2010 (Nisqually) (Grayum and Unsworth 2015). The co-managers examined the available information to identify the contributing factors and took additional management actions in 2015 and again in 2016 to provide greater assurance that the fisheries would meet the overall exploitation rate limits.²⁴ Tribal fisheries are estimated to account for 80% and 77% of the harvest of unmarked Puyallup and Nisqually Chinook, respectively, in 2017 Puget Sound salmon fisheries. As part of the proposed actions, the co-managers will (1) conduct another assessment of fishery management actions affecting achievement of objectives specified by the Plan for the Puyallup management unit (Speaks 2017) which will assess a variety of factors, and (2) provide a report on the results to NMFS by mid-February 2018, with a draft of the report exchange between parties in November 2017. The co-managers propose to address any bias found in this performance review through updates to forecasts and/or FRAM model inputs as necessary. Further review and discussion of the results may identify other responses or analysis.

The post season estimates of total exploitation rate for Puyallup Chinook exceeded the exploitation rate ceiling objective of 50% every year from 2010 to 2014 (**Table 14**). Both Canadian fisheries and freshwater sport fisheries contributed substantially in some years, but the most consistent contributor to the overage was the tribal terminal area net fishery (Grayum and Unsworth 2015). Beginning in 2012, managers improved preseason models and shaped fisheries to address the problem. In recent years, the tribal net fishery has been limited to one day or a partial day during the Chinook management period and tribal managers have shaped fisheries on other salmon species to reduce incidental catch rates on Chinook. Low exploitation rates in the sport fishery are a consequence of the mark-selective fishing rules. Major sections of the river have been closed when the tribal net fisheries for pink, coho, or Chinook salmon were open to reduce impacts on Chinook. Unfortunately rates have continued to exceed the objective. It is important to meet the exploitation rate objective such that fisheries do not represent more of a risk than is consistent with the overall strategy of recovery for the region and the ESU.

²⁴ For the purposes of assessing management performance, the objectives in place at the time are compared to the exploitation rates resulting from the FRAM model used at the time (i.e., old base period). The FRAM model was recently updated to a new base period and results using that model are different for some years.

Estimates of total exploitation rate for Nisqually Chinook exceeded its target exploitation rate in two of the past five years; one of those by only one percent (**Table 14**). Both Canadian fisheries and freshwater sport fisheries contributed substantially in some years, but the most consistent contributor to the overage was the tribal terminal area net fishery (Grayum and Unsworth 2015). Preliminary results for 2015 and 2016 suggest harvest rates in terminal fisheries were below preseason expectations suggesting total exploitation rates likely did not exceed the ceiling in those years. The Nisqually River has been managed subject to a declining set of target exploitation rate limits since 2010 (65% from 2010-11, 56% from 2012-13, and 52% in 2014-2015) (Grayum and Unsworth 2015).

The Nisqually Tribe began taking management actions to reduce fishing effort in the gillnet fishery since at least 2007 in an effort to meet the declining exploitation rate limit (Grayum and Unsworth 2015). From 2007 to 2012 effort, in terms of net-hours, was reduced by 70%; effort has been stable since 2012. An experimental tangle net fishery was first implemented in 2012 and then again in 2014 and 2015. The purpose of the fishery was to target hatchery-origin Chinook while releasing unmarked natural-origin fish. The fishery complemented other key components of the transitional strategy to improve the fitness and productivity of the natural-origin fish over time. Despite reducing the fishery by two weeks, the encounter rate and unmarked retention rate in the tangle net fishery exceeded pre-season expectations. Increased effort and efficiency of the fishery along with a potentially later peak run due to higher summer temperatures likely combined to result in higher than expected impacts. Although additional data and experience should result in more precision in terminal harvest rates for this relatively new fishery the tribe has discontinued it for now (Bowhay and Unsworth 2016, Speaks 2017). Postseason assessment of the terminal harvest rate in the 2015 gillnet and C&S fishery met preseason expectations (i.e., 19.8% preseason v 17.8% postseason). Although not a chronic contributor to overages, the sport fishery has been further restricted since 2012 to achieve management objectives and reduce conflicts between tribal net and sport fishermen. Preliminary sport catch estimate for the 2015 fisheries indicates the actual sport catch encounters were lower than pre-season prediction (Adicks 2016). River fisheries were further restricted in 2016 due to low flow and high temperature conditions.

Exploitation rates in 2017 for four of the five management units are expected to exceed their RERs or RER surrogates for the populations in those units (Lake Washington representing the Sammamish and Cedar populations, White, Puyallup, and Nisqually) (**Table 15**). Exceeding the surrogate RER for the White River population may result in some increased risk for the pace of adaptation of the local population. This may be a concern since the population is essential to the recovery of the ESU. However, growth rates and the escapement trend for the population are positive including the effects of exploitation rates during the last decade similar to the proposed actions indicating the rates have not impeded growth of the population and would not be expected to do so in 2017. The Cedar, Samammish and Puyallup River populations are in PRA Tier 3 and the life histories of these populations are represented by other populations in the region. It is important to remember when assessing the risks to populations like these that there is no increased risk to the indigenous populations in these watersheds because they are extirpated and the Puyallup population is expected to remain above its rebuilding threshold under the 2017

fisheries. The observed increasing and stable trends in escapement and growth rate for the Cedar and Sammamish, respectively, should mitigate increased risk possible as a result of exceeding the RER. If the Puget Sound salmon fisheries closed in 2017 we estimate that an additional 32 natural-origin spawners would return to the Sammamish population. These additional spawners would not likely change the status of the population because the number of recruits produced per spawner remains low indicating that habitat conditions are limiting the population's ability to grow (Sammamish = 0.7, Table 3). The low productivity of the watersheds given the much higher level of overall escapement (**Table 3** and **Table 15**) suggests natural-origin recruitment will not increase much beyond existing levels unless constraints limiting marine, freshwater, and estuary survival for these populations are alleviated.

The Nisqually population is a Tier 1 population essential to recovery of the ESU. The anticipated exploitation rate in the proposed Puget Sound salmon fisheries is 32.5% for a total exploitation rate of 47.0% for the 2017 fishing season (**Table 15**). This rate exceeds its surrogate RER of 29%. Exceeding the RER infers an increased risk to the survival and recovery of the Nisqually population which is also experiencing a strongly declining growth rate in natural recruitment and a relatively low abundance of natural-origin escapement. However, it is important to consider the degree to which other factors and circumstances mitigate the risk. The reduction in the total exploitation rate ceiling from 52 percent in 2014-2015, 50 percent in 2016-2017 and to 47 percent in 2017 represents steps in a long term transitional strategy designed to reduce rates over time in concert with improvements in habitat and adjustments in hatchery operations (Thom 2017, Turner 2016c, NCSMP 2011, Nisqually Watershed Council 2011, PSIT and WDFW 2010a, SSPS 2007). The indigenous Chinook population is extirpated and the objective is to recover the populations using the individuals that best approximate the genetic legacy of the original population, reduce the effects of the factors that have limited their production, and provide the opportunity for them to readapt to the existing conditions. Currently, there is an increasing trend for natural escapement and a stable trend in growth rate for escapement (**Table 4**). Growth rate for natural-origin escapement (i.e., fish through the fishery) is higher than growth rates for recruitment (i.e., abundance before fishing) indicating that current fisheries management is providing some stabilizing influence to abundance and productivity and thereby reducing demographic risks.

Significant work is occurring in the Nisqually and its environs to improve and restore freshwater and estuarine habitat through land acquisition, estuary improvement, and similar projects. The timing and magnitude of changes in harvest that occur in the Nisqually watershed as part of a longer-term transitional strategy must be coordinated with corresponding habitat and hatchery actions and take into account the current status of the population. The transition will occur over years and perhaps decades as the habitat improves to support better production and the current population becomes locally adapted and less reliant on hatchery production to sustain it. Over the last 15 years, the co-managers have taken significant steps to transition from hatchery goal management to an exploitation rate ceiling approach for the Nisqually population based on impacts to unmarked Chinook.

The transitional strategy for the Nisqually River included habitat restoration, a stepwise

reduction in exploitation rate from 65 to 47 percent, use of terminal selective fisheries to meet tribal and recreational harvest goals while further reducing the number of hatchery spawners, a stepping stone hatchery component designed to improve the fitness of fish in the hatchery, and operation of a weir (NCSMP 2011). The weir was the key component to the strategy and was designed to reduce the number of hatchery fish on the spawning grounds thereby improving productivity over the long term and mitigating the risks associated with the proposed harvest and hatchery programs. The selective fisheries and stepped exploitation rates were intended to further reduce the effects of harvest as a limiting factor and improve productivity, while minimizing disruption to the fishery during the transition. The strategy also emphasizes the importance of the monitoring program designed to assess progress and allow for subsequent adaptive management. Analysis of the strategy supported the conclusion that the actions if implemented over time would support the proposed exploitation rate. NMFS determined that this comprehensive approach met the requirements of the ESA (NMFS 2015b). These actions were implemented by the co-managers consistent with the transitional strategy. After several challenging years trying to operate the weir, NMFS and the co-managers jointly concluded that it had not worked as intended and was not likely to achieve its design objectives in the future. Since the weir was central to the long-term transitional strategy relied on in recent years, a new transition strategy is needed to mitigate the risks associated with the harvest and hatchery components that the weir and other associated actions were meant to address.

Managers have been working on development of a new long-term transitional strategy since fall 2015 after it was decided that continued use of the weir was no longer feasible. The co-managers are using a recovery framework developed by the Hatchery Science and Review Group (HSRG 2015, Troutt 2016a, Troutt 2016b) as the template for the new transitional strategy. NMFS supports the principles of the HSRG framework as encompassing the key characteristics of a transitional strategy. The intent was to have a new strategy in place by 2016 but further discussions with NMFS indicated that the plan needed additional work to address key aspects of the strategy (Bishop 2016a, Bishop 2016b, James 2016, Turner 2016c, NMFS 2016a). The co-managers are working with NMFS to develop a new long-term transition strategy for the Nisqually Chinook population; much of which will be captured in a revised HGMP. That work is not yet complete. As part of the proposed actions, the co-managers commit to continue to work with NMFS to complete a draft of the HGMP by October 2nd, 2017 (Unsworth and Parker 2017). The intent is to have the new strategic approach in place prior to the 2018 season.

Meanwhile, the exploitation rate on Nisqually Chinook was incrementally reduced from 52 percent to 50 percent in 2016 and then again to 47 percent in 2017 to further reduce risk to the population while constructing the new transition strategy. The basis for the incremental reductions has been described previously (Grayum and Anderson 2014, NMFS 2015b, NMFS 2016a). The RER surrogate for Nisqually Chinook is 29 percent (**Table 13**), consistent with the analysis in the Nisqually recovery plan (NCSMP 2011). Given the available analysis, the importance of the role of the Nisqually population to recovery and its current status, and the lack of a sufficient alternative plan for mitigating risk due to higher exploitation rates at this time, an incremental reduction in the exploitation rate is consistent with a gradual transition approach, provides a reduction in risk for the population and for a meaningful tribal fishery in 2017, and time to complete the alternative transition strategy that may obviate the need for additional

reductions in future years.

Given these circumstances, as discussed earlier, it is important to consider the degree to which collectively these actions mitigate the identified risk. The indigenous population is extirpated and the strategy for populations like the Nisqually as described in Section 2.3.1 is to recover the populations using the individuals that best approximate the genetic legacy of the original population, reduce the effects of the factors that have limited their production and provide the opportunity for them to readapt to the existing conditions. The reductions in harvest that have occurred so far are a part of the longer-term transitional strategy that is being coordinated with corresponding habitat and hatchery actions (NCSMP 2011). Managers continue to make substantial changes to the fishery in order to better meet preseason expectations and reduce the chances of exceeding the exploitation rate objectives while providing for meaningful exercise of treaty tribal fishing rights. Additional work to improve preseason forecasts and develop a reliable inseason update could further increase the chances of meeting the management objective. The trends in overall escapements and growth rate for natural-origin escapement are increasing and stable, the natural-origin escapement anticipated in 2017 is above its critical threshold, and managers have further reduced the exploitation rate in 2017 to reduce risks while revising the necessary substantive long-term transitional strategy by October 2017. Therefore, the additional risks associated with exceeding the RER in the 2017 fishing year should not significantly affect the long-term persistence of the Nisqually Chinook population. Such a strategy is also consistent with NMFS' responsibility as described earlier to balance its tribal trust responsibility and conservation mandates by achieving conservation benefits while reducing disruption of treaty fishing opportunity (Garcia 1998).

In summary, given the information and context presented above, the fishing regime represented by the proposed actions should adequately protect five (White, Cedar, Duwamish-Green, Puyallup and Nisqually) of the six populations in the Region in 2017. Therefore, implementation of the proposed 2017 fisheries will meet the recovery plan guidance of achieving viability for two to four populations representing the range of life histories displayed by the populations in that region including those specifically identified as needed for recovery of the Puget Sound Chinook ESU (White River and Nisqually). The Sammamish River may experience some increased risks to the pace of adaptation of the existing local stock given the current status of the natural-origin population. However, the native population has been extirpated and potential improvement in natural-origin production is limited by the existing habitat. Analysis suggests further harvest reductions in 2017 Puget Sound fisheries would not measurably affect the risks to survival or recovery for the population. The population is not essential for recovery of the Puget Sound Chinook ESU (PRA Tier 3), trends in escapement and growth rates are increasing and both the life history and Green River genetic legacy of the population are represented by other populations in the Central/South Sound Region.

Hood Canal: There are two populations within the Hood Canal Region: the Skokomish River and the Mid-Hood Canal Rivers populations (**Figure 1**). Each population forms a separate management unit. Both the Skokomish and Mid-Hood Canal Rivers populations are considered PRA Tier 1 populations. The original indigenous populations have been extirpated and hatchery

contribution to natural escapement is significant for both populations, although available data for the Mid-Hood Canal population is limited (**Table 3**, Ruckelshaus et al. 2006). NMFS determined that both populations must be at low extinction risk to recover the ESU, so both populations will need to transition to natural-origin management over time.

The historical structure of the Hood Canal Chinook salmon populations is unknown (Ruckelshaus et al. 2006). The largest uncertainty within the Hood Canal populations, as identified by the TRT, is the degree to which Chinook salmon spawning aggregations are demographically linked in the Hamma Hamma, Duckabush, and the Dosewallips rivers. The TRT identified two possible alternative scenarios to the one adopted for the Mid Hood Canal Rivers population. One is that the Chinook salmon in the Hamma Hamma, Duckabush, and Dosewallips were each independent populations (Ruckelshaus et al. 2006). Habitat differences do exist among these Mid-Hood Canal rivers. For example, the Dosewallips River is the only system in the snowmelt-transition hydroregion. The other scenario is that Chinook salmon spawning in the Hamma Hamma, Duckabush, and Dosewallips rivers were subpopulations of a single, large Hood Canal Chinook salmon population with a primary spawning aggregation in the Skokomish River. Only a few historical reports document Chinook salmon spawning in the mid-Hood Canal streams, which is consistent with one theory that they were not abundant in any one stream before hatchery supplementation began in the early 1900s. In addition the overall size of each watershed and the area accessible to anadromous fish are small relative to other independent populations (Ruckelshaus et al. 2006).

Although the TRT ultimately identified two independent populations within Hood Canal Region (the Skokomish and Mid-Hood Canal rivers populations), the TRT noted that important components of the historical diversity may have been lost, potentially due, in part, to the use of transplanted Green River origin fish for hatchery production in the region (Ruckelshaus et al. 2006). The two extant populations reflect the extensive influence of inter-basin hatchery stock transfers and releases in the region, mostly from the Green River (Ruckelshaus et al. 2006). Genetic analysis indicates the Hamma Hamma population is not distinct from spawners returning to the Skokomish Rivers or George Adams or Hoodport hatcheries (Marshall 1999; Marshall 2000). The degree to which this is influenced by straying of Skokomish River Chinook in addition to the use of George Adams broodstock in the supplementation program is uncertain. Exchange among the Duckabush and Dosewallips stocks, and other Hood Canal natural and hatchery populations is probable although information is limited due to the very low escapements (PSIT and WDFW 2010a). Beginning in 2005, the co-managers increased mark rates of hatchery fish to distinguish them from natural-origin spawners in catch and escapement. The resulting information may provide better estimates of stray rates between the Mid-Hood Canal rivers and the Skokomish River system. Uncertainty about the historical presence of a natural population notwithstanding, current habitat conditions may not be suitable to sustain natural Chinook production. There is evidence to suggest that the changes in abundance were in part related to concurrent changes in marine net pen yearling Chinook hatchery production in the area, and therefore not indicative of changes in the status or productivity of the population per se. (Adicks 2010). Genetic analysis also indicates no difference between fish originating from the George Adams hatchery and those spawning naturally in the Skokomish River (Marshall 1999,

Marshall 2000).

As described in the environmental baseline, historically, low flows resulting from operation of the Cushman dams and habitat degradation of freshwater and estuarine habitat have adversely affected the Skokomish population. A settlement agreement in 2008 between the Skokomish Tribe and Tacoma Power, the dam operator, resulted in a plan to restore normative flows to the river, improve habitat, and restore an early Chinook life history in the river using supplementation. Elements of the settlement agreement were complemented by additional actions proposed by the co-managers in 2014 (Redhorse 2014) to develop a late-timed fall Chinook stock that is better suited to the historic flow regime, reduced hatchery production and fishery adjustments. The first broodstock for the program was collected in 2014 and additional review and development of the late-timed hatchery program was undertaken in 2015 and 2016. The late-timed hatchery program complements a similar conservation hatchery program that seeks to reintroduce spring Chinook into the Skokomish River. That program was also initiated in 2014 with the transfer of the first brood stock for spawning and subsequent release. Both the spring and late-fall programs are included as part of the proposed actions in 2017 (Unsworth and Grayum 2016, Speaks 2017). In addition, significant work is occurring to stabilize river channels, restore riparian forests, improve adult access to the South Fork Skokomish, and improve and restore estuarine habitat through land acquisition, levee breaching and similar projects (Skokomish and WDFW 2010, Redhorse 2014). The timing and magnitude of changes in harvest that occur in the Skokomish watershed as part of the longer-term transitional strategy must be coordinated with corresponding habitat and hatchery actions and take into account the current status of the population. The transition will occur over years and perhaps decades as the habitat improves to support better production and the current population becomes locally adapted and less reliant on hatchery production to sustain it. Over the last decade, the co-managers have transitioned from hatchery goal management to management for natural escapement, including an exploitation rate for unmarked (primarily natural origin) Skokomish Chinook of 50% beginning in 2010.

Average natural-origin escapements for both populations are below their critical thresholds (**Table 3**). When hatchery-origin spawners are taken into account, average escapement for the Skokomish exceeds its rebuilding threshold (**Table 3**). Productivity is less than 1.0 (**Table 3**). Growth rates for recruitment are declining for both populations and growth rates for escapement are also declining for the Skokomish population. The trend in natural escapement for both populations are stable (**Table 4**). However, escapement trends in the individual rivers comprising the Mid-Hood Canal rivers population have not varied uniformly. The TRT suggests that most of the historical Chinook salmon spawning in the Mid-Hood Canal rivers was “likely to [have] occurred in the Dosewallips River because of its larger size and greater area accessible to anadromous fish” (Ruckelshaus et al. 2006). However, production from the Hamma Hamma Fall Chinook Restoration Program, a hatchery-based supplementation program, has contributed substantially to the Mid-Hood Canal rivers population. Since 1998, the spawning aggregation in the Hamma Hamma River has generally comprised the majority of the Mid-Hood Canal rivers population. In comparison, the other two rivers in the population have seen decreases in escapements during this same time period. Spawning levels have been 20 fish or less since 2010

in the Duckabush and Dosewallips rivers. The goal of the restoration program is to restore a healthy, natural-origin, self-sustaining population of Chinook salmon to the Hamma Hamma River. This hatchery production is generally responsible for the increased escapement observed in the Hamma Hamma River. From 2008 to 2015, on average 48% of the Chinook salmon spawning in the Hamma Hamma River were of hatchery origin (WDFW and PSTIT 2009; WDFW and PSTIT 2011, WDFW and PSTIT 2012, WDFW and PSTIT 2013, WDFW and PSTIT 2014, WDFW and PSTIT 2015, WDFW and PSTIT 2016). The program may also buffer demographic risks to the Mid-Hood Canal Rivers population, particularly to the natural-origin spawning aggregate returning to the Hamma Hamma River (NMFS 2004d). As with populations in other Puget Sound regions, the growth rates for escapement are higher than growth rates for recruitment (**Table 4**) indicating fisheries management seems to have had a stabilizing influence.

Total average observed exploitation rates during 2008-2014 were 22 and 57% for the Mid-Hood Canal and Skokomish populations, respectively (**Table 9**), both well above their RERs (**Table 13**). Southern U.S. exploitation rates during the same period averaged 10 and 45% for the Mid-Hood Canal and Skokomish River populations, respectively (**Table 9**). Alaska and Canadian fisheries accounted for 55 and 21% of the harvest of the Mid Hood Canal and Skokomish rivers populations (**Table 9**). In 2017 Puget Sound fisheries, 88 and 34% of the harvest is expected to occur in tribal treaty fisheries for the Skokomish and Mid-Hood Canal populations, respectively.

Under the proposed actions, escapement for both populations is expected to be below the critical thresholds (**Table 15**). Total exploitation rates for both populations are expected to exceed their RER or RER surrogate (**Table 15**). For the Mid-Hood Canal population, the exploitation rate in 2017 Puget Sound salmon fisheries under the proposed actions is expected to be low (5.1%; **Table 15**). If Puget Sound salmon fisheries were closed in 2017 we estimate that seven additional natural-origin spawners would return to the Mid-Hood Canal population. Approximately 202 additional natural origin Chinook spawners would return to the Skokomish River. This would not change the status of the Mid-Hood Canal Rivers population in 2017 relative to its critical and rebuilding thresholds but would increase the Skokomish spawning escapement above its critical threshold.

For the Skokomish population, the anticipated exploitation rate in 2017 under the proposed actions from Puget Sound salmon fisheries is 32.5 percent with a total exploitation rate in 2017 of 47.5 percent. Exceeding the RER infers an increased risk to the survival and recovery of the Skokomish population which is experiencing declining growth rates in natural recruitment and escapement, low abundance of natural-origin escapement and is essential to the recovery of the ESU. Modelling suggests that a 50% exploitation rate if implemented over a 25 year period would represent a 50 percentage point decrease in the probability of a rebuilt Skokomish population compared with achieving the RER of 29 percent and a very small change (1 percentage point) in the probability that the population will fall below the critical level (NMFS 2011b). In addition, available information indicates that observed exploitation rates have exceeded the management objective of 50% in almost all years since its adoption in 2010, likely resulting in an even greater risk to rebuilding a sustainable population. Post season estimates of the total exploitation rate are available through 2014. The ceiling was exceeded each year from

2010 to 2012 (Grayum and Unsworth 2015) by 3.5% to 10.1% with virtually all of the overage occurring in the terminal net fisheries. Post season estimates of exploitation rates in preterminal fisheries were generally below expected levels. Errors in forecasting terminal abundance and estimating catch per unit effort were identified as the primary contributing factors. A reliable inseason update could help reduce the effect of these errors although past efforts to identify one have been unsuccessful (Gray 2016).

In response, managers have tackled the problem on two fronts; improving forecast methods and making changes in both the terminal tribal net and sport fisheries in 2013-2016. Managers increasingly restricted and restructured the tribal net fishery to reduce the harvest rate and meet the target levels. The number of fishing days during the Chinook management period was reduced from 24 in 2010 to 9 days in 2016 with additional delays in the coho fishery. The lower Skokomish River was closed during the Chinook management period (Bowhay and Warren 2016, James 2016, Speaks 2017). This schedule results in no treaty net fishing in the Skokomish River over six continuous weeks; the last three weeks of the Chinook management period and the first three weeks of the coho management period. These substantial changes implemented in the fishery in 2016 are proposed again for 2017. Changes also have been made in the management of the sport fishery in the Skokomish River. The harvest rate in the sport fishery was reduced from about 14% to an average of less than 3% with the implementation of mark selective fishing beginning in 2010. Skokomish River sport fisheries were closed in 2016 (Bowhay and Warren 2016) and will be closed in 2017 (Speaks 2017). Despite these changes, the terminal area harvest rates in 2015 and 2016 exceeded preseason projections resulting in a high likelihood that the overall exploitation rate objective of 50% was exceeded (NMFS unpublished). However, we note that the anticipated exploitation rate in 2017 is 47.5%, below the ceiling of 50%. This should improve the likelihood that the exploitation rate objective will be met in 2017. Work on improving abundance forecasts continues.

As part of the proposed actions, the co-managers will conduct another assessment of fishery management actions affecting achievement of objectives specified by the Plan for the Skokomish management unit (Speaks 2017) which will assess a variety of factors. The co-managers will provide a report on the results to NMFS by mid-February 2018, with a draft of the report exchange between parties in November 2017. The co-managers propose to address any bias found in this performance review through updates to forecasts and/or FRAM model inputs as necessary. Further review and discussion of the results may identify other responses or analysis.

Given these circumstances, as discussed earlier, it is important to consider the degree to which other factors and circumstances mitigate the risk. The indigenous population is extirpated and the strategy for populations like the Skokomish as described in Section 2.3.1 is to recover the populations using the individuals that best approximate the genetic legacy of the original population, reduce the effects of the factors that have limited their production and provide the opportunity for them to readapt to the existing conditions. The reductions in harvest that have occurred so far are a part of the longer-term transitional strategy that is being coordinated with corresponding habitat and hatchery actions (Skokomish and WDFW 2010, Redhorse 2014). Managers continue to make substantial changes to the fishery in order to better meet preseason

expectations and reduce the chances of exceeding the exploitation rate objectives while providing for meaningful exercise of treaty tribal fishing rights. Additional work to improve preseason forecasts and develop a reliable inseason update could further increase the chances of meeting the management objective. As part of the proposed actions and in response to commitments in the 2010 Puget Sound Chinook Harvest RMP (PSIT and WDFW 2010a), the co-managers also developed a plan for late-timed Skokomish fall Chinook (Redhorse 2014), in addition to the program to reintroduce spring Chinook, that was initiated in 2014 and as discussed above, has been developed further as part of the proposed actions in 2017. The two-track strategy of reintroduction and local adaptation should maximize the prospect for establishing at least one self-sustaining Chinook population in the Skokomish River. The run-timing for these programs (earlier and later) will be better suited to the environmental conditions in the river on their return (Skokomish and WDFW 2010) than the timing of the current Chinook population that returns in late summer when flow and temperatures can cause adverse spawning and incubation conditions. If successful, establishment of a self-sustaining spring Chinook run and/or a late-timed component of the extant fall Chinook population should significantly contribute to recovery of the Skokomish Chinook population. The total average escapement is above the rebuilding threshold, the escapement trend of natural spawners is at least stable and, in particular, growth rates for natural-origin escapement are slightly higher than growth rates for recruitment. This indicates that current fisheries management is providing some stabilizing influence to abundance and productivity; reducing demographic risks. However, the low productivity, continued critical status of natural-origin escapement and negative growth rates in recruitment and escapement for the Skokomish Chinook population underscore the importance of meeting the exploitation rate objective such that fisheries do not represent more of a risk than is consistent with a transitional strategy to recovery.

Strait of Juan de Fuca: The Strait of Juan de Fuca Region has two watershed PRA Tier 1 populations including an early-timed population in the Dungeness, and a fall-timed population on the Elwha (**Figure 1**). Each population is managed as a separate management unit. NMFS determined that both populations must be at low extinction risk to recover the ESU. The status of both populations is constrained by significant habitat-related limiting factors that are in the process of being addressed. Survival and productivity of the Dungeness population are adversely affected by low flows from agricultural water withdrawals and by other land use practices (PSIT and WDFW 2010a, SSPS 2005a). Projects have been implemented to pipe irrigation lines to reduce evaporation, improve management of groundwater withdrawal, purchase available property to contribute to restoration of the flood plain. Until recently all but the lower 5 miles of the Elwha River was blocked to anadromous fish migration by two dams, and the remaining habitat in the lower river was severely degraded. Ambitious plans to remove the dams and restore natural habitat in the watershed began in 2011. Dam removal was completed in 2014. With dam removal, river channels are cutting through the old dam reservoir lake beds and significant restoration projects are underway to assist riparian regeneration and improve spawning and rearing habitat as the river recovers. The estuary is reforming rapidly as silt previously entrained by the dams moves through the system and out into the Strait of Juan de Fuca. Chinook began moving upstream into previously inaccessible reaches of the watershed almost immediately. The actions and the continuously improving estuarine and river conditions

should significantly increase productivity and abundance of Elwha Chinook and enhance spatial structure and diversity. However, improvements are still likely to take years or and possibly decades before they are fully realized.

Given the condition of salmon habitat in the Dungeness watershed and the significant disruption to the Elwha system as a result of dam removal, the conservation hatchery programs currently operating in the Dungeness and Elwha will be key to protecting for the near-term, and ultimately restoring the Chinook populations in the Strait of Juan de Fuca Region. Analyses of the growth rate of recruitment demonstrates a relative lack of response in natural-origin production by either population (Dungeness=1.04 growth rate of recruits, Elwha=0.91 growth rate of recruits, **Table 4**) which is consistent with other analysis that habitat and environmental factors within the watershed and in marine waters are limiting natural-origin recruitment (Ward et al. 2008).

The average natural-origin escapement for both populations is estimated to be below their critical thresholds and productivity is likely less than 1.0 although direct estimates are not currently available for the Elwha population (**Table 3**). When hatchery-origin spawners are taken into account, average escapement exceeds the critical threshold for the Dungeness and the rebuilding threshold for the Elwha. The trend for natural escapement is stable for both populations (**Table 4**). The trends in growth rate are positive for the Dungeness and strongly negative for the Elwha (**Table 4**) which is not surprising given the historically poor conditions in the watershed. The conservation hatchery programs operating in the Dungeness and Elwha Rivers buffer demographic risks and preserve the genetic legacies of the populations as degraded habitat is recovered. Average observed exploitation rates during 2008-2014 were 20 and 19% (total) and 5 and 4% (SUS) for the Dungeness and Elwha River populations, respectively (**Table 9**), both above their RERs (**Table 13**). However, seventy-two percent or more of the harvest of both populations occurred in Alaska and Canadian fisheries (**Table 9**).

Under the proposed actions, escapement for both populations is expected to be below the critical thresholds (**Table 15**). However, when hatchery spawners are taken into account, escapements are much higher, similar to recent year averages (**Table 3** and **Table 13**). Total exploitation rates for both populations are expected to exceed their RER surrogates and this is a concern given the challenges to the populations from other sectors. However, a significant majority of the harvest occurs outside the jurisdiction of the co-managers (**Table 9** and **Table 15**) and exploitation rates in 2017 Puget Sound salmon fisheries are expected to be 5% or less (**Table 15**). If Puget Sound salmon fisheries closed in 2017 we estimate that only one additional natural-origin spawner would return to each of the Dungeness and Elwha escapements, respectively. Therefore, further constraints on 2017 Puget Sound fisheries would not substantively effect the persistence of either population by providing sufficient additional spawners to significantly change its status or trends than what would occur without the fisheries.

2.5.1.3 Effects on Critical Habitat

Critical habitat is located in many of the areas where the fisheries under the proposed actions would occur. However, fishing activities will take place over relatively short time periods in any particular area. The PBFs most likely to be affected by the proposed actions are (1) water quality,

and forage to support spawning, rearing, individual growth, and maturation; and, (2) the type and amount of structure and rugosity that supports juvenile growth and mobility.

Most of the harvest related activities in Puget Sound occur from boats or along river banks, with most of the fishing activity in the marine and nearshore areas. The gear fishermen use include hook-and-line, drift and set gillnets, beach seines, and to a limited extent, purse seines. These types of fishing gear in general actively avoid contact with the substrate because of the resultant interference with fishing and potential loss of gear. Derelict fishing gear can affect habitat in a number of ways including barring passage, harming eelgrass beds or other estuarine benthic habitats, or occupying space that would otherwise be available to salmon.

Due to recent additional outreach and assessment efforts (i.e. Gibson 2013), and recent lost net inventories (Beattie and Adicks 2012; Beattie 2013; James 2015) it is likely that fewer nets will become derelict in the upcoming 2017/18 fishing season compared to several years ago (previous estimates of derelict nets were 16 to 42 annually (NRC 2010)). In 2014, an estimated 13 nets became derelict, and 12 of them were recovered (James 2015), in 2013 an estimated 15 nets became derelict, 12 of which were recovered (Beattie 2013), and in 2012 eight nets were lost, and six were recovered (Beattie and Adicks 2012). In a more recent report - from June 2012 to February 2016 a total of 77 newly lost nets were reported, and only 6 of these were reported by commercial fishermen (Drinkwin 2016). Based on this new information we estimate that a range of six to 20 gill nets may be lost in the 2017/2018 fishing season, but up to 75% of these nets would be removed within days of their loss and have little potential to damage critical habitat.

Possible fishery-related impacts on riparian vegetation and habitat would occur primarily through bank fishing, movement of boats and gear to the water, and other stream side usages. The proposed fishery implementation plan includes actions that would minimize these impacts if they did occur, such as area closures. Any impact to water quality from vessels transiting critical habitat areas on their way to the fishing grounds or while fishing would be short term and transitory in nature and minimal compared to the number of other vessels in the area (NMFS 2004c). Also these activities would occur to some degree through implementation of fisheries or activities other than the Puget Sound salmon fisheries, i.e., recreational boating and marine species fisheries. Construction activities related to salmon fisheries are limited to maintenance and repair of existing facilities (such as boat launches), and are not expected to result in any additional impacts on riparian habitats.

By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for the ESU. The proposed actions incorporate management for maximum sustainable spawner escapement and implementation of management measures to prevent over-fishing. Both of these actions have been recommended as ways to address the potential adverse effects of removing marine derived nutrients represented by salmon carcasses (PFMC 2014b). Because these measures are part of the proposed actions, there will be minimal disturbance to vegetation, and negligible harm to spawning or rearing habitat, water quantity and water quality from the proposed actions.

2.5.2 Puget Sound Steelhead

2.5.2.1 Assessment Approach

As discussed in the Environmental Baseline (Section 2.3.1), available data on escapement of steelhead populations in Puget Sound are limited. Since data are currently insufficient to provide a full run reconstruction for most natural origin steelhead populations needed to assess harvest rates on summer run steelhead populations as well as most summer/winter and winter run populations, an alternative approach was developed.

This alternative approach took into account information from the listing determination for Puget Sound steelhead. NMFS determined that the harvest management strategy that eliminated the direct harvest of natural origin steelhead in the 1990s, prior to listing, largely addressed the threat of harvest to the listed DPS (72 Fed. Reg. 26722, May 11, 2007). A key consideration in recent biological opinions was therefore whether catch rates had continued to decline since listing which would reinforce the conclusion that the threat of harvest to the DPS continued to be low. To assess this premise, NMFS first compared the average catch of steelhead in mixed stock marine area fisheries (**Figure 13**; areas outside river and lake systems) at the time of listing to catches in more recent years and concluded that catch had declined by an average of 46% described in Section 2.3.1, **Table 10**. NMFS then compared the harvest rates in terminal area fisheries (freshwater) for a set of five index population for the same set of years and concluded that the average harvest rate had declined by 62% described in Section 2.3.1, **Table 11**.

Available information on harvest continues to be limited. In the recent status review, NMFS concluded that the status of Puget Sound steelhead has not changed significantly since the time of listing (Ford 2011; NWFSC 2015; NMFS 2017a) and reaffirmed the observation that harvest rates on natural-origin steelhead continue to decline and are unlikely to substantially affect the abundance of Puget Sound steelhead (NWFSC 2015). As a result, NMFS continues to rely on the logic described above. In this opinion, NMFS supplements the earlier analysis for marine fisheries by comparing estimated catch to a conservative minimum estimate of the abundance of the Puget Sound steelhead DPS, thus providing an outside and very conservative estimate of what the harvest rate of the marine fisheries could be. To further assess the harvest rates in freshwater fisheries, NMFS considered the harvest rates for the five index populations associated with the proposed actions. In this supplemental analysis, NMFS therefore also considers how the terminal harvest rates under the proposed actions compare to the rates at the time of listing and in more recent years, i.e., do the terminal harvest rates under the proposed actions continue to be low?

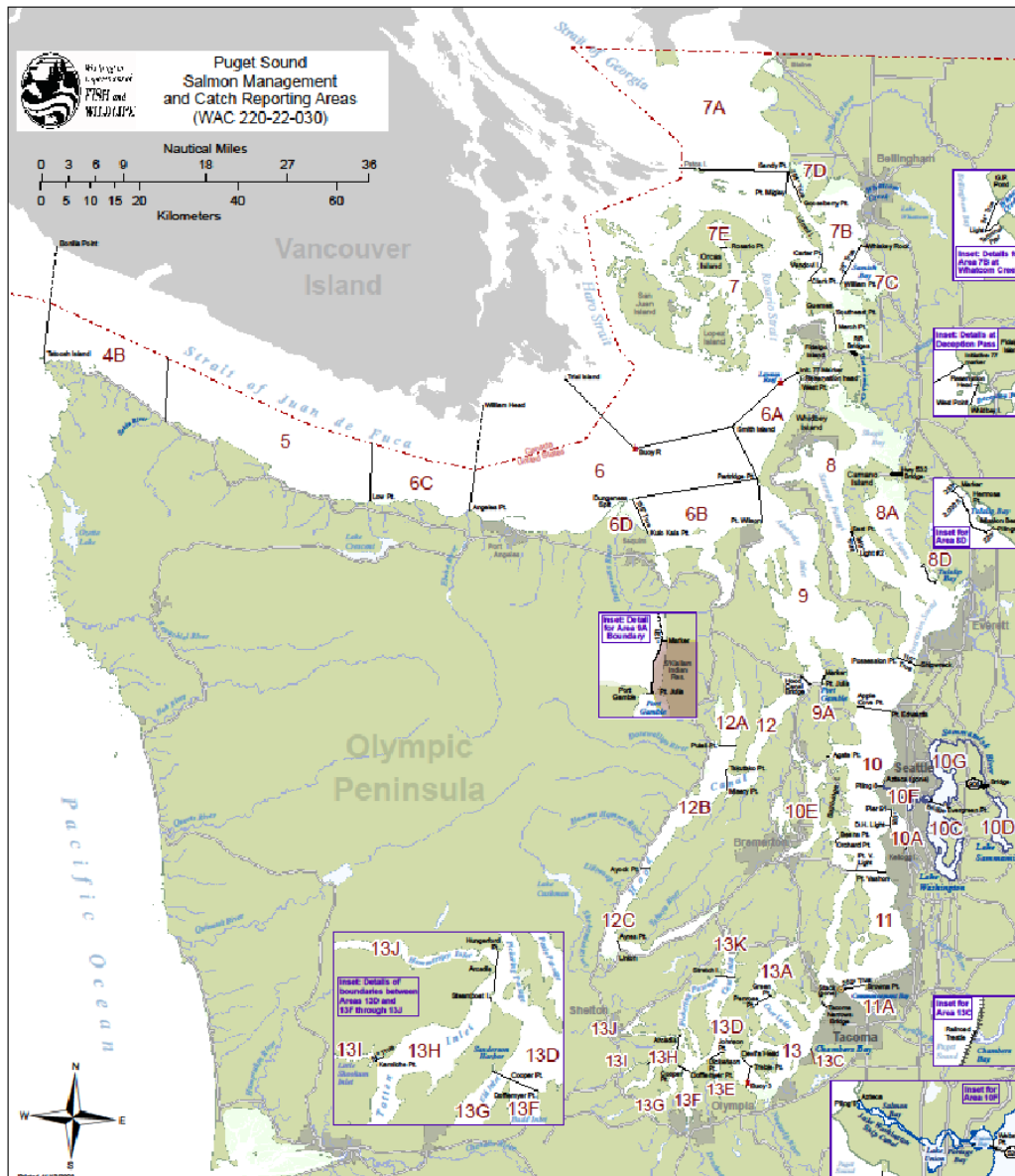


Figure 13. Puget Sound Commercial Salmon Management and Catch Reporting Areas (WAC 220-22-030).

2.5.2.2 Effects on Species

Due to data limitations for nearly all Puget Sound steelhead populations, it is not possible to determine the total abundance of steelhead within the DPS at this time. However, it is possible to provide a minimum estimate that includes information for the populations that are available. The resulting annual minimum average abundance of 22,361 steelhead includes listed and unlisted hatchery fish, and listed natural-origin fish based on fisheries data provided by co-managers (Marshall 2013; Beattie 2014; Leland 2014). The estimate includes total run size information for five out of the 32 historical steelhead populations (i.e., Skagit River summer/winter run; Snohomish winter run; Green winter run; Puyallup winter run; and Nisqually winter run) (PSSTRT 2013b). It also includes escapement estimates for 15 additional steelhead populations, although it does not include their associated harvest because the population specific catch data are not available. The estimate does not include anything for 12 of the 32 historical steelhead populations or any fish that return to the hatchery racks for either the listed or unlisted hatchery programs. It also does not include anything related to Canadian steelhead populations that are also part of the composition of steelhead affected by marine area fisheries. Therefore, the estimate of 22,361 is a partial and very conservative estimate of the overall abundance of Puget Sound steelhead that are available to marine area fisheries. Nonetheless, it provides some useful perspective about the likely impact of marine area fisheries.

Previous biological opinions have assessed impacts of up to 325 steelhead in Puget Sound marine waters described in Section 2.3.1; Table 10 (NMFS 2011a, NMFS 2014a, NMFS 2015b, NMFS 2016a). This number represents unlisted and listed steelhead taken in tribal and non-tribal marine area salmon fisheries under fishing regimes that had eliminated the directed harvest of wild steelhead. This estimate is consistent with the assessment of impacts at the time of listing that provided the basis for the conclusion that the regime had largely addressed the threat of decline to the listed DPS posed by harvest. Under the proposed actions, the expected impact on Puget Sound steelhead in marine fisheries from implementation of the proposed fisheries could be as high as this level during the 2017-2018 season (Speaks 2017). Impacts of up to 325 steelhead would represent an overall harvest rate on Puget Sound steelhead of 1.5% ($325/22,361 = 1.5$). As described above, because the estimate of overall abundance is low, this is a very conservative estimate of what the harvest rate to Puget Sound steelhead in marine area fisheries is likely to be. More likely, the catch of steelhead in marine area fisheries in recent years (176) has been well below the 325 reported at the time of listing and better represents what the expected catch is likely to be. As described in Section 2.3.1 and summarized in **Table 10**, this represents a 46% decline in recent years.

The average harvest rate in terminal area fisheries for the five index populations (i.e., Skagit River summer/winter run; Snohomish winter run; Green winter run; Puyallup winter run; and Nisqually winter run) under implementation of the proposed actions is anticipated to be below 4.2 percent based on the similarity of catch patterns and fishing regulations (Speaks 2017). This expectation is substantiated by the consistent pattern of significantly lower harvest rates observed in recent years described in Section 2.3.1 and summarized in **Table 11**, which showed a 62% reduction in the average terminal harvest rate for the five index populations. The harvest rate of 4.2 percent was the assessment of impacts at the time of listing that provided the basis for the

conclusion that the regime had largely addressed the threat of decline to the listed DPS posed by harvest.

Therefore, based on the best available information, the anticipated impacts to Puget Sound steelhead populations under the proposed actions, are expected to remain low and consistent with levels that NMFS has previously concluded unlikely to substantially affect the abundance and overall productivity of Puget Sound steelhead.

Fishery Related Research

Three harvest research projects are proposed during the 2017-18 steelhead fishery season. Each test fishery study has the potential for incidental take of Puget Sound steelhead. Harvest research projects are described and their impacts summarized below. The total anticipated impacts from the research projects are 15 steelhead.

Pacific Salmon Commission (PSC) Fall Chum Salmon Study

A PSC Chum Technical Committee has received funding from the Southern Endowment Fund to implement a fall chum salmon genetic stock composition research test fishery study on fall chum salmon migrating through the Strait of Juan de Fuca during the 2017 steelhead fishery season. The fall chum research proposal is summarized here and incorporated by reference (Speaks 2017, Unsworth and Parker 2017). This is the second year of the study and follows the same methodology as in 2016. The proposed study will use one purse seine vessel four days per week for five weeks during October and November in Area 5 (U.S. territory) (**Figure 14**). Catch per

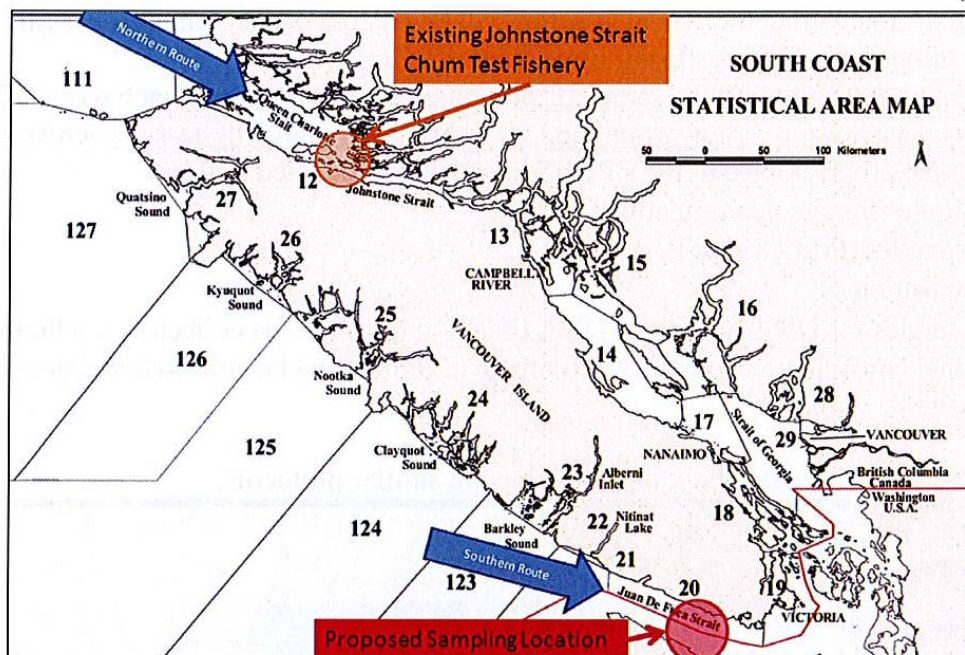


Figure 14. Location of proposed sampling site for PSC chum genetic sampling study.

Unit Effort information will be collected as well as biological samples for stock identification purposes. Sampled chum will be removed by dipnet from the seine, all other fish will be released directly from the seine while still in the water, by submerging the cork line (Speaks 2017, Unsworth and Parker 2017). Implementation

of the study in 2016 resulted in 0 encounters with ESA-listed species in 2016 (Speaks 2017).

There is the potential to encounter small numbers of non-listed and ESA-listed Puget Sound natural and hatchery steelhead and Chinook during implementation of the study. Anticipated steelhead encounters would be no more than 10 steelhead, released in-water, alive with minimal handling with a potential mortality of 2 dead steelhead of unknown origin and listing status. Given the study would occur in a pre-terminal area, some portion of the encountered fish could be Canadian or coastal steelhead from outside the Puget Sound DPS. The fish are not sampled for marks (Section 2.4.1) so it is not possible at this time to assign harvest encounters to specific populations. The estimate of 22,361 is a partial and very conservative estimate of the overall abundance of Puget Sound steelhead that are affected by marine area fisheries and provides some useful perspective about the likely impact of marine area research and monitoring activities. Ten steelhead encounters would represent 0.05% of the total natural-origin abundance of Puget Sound steelhead assuming all encountered steelhead were from the Puget Sound DPS. This research impact is considered to have a negligible effect on natural-origin steelhead abundance, productivity, spatial structure, and diversity and is unlikely to impede the Puget Sound Steelhead DPS from reaching viability.

The study is also expected to encounter no more than 60 immature Chinook, some of which may be listed. This level of encounters would result in an extremely small increase in the total exploitation rate on individual Puget Sound populations, ranging from 0 to 0.08%. For most populations, the increase would be 0.01% or less (Speaks 2017, Unsworth and Parker 2017). These low exploitation rates when combined with other research fishing activities are expected to fall below the 1% exploitation rate per Puget Sound Chinook management allowance reserved for this type of activity as described in the 2010 RMP and therefore part of the proposed actions (Speaks 2017, PSIT and WDFW 2010a). Based on the results of the 2016 study in which no listed species were encountered, we expect the impacts would be less. This research impact is considered to have a negligible effect on natural-origin Chinook abundance, productivity, spatial structure, and diversity and is unlikely to impede the Puget Sound Chinook ESU from reaching viability.

Lake Washington/Lake Sammamish Test Fisheries

Two studies are proposed to occur within the Lake Washington area. Both are designed to remove warm water fish species that prey on salmon and steelhead although the focus of the studies differ. Both proposals are summarized here and incorporated by reference (Speaks 2017, Tribble 2017).

The Muckleshoot Indian Tribe (MIT) proposes to implement a test fishery to collect information on the feasibility and potential impacts of a directed ceremonial and subsistence and commercial warm water fish species fishery in the Lake Washington Basin. This is the second year of the study. The MIT proposed warm water test fishing study area is divided into seven zones (**Figure 15**). The test fishery will occur during times and in places and using gear designed to avoid encountering ESA-listed species including steelhead (Speaks 2017). The first year of the study in 2016 encountered no steelhead. Nonetheless the warm water test fishery includes a precautionary estimate that it may impact up to three Puget Sound adult steelhead. The test fishery will

discontinue upon encountering the third adult steelhead (Speaks 2017).

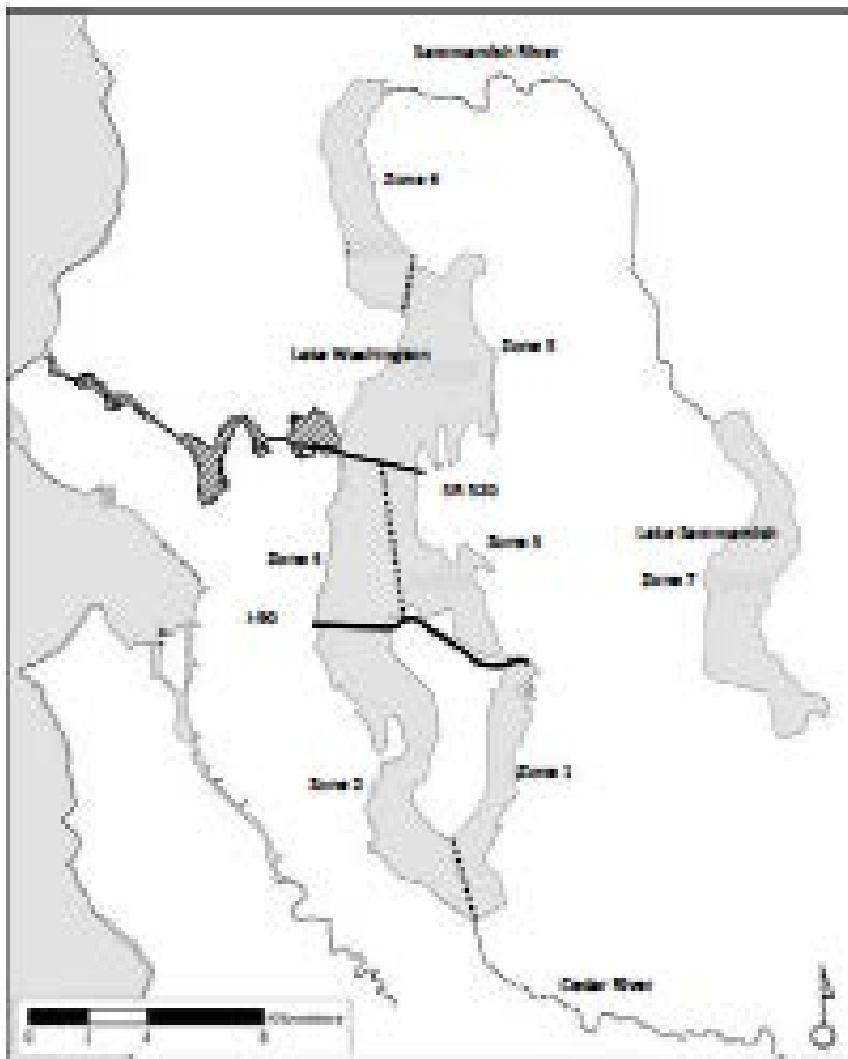


Figure 15. Muckleshoot Indian Tribe proposed warm water test fishery zones (1-7) and exclusion areas (cross-hatched) that will not be fished in order to minimize the potential for adult steelhead encounters (Speaks 2017).

The WDFW proposes to implement a gillnet test fishery and electrofishing in the Lake Washington Shipping Canal (LWSC). The objective of the proposed study is to describe the feasibility of gillnetting and electrofishing to remove predators of salmonids such as Smallmouth Bass, Largemouth Bass, and Northern Pikeminnow (Tribble 2017). Electrofishing would occur from early September to mid-October 2017, and April to June in 2017 and 2018. The gill net portion of the study would only occur during the April to June time period. The program will

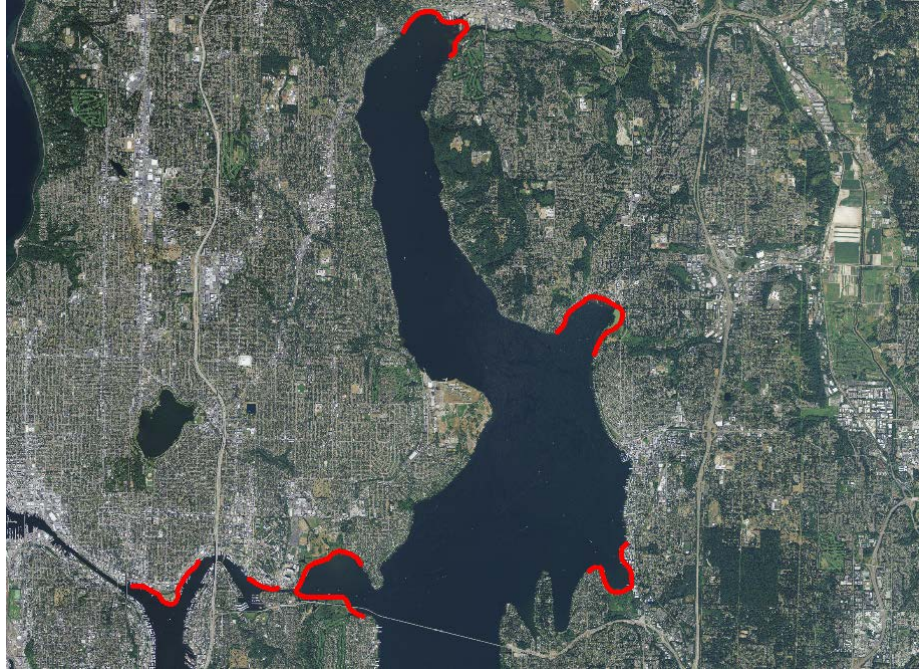


Figure 16. Proposed WDFW predator removal study area within the north half of Lake Washington including the Shipping Canal and Lake Union (Speaks 2017).

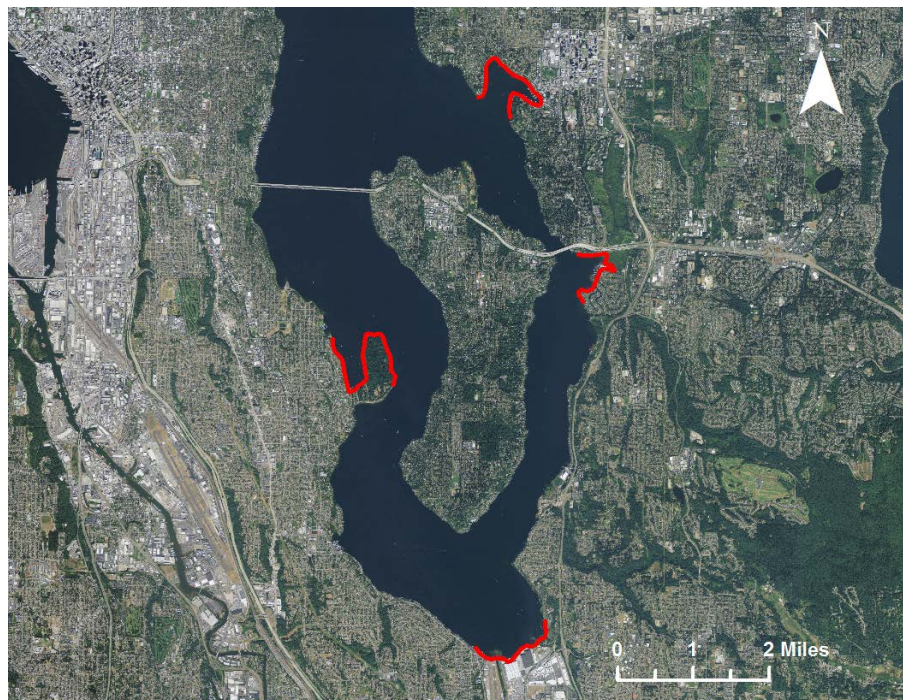


Figure 17. Potential index sites in the south half of Lake Washington.

occur in the LWSC and selected areas of Lake Washington (**Figures 16 and 17**). The shoreline study area was divided into 400-meter sampling sections in order to randomize sampling effort (Speaks 2017, Tribble 2017).

WDFW does not anticipate encountering adult steelhead during the proposed spring predator study because any adult steelhead would not be migrating during the periods of the study (Speaks 2017, Tribble 2017). Juvenile steelhead are anticipated to have migrated through the system already and would not be present in the study area. However, rare encounters with late juvenile steelhead migrants may occur (Speaks 2017, Tribble 2017). The mesh size used in the proposed predator study would be too large for a steelhead smolt to be entangled (Speaks 2017, Tribble 2017). In addition, outmigrating steelhead smolts are known to use deeper mid-channel areas where electrofishing would not occur (i.e., nearshore areas) (Speaks 2017, Tribble 2017). Although the study proponent expects that no steelhead will be encountered, WDFW estimates precautionary impacts to Puget Sound steelhead of up to one adult and two juvenile steelhead.

The Puget Sound Steelhead Technical Review Team (PSSTRT) identified two steelhead populations in the proposed test fishing area: North Lake Washington/Lake Sammamish winter-run and Cedar River winter-run (PSSTRT 2013b). These demographically independent populations (DIPs) are part of the Central and South Puget Sound Major Population Group (MPG). In the 5-year status review update for Pacific Northwest Salmon and Steelhead listed under the ESA, the NWFSC (2015) reported decreases in the 5-year geometric mean natural spawner counts for the two steelhead DIPs in the most recent two five year periods. Estimates represent a larger decrease in abundance for the Cedar River winter-run DIP (**Table 16**). No estimates were available for the North Lake Washington/Lake Sammamish winter-run DIP for the 2010-2014 time period. Cedar River and North Lake Washington and Lake Sammamish winter-run steelhead are already estimated to be below their Quasi-extinction Threshold (QET) abundances of 35 and 36 fish, respectively (PSSTRT 2013a). However, the 95% confidence intervals around these estimates were generally wide over the 100-year time frame (PSSTRT 2013a). There is no doubt that productivity of the Cedar River and North Lake Washington and Lake Sammamish winter-run steelhead populations are below replacement (Section 2.2.1.2; Figure 6).

Table 16. 5-year geometric mean of raw natural spawner counts for the Lake Washington/Lake Sammamish watershed, where available (NWFSC 2015).

MPG	DIP	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Central and South Puget Sound	North Lake WA/ Lake Sammamish winter	321	298	37	12	--	--
	Cedar River winter	321	298	37	12	4	-67

The total anticipated research incidental mortality would be up to three adult Puget Sound steelhead for the MIT test fishery and one adult/two juvenile steelhead for the WDFW predator removal study. Based on steelhead abundance data from (NWFSC 2015) for the Cedar River

winter-run DIP during the 2010-2014 time period, should the impacts occur it could result in potentially large negative effects to its abundance, productivity, spatial structure, and diversity. However, there is a very small to zero potential impact for the studies to interact with adult or juvenile steelhead in Lake Washington for reasons described above and discussed in detail in Speaks 2017. These reasons are supported by the lack of steelhead encounters in the 2016 MIT test fishery. Current data from the MIT suggests that natural-origin steelhead have already been extirpated from the Lake Washington watershed (MIT 2016).

The PSSTRT (PSSTRT 2013a) also examined a number of recent studies on the interactions between Puget Sound resident and anadromous *O. mykiss*. In general, there appears to be a relatively close relationship between sympatric resident and anadromous forms below long-standing barriers, such as the Ship Canal in Lake Washington (PSSTRT 2013a). In the Lake Washington Basin, which includes the Cedar River, the anadromous populations of *O. mykiss* and cutthroat trout have decreased to near zero levels, yet resident fish of both species are currently widely abundant and thought to be due, in part, to improvements in the productivity of Lake Washington and Lake Sammamish (PSSTRT 2013a). Interactions between resident and anadromous fish can be especially beneficial when the abundance of anadromous is very low (near the quasi-extinction threshold) and resident fish may be most important, not in bringing a DIP to full viability but, in preventing the DIP from being extirpated (PSSTRT 2013a).

Despite the potential for negative effects to occur to the Lake Washington/Lake Sammamish and Cedar River winter-run DIPs, encounters with natural-origin adult or juvenile steelhead are unlikely to occur and the high presence of resident *O. mykiss* in the Lake Washington watershed may assist in guarding the DIP from potential extirpation. Four out of eight DIPs in this Central and South Puget Sound MPG are required for viability and two of these DIPs demonstrate recent increasing trends (18% Nisqually River; 136% White River; Section 2.2.1.2, **Table 7**).

Precautionary measures such as important exclusion zones, timing of the fishery, immediate reporting, careful release measures for encounters, and close research monitoring by Tribal and WDFW members, technical staff, and enforcement staff will guard against potential natural-origin steelhead mortalities from the Lake Washington/Lake Sammamish and Cedar River DIPs. After considering the above factors, effects from the test fishery proposals are largely negative on the population level, but these effects are considered rare and unlikely to occur. Both studies will reduce predator populations that could be a substantial mortality factor on salmonids and provide future evidence to resolve questions regarding the presence of ESA-listed steelhead in Lake Washington.

The proposed study is also unlikely to encounter Chinook. The portion of the study that will occur in the spring will occur prior to adults entering the system and in areas where juveniles are less likely to be present (shallow nearshore areas). Gillnetting will not occur in the fall portion of the study when adults will be migrating through the lake and electrofishing will occur in areas where adults are unlikely to be present (i.e., shallow nearshore areas). Nevertheless, encounters could occur and the WDFW estimates precautionary impacts of up to 10 adults and 30 juvenile Puget Sound Chinook. Electroshocking would stop once the limit of 30 juvenile Chinook was reached (Speaks 2017, Tribble 2017).

This level of encounters would result in an extremely small increase in the total exploitation rate on the Lake Washington Chinook populations; at most 0.26 percent (Speaks 2017). This extremely low exploitation rates when combined with other research fishing activities are expected to fall below the 1% exploitation rate per Puget Sound Chinook management allowance reserved for this type of activity as described in the 2010 RMP and therefore part of the proposed actions (Speaks 2017, PSIT and WDFW 2010a).

2.5.2.3 Effects on Critical Habitat

Critical habitat is located in many of the areas where Puget Sound recreational and commercial salmon fisheries occur. However, fishing activities will take place over relatively short time periods in any particular area. The PBFs most likely to be affected by the proposed actions are (1) water quality, and forage to support spawning, rearing, individual growth, and maturation; and, (2) the type and amount of structure and rugosity that supports juvenile growth and mobility.

Most of the harvest related activities in Puget Sound occur from boats or along river banks with the majority of the fishing activity occurring in the marine and nearshore areas. The gear that would be used includes hook-and-line, drift and set gillnets or stake nets, beach seines, and to a limited extent, purse seines. If hooks, lines, or nets come in contact with the substrate or other habitat features, their capture efficiency is dramatically reduced. As a result, fishermen endeavor to keep gear from being in contact or entangled with substrate and habitat features because of the resultant interference with fishing and potential loss of gear. Derelict fishing gear can affect habitat in a number of ways including barring passage, harming eelgrass beds or other estuarine benthic habitats, or occupying space that would otherwise be available to salmon. Any impact to water quality from vessels transiting critical habitat areas on their way to the fishing grounds or while fishing would be short term and transitory in nature and minimal compared to the number of other vessels in the area (NMFS 2004c). Construction activities related to salmon fisheries are limited to maintenance and repair of existing facilities (such as boat launches), and are not expected to result in any additional impacts on riparian habitats. Also, these activities would occur to some degree through implementation of fisheries or activities other than the Puget Sound salmon fisheries (i.e., recreational boating and marine species fisheries).

By removing adults that would otherwise return to spawning areas, harvest could affect water quality and forage for juveniles by decreasing the return of marine derived nutrients to spawning and rearing areas, although this has not been identified as a limiting factor for the DPS. The proposed actions incorporate management for maximum sustainable spawner escapement and implementation of management measures to prevent over-fishing. Both of these actions have been recommended as ways to address the potential adverse effects of removing marine derived nutrients represented by steelhead carcasses. Therefore, there will be minimal disturbance to vegetation, and negligible effects to spawning or rearing habitat, water quantity and water quality from the proposed actions.

2.5.3 Puget Sound/Georgia Basin Rockfish

We first assess the general effects of proposed fisheries on individual yelloweye rockfish and bocaccio. Next we assess the population-level effects. We analyze direct effects on listed rockfish in two steps. First, we estimate the number of listed rockfish likely to be caught in the salmon fishery and assess both the sublethal and lethal effects on individuals. Second, we consider the consequences of those sublethal and lethal effects at the population level. We analyze indirect effects by considering the potential effects of fishing activities on benthic habitats. Throughout, we identify data gaps and uncertainties, and explain how we base assumptions in our analysis on the best available science.

Hook and Line Fishing

Fishermen targeting salmon use lures and bait that can incidentally catch yelloweye rockfish and bocaccio. Under the proposed actions, recreational salmon fisheries would occur within all areas of the U.S. portion of the Puget Sound/Georgia Basin (WDFW Marine Catch Areas 6 through 13). For rockfish caught in waters deeper than 60 feet (18.3 m), the primary cause of injury and death is barotrauma. Barotrauma occurs when rockfish are brought up from depth, and the rapid decompression causes over-inflation and/or rupture of the swim bladder, which can result in multiple injuries, including organ torsion, stomach eversion, and exophthalmia (bulging eyes), among other damages (Parker et al. 2006, Jarvis and Lowe 2008, Pribyl et al. 2011). These injuries cause various levels of disorientation, which can result in fish remaining at the surface after they are released and making them subject to predation, damage from solar radiation, and gas embolisms (Hannah and Matteson 2007, Palsson et al. 2009). Injuries can include harm from differences in water pressure experienced by fish brought to the surface from depths (barotraumas), differences in water temperatures (between the sea and surface), and hypoxia upon exposure to air. The severity of these injuries is dictated by the depth from which the fish was brought, the amount of time fish are held out of the water, and their general treatment while aboard. Physical trauma may lead to predation after fish are released (Palsson et al. 2009, Pribyl et al. 2011) by birds, marine mammals or other rockfish and fish (such as lingcod).

A number of devices have been invented and used to return rockfish to the depth of their capture as a means to mitigate barotrauma. When rockfish are released at depth, there are many variables that may influence long-term survival, such as angler experience and handling time in addition to thermal shock and depth of capture (Schroeder and Love 2002; Jarvis and Lowe 2008; Pribyl et al. 2009; Pribyl et al. 2011). A recent study of boat-based anglers in Puget Sound revealed that few anglers who incidentally captured rockfish released them at depth (approximately 3 percent), while a small number of anglers attempted to puncture the swim bladder (Sawchuk 2012), which could cause bacterial infections or mortality. However, recently NMFS provided funding to Pacific States Marine Fisheries Commission and Puget Sound Anglers (PSA) to purchase and distribute descending devices to local fishermen. The PSA has distributed the devices to many of the saltwater fishing guides that operate in the Puget Sound area, and beginning in 2017/18 anglers targeting bottomfish and halibut must release rockfish with barotrauma with a descending device. The vast majority of anglers target salmon by trolling with downriggers (Sawchuk 2012). There may be greater injury to listed-rockfish caught by anglers targeting salmon by trolling with downriggers because the fish may not trigger the release mechanism and be dragged for a period of time prior to being reeled in.

In our consultation on the WDFW Incidental Take Permit for the recreational bottom fish fishery in Puget Sound we were able to estimate the proportion of listed rockfish killed as a result of the state regulation limiting gear above 120 feet deep (consultation number F/NWR/2012/1984). This allowed us to use similar methods as the PFM (2008) to estimate the mortality rate for yelloweye rockfish and bocaccio by fishermen targeting bottom fish. The recreational salmon fishery does not have a 120 foot rule, complicating the assessment of survival estimates of listed rockfish caught at various depths while targeting salmon. Recent research found that short term (48 hours) survival for recompressed yelloweye rockfish was 95.1 %, (Hannah et al. 2014) and there is emerging evidence that female yelloweye rockfish can remain reproductively viable after recompression. A recent study conducted in Alaska found that recompressed female yelloweye rockfish remained reproductively viable a year or two after the event (Blain 2014). As a result of the emerging research on the effects of barotrauma and survivability of recompressed fish the PFM adopted new mortality estimates for recreationally caught and released yelloweye rockfish, canary rockfish (and cowcod) based on the depth of capture and use of descending devices (Table 35 - Supplemental GMT Report 2 2014) (**Table 17**).

Table 17. Mortality estimates (%) by depth bin for canary rockfish and yelloweye rockfish at the surface, from Supplemental GMT Report 2 (2014).

Depth range (feet)	Canary Rockfish Surface release mortality (%)	Yelloweye Rockfish Surface release mortality (%)
0 - 60	21	22
60 - 120	37	39
120 - 180	53	56
180 - 300	100	100
300 - 600	100	100
> 600	100	100

Though some anglers, and presumably most fishing guides, will release listed rockfish with barotrauma with descending devices, data reported in Sawchuk (2012) indicate that the vast majority have not. As such we make the conservative assumption that for the 2017/18 fishing season listed rockfish caught in salmon fisheries would not be recompressed, but rather released at the surface. As such we use the “current surface release mortality” estimates in the GMT report (2014) to estimate mortality rates for caught and released yelloweye rockfish to estimate mortality rates in Puget Sound fisheries targeting salmon. There are no analogous release mortality estimates for bocaccio, thus for this species we use the same release mortality estimates as for canary rockfish because of generally similar life history and physiology between the two species. The GMT estimated mortality rates for surfaced released fish from the surface to over 600 feet deep. There is no reported depth of capture from anglers targeting salmon that incidentally catch rockfish for us to partition mortality rates for each depth range, as done by the PFM. To estimate mortalities by anglers targeting salmon we use the release mortality rates estimates from the 120 to 180 feet depth range. We choose this depth range as a conservative estimate for bycaught listed rockfish given that most anglers likely target salmon at shallower depths than 180 feet deep, but note that bycatch in depths greater than 180 feet deep may nonetheless occur.

Fishing with Nets

Most commercial salmon fishers in the Puget Sound use purse seines and gill nets (PSIT and WDFW 2010a, Speaks 2017). A relatively small amount of salmon is harvested within the DPS by reef nets and beach seines. Tribal and non-tribal fishermen participating in the U.S. Fraser Panel fisheries use gillnets, purse seines and reef nets. Gill nets and purse seines rarely catch rockfish of any species. From 1990 to 2008, no rockfish were recorded caught in the purse seine fishery (WDFW 2010). In 1991, one rockfish (of unknown species) was recorded in the gill net fishery, and no other rockfish were caught through 2008 (WDFW 2010). Low encounter rates may be attributed to a variety of factors. For each net type, the mesh size restrictions that target salmon based on size tend to allow juvenile rockfish to pass through. Gill net and purse seine operators also tend to avoid fishing over rockfish habitat, as rocky reef structures can damage their gear. In addition, nets are deployed in the upper portion of the water column away from the deeper water rockfish habitat, thus avoiding interactions with most adult rockfish. In the mid-1990s commercial salmon net closure zones for non-tribal fisheries were established in northern Puget Sound for seabird protection although tribal fishermen may still access the areas. Some of these closed areas overlap with rockfish habitat, reducing to some degree the potential for encountering rockfish. Specific areas are: (1) a closure of the waters inside the San Juan Islands, (2) a closure extending 1,500 feet along the northern shore of Orcas Island, and (3) a closure of waters three miles from the shore inside the Strait of Juan de Fuca (WDFW 2010).

The greatest risk to rockfish posed by gill nets and purse seines comes from the nets' inadvertent loss. Derelict nets generally catch on bottom structure such as rocky reefs and large boulders that are also attractive to rockfish (NRC 2007). Dead rockfish have been found in derelict nets because the net can continue to 'fish' when a portion of it remains suspended near the bottom and is swept by the current. Aside from killing fish, derelict nets alter habitat suitability by trapping fine sediments out of the water column, making a layer of soft sediment over rocky areas that changes habitat quality and suitability for benthic organisms (NRC 2007). This gear covers habitats used by rockfish for shelter and pursuit of food, and may thereby deplete food sources. For example, a study of several derelict nets in the San Juan Islands reported an estimated 107 invertebrates and 16 fish (of various species) entangled per day (NRC 2008). One net had been in place for 15 years, entangling an estimated 16,500 invertebrates and 2,340 fish (NRC 2008). Though these estimates are coarse, they illustrate the potential impacts of derelict gear on the DPS. In 2012 the state of Washington passed a law (Senate Bill 5661) requiring non-tribal fishermen to report lost fishing nets within 24 hours of the loss, and has established a no-fault reporting system for lost gear. There are no devices installed on nets to track their location after they are lost, which complicates the recovery effort. In 2013 a NOAA-funded report was issued that assessed the reasons for gill net loss, best practices to prevent loss, and potential gear changes that may aid in the prevention of derelict nets (Gibson 2013).

Reef nets are deployed near rockfish habitat in the San Juan Islands, and are subject to the same area closures as gill nets and purse seines. Beach seines are used next to sandy or gravelly beaches, and in each fishery all non-targeted fish are released. Because most adult yelloweye rockfish and bocaccio occupy waters much deeper than surface waters fished by reef nets and beach seines, the bycatch of adults is likely minimal to non-existent. Similarly, such nets are not

likely to catch juvenile rockfish because many are small enough to pass through the mesh. Moreover, juvenile yelloweye rockfish and bocaccio are unlikely to be caught in beach seines because the seines are generally not used along kelp areas where juvenile bocaccio could occur in appreciable numbers (WDFW 2010). If adult or juvenile yelloweye rockfish and bocaccio were to be caught, the released fish would have a large chance of survival because they would not be brought to the surface from extreme depths thus avoiding barotrauma.

2.5.3.1 Bycatch Estimates and Effects on Abundance

Given the nature of the commercial salmon fisheries described above, we do not anticipate that any adult or juvenile yelloweye rockfish or bocaccio will be incidentally caught by actively fished nets and some listed rockfish could be caught in commercial hook and line fisheries. It is likely that some gill nets would become derelict near rockfish habitat and kill some listed rockfish, though we are unable to quantify the number of fish killed from new derelict nets.

Many methods of recreational salmon fishing in marine waters have the potential to encounter ESA-listed rockfish. The WDFW estimates the annual bycatch of rockfish from anglers targeting salmon, halibut, bottom fish and ‘other’ marine fishes. There are a number of uncertainties regarding the WDFW recreational fishing bycatch estimates because: (1) they are based on dockside (boat launch) interviews of 10 to 20% of fishers, and anglers whose trips originated from a marina are generally not surveyed; (2) since rockfish can no longer be retained by fishermen, the surveys rely upon fishermen being able to recognize and remember rockfish released by species. Research has found the identification of rockfish to species is poor; only 5% of anglers could identify bocaccio and 31% yelloweye in a study based throughout the Puget Sound (Sawchuck et al. 2015), and; (3) anglers may under-report the numbers of released fish. A study in Canadian waters compared creel survey reports to actual observer-generated information on recreational fishing boats in the Southern Georgia Strait. Substantial differences were documented, with the number of released rockfish observed significantly higher than the number reported by recreational anglers during creel surveys (Deiwert et al. 2005). These factors could make the actual bycatch of yelloweye rockfish or bocaccio higher or lower than WDFW’s estimates. There is additional uncertainty regarding these estimates because the WDFW continues to change the methodology to calculate them. As a result there are large differences between past and more current bycatch estimates.

In our previous consultation on the salmon fisheries, we used WDFW bycatch estimates from the 2003 through 2009 time period (WDFW 2011) and supplemented our analysis when the WDFW provided us catch estimates for the 2003 through 2011 time period (WDFW 2014b). WDFW provides us annual estimates, including for the 2016 fishery (WDFW 2017). The previous estimates are much larger than the new estimates even though they span the same time period from 2003 through 2009 (the new estimates include the years 2010 and 2011). WDFW’s estimates of rockfish bycatch from 2014 are similarly small with the exception of bocaccio. WDFW estimated that 132 bocaccio were caught by anglers targeting salmon (all in the San Juan Island area). WDFW estimated that 18 yelloweye rockfish were caught by anglers targeting salmon in 2014. In 2015 the WDFW estimated that anglers targeting salmon caught zero yelloweye rockfish and 30 bocaccio (WDFW 2016). In 2016, WDFW estimated that anglers

targeting salmon caught zero bocaccio and nine yelloweye rockfish.

Since the WDFW continues to change the methods to derive bycatch estimates, we show data from each method to represent a potential range of bycatch for yelloweye rockfish and bocaccio, but use the higher estimates to form a precautionary analysis. We consider using bycatch estimates from 2003 to 2011 valid because we anticipate that recreational salmon fisheries proposed for 2017/18 will result in generally similar fishing techniques, locations, and anticipated numbers of angler-trips as in the past decade. From 2010 to 2015 WDFW estimated there are approximately 415,000 recreational fishing trips targeting salmon annually within the Puget Sound (WDFW 2016) and estimated 143,823 fishing trips targeting salmon in 2016 (WDFW 2017).

As described above in Section 2.2, Rangewide Status of the Species and Critical Habitat, there are no reliable estimates of the abundance of any of the listed-rockfish DPSs. The best available abundance data for any basin for each species comes from the 2008 WDFW ROV surveys in the surveyed San Juan Island and Strait of Georgia regions (Pacunski et al. 2013), and we use this survey as a fundamental source to understand the total abundance of the DPSs (summarized in **Table 8**). WDFW may have over or underestimated the abundance of each species when it expanded the data from the ROV, drop camera, and bottom trawl surveys to produce abundance estimates. This risk is inherent in the study design of each methodology and a common challenge to fisheries management and species conservation. To address the possibility that each survey method resulted in over-estimates of abundance, our analysis includes two population scenarios—one based on the WDFW estimates and one that is roughly 20% less. We incorporated these reductions in our analysis to test the sensitivities of the abundance estimate for each species. We note that there may be equal probability that the WDFW population numbers are underestimates of abundance for each species. The structure of this assessment underestimates the total abundance of each DPS, resulting in a conservative evaluation of cumulative fishery bycatch mortality for each species.

2.5.3.1.1 Yelloweye Rockfish

We use annual estimated bycatch of yelloweye rockfish from salmon anglers of 4 (WDFW 2014b) to 117 (WDFW 2011a) fish (**Table 18**). These fish would be released, and using the PFMC methodology we estimate that 56% would likely perish from barotrauma and related hooking injuries and/or predation induced by injury.

Table 18. Yelloweye rockfish bycatch estimates.

Species	Low Estimate (number mortalities)	High Estimate (number mortalities)	Estimated Percent Mortality	Abundance Scenario	Percent of DPS killed (low estimate)	Percent of DPS killed (high estimate)
Yelloweye Rockfish	4 (2)	117 (68)	56%	40,000	0.005	0.017
				47,407	0.004	0.014

2.5.3.1.2 Bocaccio

The average annual estimated bycatch of canary rockfish from salmon anglers ranges from 2 (WDFW 2014b) to 145 (WDFW 2015) fish (**Table 20**). These fish would be released, and using the PPMC methodology we estimate that 53% would likely perish from barotrauma and related hooking injuries and/or predation induced by injury.

Table 20. Bocaccio bycatch estimates.

Species	Low Estimate (number mortalities)	High Estimate (number mortalities)	Estimated Percent Mortality	Abundance Scenario	Percent of DPS killed (low estimate)	Percent of DPS killed (high estimate)
Bocaccio	2(1)	145 (77)	53%	3,000	0.03	2.6
				4,606	0.02	1.7

In addition to fishery mortality, rockfish are killed by derelict fishing gear (Good et al. 2010), though we are unable to quantify the number of yelloweye rockfish and bocaccio killed by pre-existing derelict gear or new gear that would occur as part of commercial fisheries addressed in the proposed actions. As elaborated in Section 2.4.3.4, due to recent changes in state law, additional outreach and assessment efforts (i.e. Gibson 2013), and recent lost net inventories (Beattie and Adicks 2012, Beattie 2013) it is likely that fewer nets will become derelict in the upcoming 2017/18 fishing season compared to several years and decades ago. Because of the low number of anticipated derelict gill nets, it is likely that few (if any) yelloweye rockfish and bocaccio mortalities will occur from new derelict gill nets, and that any additional mortality would not induce additional risk to any population.

2.5.3.2 Effects on Spatial Structure and Connectivity

Bycatch (or death of fish in new derelict gear) of listed-rockfish could alter spatial structure. If fishermen incidentally catch a greater proportion of the total population of yelloweye rockfish or bocaccio in one or more of the regions of the DPSs, the spatial structure and connectivity of each DPS could be degraded. The lack of reliable population abundance estimates from the individual basins of Puget Sound proper complicates this type of assessment. Yelloweye rockfish are the most susceptible to spatial structure impacts because of their sedentary nature. Localized losses of yelloweye rockfish are less likely to be replaced by roaming fish, compared to bocaccio, which are better able to recolonize habitats due to the propensity of some individuals to travel long distances.

2.5.3.3 Effects on Diversity and Productivity

Bycatch of listed rockfish can alter diversity primarily by the removal of larger fish. Larger fish of each species are able to target baits and lures more so than juveniles, and typically enter fisheries at or near 12 inches long (30 centimeters) as they also they approach sexual maturity - thus bycatch disproportionately kills larger yelloweye rockfish and bocaccio. The loss of fish that are reproductively mature, or nearly so, would hinder the demographic diversity (and productivity) of each species.

2.5.3.4 Effects on Critical Habitat

Critical habitat is located in some of the areas fished by fishermen targeting salmon within the Puget Sound/Georgia Basin. We do not have spatial information at a fine enough scale to determine the proportion of the fishery occurring inside or outside of critical habitat. We designated critical habitat in some waters shallower than 98 feet (30 m) for bocaccio and critical habitat in some waters deeper than 98 feet (30 m) for each ESA-listed rockfish. For each species of listed rockfish we designated deep water habitats for sites deeper than 98 feet (30 m) that possess or are adjacent to areas of complex bathymetry consisting of rock and/or highly rugose habitat (Section 2.2.2.3). Several attributes of these habitats are essential to the conservation of listed rockfish. These attributes include: (1) quantity, quality, and availability of prey species to support individual growth, survival, reproduction, and feeding opportunities; (2) water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities; and (3) the type and amount of structure and rugosity that supports feeding opportunities and predator avoidance.

Motors used by commercial fishermen have the potential to pollute waters through the discharge of small levels of hydrocarbons. However, engines have become more efficient and less polluting in response to better technology and improved standards, which are administered by the Environmental Protection Agency (75 Fed. Reg. 179, September 16, 2010). As such, it is extremely unlikely that water quality and dissolved oxygen attributes of rockfish critical habitat would be adversely affected by the proposed actions.

Effects to proposed rockfish critical habitat come from lost commercial salmon gill nets. Nets are lost due to inclement weather, tidal and current action, catching upon the seafloor, the weight of catch causing submersion, vessels inadvertently traveling through them, or a combination of these factors (NRC 2008). Nets fished in rivers and estuaries can be lost from floods and/or as large logs are caught moving downstream, and a few of these nets can drift to the marine environment. Nets can persist within the marine environment for decades because they do not biodegrade and are resistant to chemicals, light, and abrasion (NRC 2008). In some cases, nets can drift relatively long distances before they catch on the bottom or wash up on the shore (NRC 2008). When derelict nets drift, they can entangle crab pots, thereby recruiting more derelict gear (NRC 2008). Most nets hang on bottom structure that is also attractive to rockfish. This structure consists of high-relief rocky substrates or boulders located on sand, mud or gravel bottoms (Good et al. 2010). The combination of complex structure and currents tend to stretch derelict nets open and suspend them within the water column, in turn making them more deadly for marine biota (Akiyama et al. 2007, Good et al. 2010)(**Figure 18**).

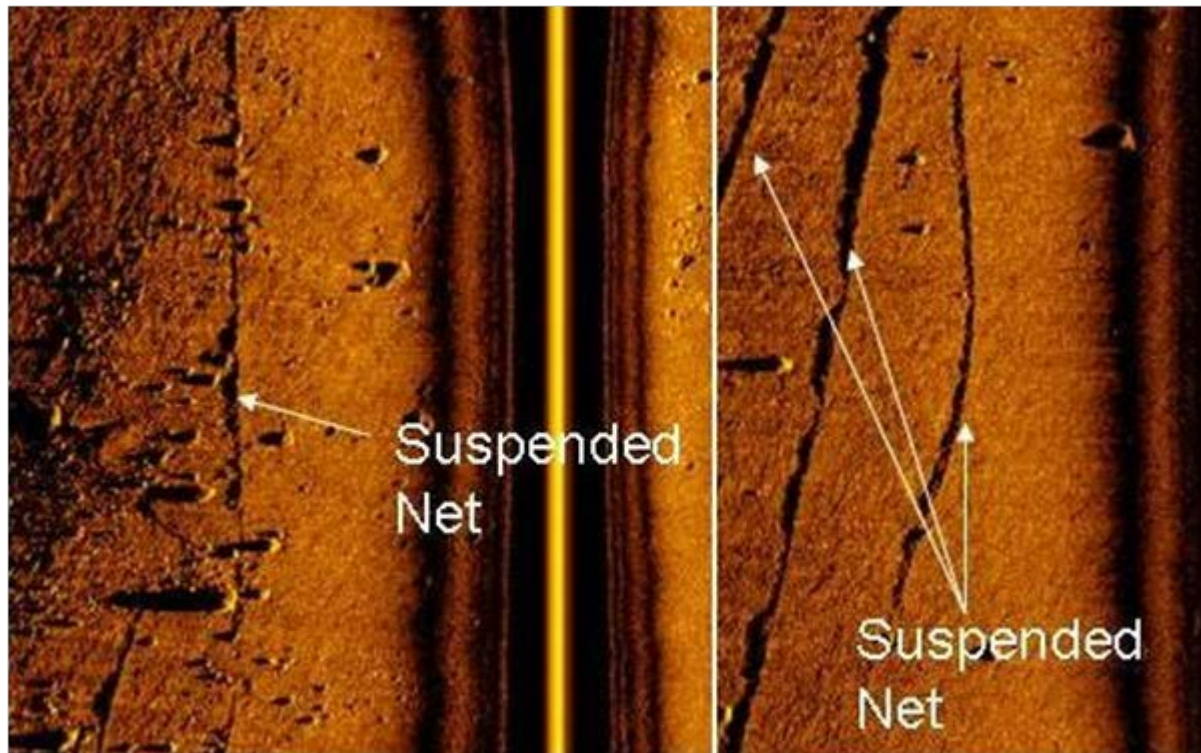


Figure 18. Sidescan sonar images of derelict nets located on Point Roberts Reef of the San Juan basin. Suspended nets have a larger acoustic shadow than nets flush with the bottom. Image used by permission of Natural Resource Consultants (NRC).

Derelict nets alter habitat suitability by trapping fine sediments out of the water column. This makes a layer of soft sediment over rocky areas, changing habitat quality and suitability for benthic organisms (Good et al. 2010). Nets can also cover habitats used by rockfish for shelter and pursuit of food, rendering the habitat unavailable. Nets can reduce the abundance and availability of rockfish prey that include invertebrates and fish (Good et al. 2010).

Based on data presented by Good et al. (2010) regarding the depth of derelict nets that are recovered, we presume that most newly lost nets would catch on bottom habitats shallower than 120 feet where they would present a limited risk to most adult ESA-listed rockfish, yet remain a risk for some juveniles, subadults and adult listed rockfish. Though we cannot estimate the number of yelloweye rockfish or bocaccio killed on an annual basis from newly lost nets, we can estimate the amount of habitat altered by them. Most recovered nets are fragments of their original size; drift gill nets can be as long as 1,800 feet, and skiff gill nets can be as long as 600 feet, yet most recovered derelict nets cover an area of only about 7,000 square feet (Good et al. 2010), suggesting that fishers may cut nets free if they are caught on the bottom or otherwise damaged. For most derelict nets, the maximum suspension off the bottom (for a portion of the net) was less than 1.5 meters when they were recovered (Good et al. 2010), and we consider suspended and non-suspended nets to degrade benthic habitats.

Due to recent additional outreach and assessment efforts (i.e. Gibson 2013), and recent lost net

inventories (Beattie and Adicks 2012; Beattie 2013) it is likely that fewer nets will become derelict in the upcoming 2017/18 fishing season compared to several years and decades ago (previous estimates of derelict nets were 16 to 42 annually (NRC 2010)). In 2014, an estimated 13 nets became derelict, and 12 of them were recovered (James 2015), in 2013 an estimated 15 nets became derelict, 12 of which were recovered (Beattie 2013), and in 2012 eight nets were lost, and six were recovered (Beattie and Adicks 2012). From June 2012 to February 2016 a total of 77 newly lost nets were reported, and only 6 of these were reported by commercial fishermen (Drinkwin 2016). We do not have estimates of the number of nets lost in the 2016/2017 salmon fisheries. Based on this new information we estimate that a range of six to 20 gill nets may be lost in the 2017/2018 fishing season, but up to 75% of these nets would be removed within days of their loss and have little potential to damage rockfish critical habitat. In the worst case analysis assuming that 20 nets are lost and five of these become derelict they would damage up to 35,000 square feet (0.8 acre) of habitat (assuming an average of 7,000 square feet). Even presuming that all lost nets would be in critical habitat (438.45 square miles for yelloweye rockfish and 1,083.11 square miles for bocaccio), they would damage a fraction of the area proposed for listed rockfish and not degrade the overall condition of critical habitat.

2.5.4 Southern Resident Killer Whales

2.5.4.1 Effects on the Species

The proposed fisheries would have an indirect effect on Southern Resident killer whales by affecting Puget Sound Chinook stocks during the May 1, 2017-April 30, 2018 fishing season. For the reasons summarized below, the effects during this time are likely to be similar to the effects previously considered in the 2011, 2014, 2015, and 2016 biological opinions (NMFS 2011a, NMFS 2014a, NMFS 2015b, NMFS 2016a) and we incorporate by reference these previous biological opinions.

Given that the abundance of Chinook salmon affected by Puget Sound fisheries during the May 1, 2017-April 30, 2018 fishing season is similar to the effects previously analyzed in the 2011, 2014, 2015, and 2016 biological opinions (NMFS 2011a, NMFS 2014a, NMFS 2015b, NMFS 2016a), it is our opinion that the effects would be no greater than those contemplated in the previous opinions. Exploitation rates for the proposed fisheries will be comparable to or lower than exploitation rates planned for the previous several years (Speaks 2014, Shaw 2016, also see section 2.4.1.2, Table 15); the projected Chinook salmon abundance this year is estimated to be within the range of that estimated previously; and corresponding impacts to Southern Resident killer whale prey base are also anticipated to be within the range of the previously estimated average effects.

The abundance of 3-5 year old Chinook salmon during July-September from the final 2016 preseason Fishery Regulation and Assessment Model (FRAM)²⁵ run is 1,670,851 (compared to 1,243,352 in 2016), which is at the upper end of the range of Chinook salmon abundance

²⁵ The primary model used by managers to assess the effects of proposed fishing regimes for salmon fisheries in Puget Sound and ocean fisheries under the jurisdiction of the Pacific Fishery Management Council.

scenarios assessed in 2011 that NMFS found would not jeopardize the survival and recovery of Southern Resident killer whales. In the 2011 opinion we described the effects of take associated with a range of 3-5 year old Chinook during July-September (873,766 – 1,747,166) which reflected a 6.6% reduction in abundance from proposed fisheries as compared to the No Action scenarios. The 2017 preseason projection is within the range of Chinook abundance referenced in the scenarios analyzed in the 2011 opinion. Ward et al. (2013; figure 22) modeled killer whale extinction risk and the probability of meeting downlisting criteria at different Chinook abundance levels. The analysis by Ward et al. (2013) was not based on FRAM projections, but an alternate abundance index that included Canadian fall, coastal Washington and Oregon fall, Puget Sound summer/fall and Columbia tule and bright stocks. Ward et al. (2013) analyzed indices ranging from 600,000 to 1.7 million which indicated a low probability of quasi-extinction and a moderate or higher probability of meeting the ESA downlisting criteria at the upper end of the range. We note that the 2017 preseason forecast of Canadian fall, coastal Washington fall, Puget Sound fall and Columbia River tule and bright stocks is 1.15 million (PFMC 2017; Table 1-1). We also note that the 2017 forecast of all Canadian and southern U.S. Chinook stocks within the migratory range of Southern Resident killer whales is 2.21 million. This is primarily a forecast of ocean escapement (entering river mouths where they empty into the ocean from California to Washington or the Strait of Juan de Fuca). Therefore, the actual abundance available to Southern Resident killer whales as prey in the ocean in 2017, using multiple abundance indices, is in the range of values analyzed in the previous opinions (NMFS 2011a, NMFS 2014a, 2015c, 2016b) and in the recent analysis (Ward et al. 2013).

As described in Section 2.2.1.4, the data now suggests a downward trend in the Southern Resident killer whale population growth projected over the next 50 years; however, the data show some stability and even a slight increase in growth during the proposed fishing action and over the next decade. This projected decline over the next 50 years is in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016. The proposed actions may result in a small decrease in the rate of growth of the population when compared to the growth rate without the action, but the anticipated decrease in growth would be less than previously anticipated in the 2011 biological opinion because of both the reduced time period considered and because the underlying relationship between Chinook abundance and killer whale population dynamics used to predicted effects likely overestimates impacts (Hilborn et al. 2012, Ward et al. 2013). We note that the predictive models linking salmon abundance and population growth consider long-term model predictions for specific levels of Chinook abundance, incorporating variation over time. It is therefore difficult to consider how one year of projected Chinook salmon abundance will truly influence population growth using these models. NMFS is actively working to pursue the research recommendations in the independent science panel's report and incorporate new information as it becomes available (Hilborn et al. 2012). New information will be considered as we continue to develop a risk assessment framework that may inform future consultations that evaluate the effects of changes in Chinook abundance on Southern Resident killer whales, including future consultations on Puget Sound harvest.

2.5.4.2 Effects on Critical Habitat

The Southern Resident killer whale DPS was listed as endangered under the ESA in 2005 (70 Fed. Reg. 69903, November 18, 2005) and critical habitat was designated in 2006 (71 Fed. Reg. 69054, November 29, 2006). Based on the natural history of the Southern Residents and their habitat needs, NMFS identified three physical or biological features essential to conservation in designating critical habitat: (1) Water quality to support growth of the whale population and development of individual whales, (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. As identified in the previous consultations, any effects on the whales, water quality or passage from the fishing vessels are likely to be minor. Our effects analyses in section 2.5.4.1 focused on the likely reduction in Chinook prey available to the whales as a result of the proposed fishing. The analysis concluded that the reduction in prey would not affect the current ability for the prey PBF to serve the intended conservation role for the species. Therefore, NMFS finds that the proposed fisheries are similar to the effects considered in the previous biological opinions (NMFS 2011a, NMFS 2014a, NMFS 2015b, NMFS 2016a), and that they would not adversely modify their critical habitat

2.6 Cumulative Effects

“Cumulative effects” are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed actions 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).

Activities occurring in the Puget Sound area were considered in the discussion of cumulative effects in the biological opinion on the Puget Sound Harvest Resource Management Plan (NMFS 2011a) and in the cumulative effects sections of several section 7 consultations on large scale habitat projects affecting listed species in Puget Sound including Washington State Water Quality Standards (NMFS 2008b), Washington State Department of Transportation Preservation, Improvement, and Maintenance Activities (NMFS 2013a), the National Flood Insurance Program (NMFS 2008c), and the Elwha River Fish Restoration Plan (Ward et al. 2008). We anticipate that the effects described in these previous analyses will continue into the future and therefore we incorporate those discussions by reference here. Those opinions discussed the types of activities taken to protect listed species through habitat restoration, hatchery and harvest reforms, and water resource management actions. The Puget Sound Salmon Recovery Plan was published in 2007 (NMFS 2006c; SSPS 2007). Puget Sound steelhead recovery planning is

underway. A Final Recovery Plan for Southern Resident killer whales was published January 24, 2008 (NMFS 2008f). Rules on vessel traffic to protect Southern Residents from vessel effects were adopted in 2011 (76 FR 20870). Outreach and enforcement of these regulations will reduce the vessel effects (as described in the environmental baseline) of recreational and whale watching vessels in U.S. waters of the action area. However, vessel effects in Canadian waters of the action area are likely to continue into the future at comparable levels to those seen in the present and recent past, because our regulations are specific to U.S. waters and Canada does not have equivalent regulations. Although state, tribal and local governments have developed plans and initiatives to benefit ESA listed salmon, they must be applied and sustained in a comprehensive way before NMFS can consider them “reasonably certain to occur” in its analysis of cumulative effects.

Some types of human activities that contribute to cumulative effects are expected to have adverse impacts on populations and PBFs, many of which are activities that have occurred in the recent past and had an effect on the environmental baseline. These can be considered reasonably certain to occur in the future because they occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Within the freshwater portion of the action area, non-Federal actions are likely to include human population growth, water withdrawals (i.e., those pursuant to senior state water rights), and land use practices. In marine waters within the action area, state, tribal, and local government actions are likely to be in the form of legislation, administrative rules, or policy initiatives, shoreline growth management, and resource permitting. Private activities include continued resource extraction, vessel traffic, development, and other activities which contribute to non-point source pollution and storm water run-off. Although these factors are ongoing to some extent and likely to continue in the future, past occurrence is not a guarantee of a continuing level of activity. That will depend on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, although NMFS finds it likely that the cumulative effects of these activities will have adverse effects commensurate to those of similar past activities; it is not possible to quantify these effects.

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 actions. 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 actions 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 Puget Sound Chinook

NMFS describes its approach to the analysis of the proposed actions in broad terms in section 2.1, and in more detail as NMFS focuses on the effects of the action in Section 2.4.1. The

approach incorporates information discussed in the Status (Section 2.2.1.1), Environmental Baseline (Section 2.3.1), and Cumulative Effects (Section 2.5) sections. In the effects analysis, NMFS first analyzes the effects of the proposed actions on individual salmon populations within the ESU using quantitative analyses where possible and more qualitative considerations where necessary. Risk to the survival and recovery of the ESU is then determined by assessing the distribution of risk across the populations within each major geographic region and then accounting for the relative role of each population to the viability of the ESU. The derivation of the RERs, and the status and trends include the impacts of the harvest, hatchery and habitat actions discussed in the Environmental Baseline. The derivation of the RERs also make assumptions about the effects of the actions discussed in the Cumulative Effects (i.e., variability in management error, environmental conditions, marine survival). By considering the RERs, status, and trend information in the discussion of effects of the proposed actions, the effects of the activities in those sections of the biological opinion are integrated into our risk assessment.

The risk assessment is presented in two stages. In the first stage, a potential area of concern or risk is identified by region based on the status of the populations relative to their escapement thresholds and RERs. The second stage of the analysis considers all of the populations in each region, with particular attention to those identified to be at higher risk in stage one. NMFS considers the factors and circumstances that mitigate the risks identified in the first stage leading to conclusions regarding the viability of each region and the ESU as a whole. We evaluate the likelihood of that concern or risk occurring and consider the practical influence harvest may have on the potential concern or risk.

The results of this evaluation also highlight the importance of habitat actions and hatchery conservation programs for the preservation and recovery of these populations specifically, and to the ESU in general. The status of many of these stocks is largely the result of reduced productivity in the wild from habitat loss and degradation and from other sources of human induced mortality. The analysis in this evaluation suggests that it is unrealistic to expect to achieve substantive increases in Chinook population abundance and productivity and population recovery through harvest reductions alone without also taking substantive action in other areas to improve the survival and productivity of the populations. Recovery of the Puget Sound Chinook ESU depends on implementation of a broad based program that addresses the identified major limiting factors of decline.

The analysis is unavoidably complex. It involves 22 populations spread across five geographic regions. NMFS uses a variety of quantitative metrics (e.g., RERs, critical and rebuilding thresholds, measures of growth rate and productivity) and qualitative considerations (e.g., PRA designation, whether a population is essential to a recovery scenario, the need for and status of a long-term transitional adaptation and recovery plan where the indigenous population has been extirpated, the magnitude of harvest in SUS fisheries, treaty fishery contribution) in its assessment of the proposed actions. These are discussed in Sections 2.4.1 (Environmental Baseline) and 2.5.1 (Effects of the Action). The Integration and Synthesis section summarizes and explains the considerations that lead to NMFS' biological opinion for the proposed actions. In the following, NMFS summarizes the considerations taken into account for each population in

a discussion that is organized by region. The same information is displayed and summarized in **Table 21** which may help navigate the complexities of the narrative.

Both Chinook populations in the Georgia Basin Region are near or at critical status. This is cause for concern given their role in recovery of the ESU. However, impacts from the proposed actions in Puget Sound fisheries are low (7%), and our analysis indicates that further harvest reductions in 2017 Puget Sound fisheries would not measurably affect the risks to survival or recovery for either Nooksack population. This result is consistent with information that indicates productivity is low and that past harvest constraints have had limited effect on increasing escapement of returning natural-origin fish, when compared with the much higher natural escapement including adults from the conservation hatchery programs. Escapement and growth trends are positive for both populations but low. The conservation hatchery programs are key components in recovery of the Nooksack early Chinook populations and should buffer demographic and genetic risks. Measures to minimize impacts to Nooksack early Chinook, particularly the South Fork population, are part of the proposed actions, and past patterns indicate exploitation rates under the proposed actions are likely to be lower than anticipated.

For the Whidbey/Main Basin Region, the effects of the proposed actions in 2017 will meet the recovery plan guidance of two to four populations representing the range of life histories displayed in this region at low risk including those specifically identified as needed for recovery of the Puget Sound Chinook ESU. The Whidbey/Main Basin Region is a stronghold of Chinook production in the ESU. Most populations in the region are doing well relative to abundance criteria and RERs, representing a diversity of healthy populations in the region as a whole. NMFS considers fisheries to present a low risk to populations where estimated impacts of the proposed fisheries are less than or equal to the RERs. The stable escapement trends and, in particular, the relatively robust status of the populations compared with their thresholds should mitigate the increased risk that results from exceeding the RER in 2017 for the Lower Skagit, Lower Sauk, and North Fork Stillaguamish populations. However, North Fork Stillaguamish escapement has declined in the last several years and is anticipated to be below the critical escapement in 2017. The Stillaguamish populations are PRA Tier 2 watersheds and their life history types are represented by other healthier populations in the region which are expected to be below their RERs (**Figure 2, Table 15**). Exploitation rates in 2017 Puget Sound fisheries are expected to be low across the four management units (5.8%-15.5%)(**Table 15**). If the proposed actions were not to occur in 2017, we estimate that an additional 4 and 15 natural-origin spawners would return to the South Fork and North Fork Stillaguamish Rivers, respectively, which would not provide sufficient additional spawners to significantly change the status or trends of the populations from what would occur without the fisheries. Growth rates for natural-origin escapement are consistently higher than growth rates for natural-origin recruitment. This indicates that sufficient fish are escaping the fisheries to maintain or increase the number of spawners from the parent generation; providing some stabilizing influence for abundance and reducing demographic risks.

For the Central/South Sound Region, implementation of the proposed 2017 fisheries will meet the recovery plan guidance of not impeding two to four populations representing the range of life

histories displayed by the populations in that region from achieving low risk including those specifically identified as needed for recovery of the Puget Sound Chinook ESU (White River and Nisqually). Most populations in the region are doing well relative to abundance criteria (**Table 21**). The Green River population is expected to meet its RER under the proposed actions indicating a low risk of the proposed actions to the population. Other populations are anticipated to exceed their RERs in 2017. The additional risks associated with exceeding the RER in the 2017 fishing year should not impede the survival and recovery of the Nisqually Chinook or White River populations. For the White River, growth rates and the escapement trend for the population are positive which include the effects of exploitation rates during the last decade similar to the proposed actions indicating the rates have not impeded growth of the population and would not be expected to do so in 2017. For the Nisqually population, this conclusion is based on four considerations: (1) the extirpated status of the indigenous Chinook population, (2) the trend in overall escapements and growth rate for natural-origin escapement, (3) the escapement anticipated in 2017, and (4) the further reduction in exploitation rate managers will take in 2017 to reduce risks while revising the long-term transitional strategy. The additional actions being taken by the co-managers as part of the proposed actions described in Section 2.4.1.2 will also help improve the status of the Nisqually Chinook population. This approach is also consistent with NMFS' responsibility to balance its tribal trust responsibility and conservation mandates by meeting the ESA's requirements while minimizing to the degree possible disruption of treaty fishing opportunity (Garcia 1998). Growth rates for natural-origin escapement are consistently higher than growth rates for natural-origin recruitment. This indicates that sufficient fish are escaping the fisheries to maintain or increase the number of spawners from the parent generation, providing some stabilizing influence for abundance and reducing demographic risks.

The Puyallup, Cedar and Sammamish River may experience some increased risks to the pace of adaptation of the existing local stock by exceeding their RERs. These populations are in PRA Tier 3 and their life histories are represented by other populations in the region. The indigenous Chinook populations have been extirpated, and potential improvement in natural-origin production is limited by the existing habitat. The Puyallup population is expected to remain above its rebuilding threshold under the 2017 fisheries. The observed increasing and stable trends in escapement and growth rate for the Cedar and Sammamish, respectively, should mitigate increased risk possible as a result of exceeding the RER. For the Sammamish population both the life history and Green River genetic legacy of the population are represented by other healthier populations in the Central/South Sound Region. The exploitation rate objective for the Puyallup population was exceeded in most or all years since exploitation rate objectives were adopted in 2003 (Grayum and Unsworth 2015). As part of the proposed actions, the co-managers will conduct another assessment of fishery management actions affecting achievement of objectives specified by the Plan for the Puyallup management unit (Speaks 2017) which will assess a variety of factors. The co-managers will provide a report on the results to NMFS by mid-February 2018, with a draft of the report exchange between parties in November 2017. The co-managers propose to address any bias found in the performance review through updates to forecasts and/or FRAM model inputs as necessary. Further review and discussion of the results may identify other responses or analysis.

In summary, given the information and context presented above, the fishing regime represented by the proposed actions for 2017 should not impede the long-term persistence of five (White, Cedar, Duwamish-Green, Puyallup and Nisqually) of the six populations in the Region in 2017. Therefore, implementation of the proposed 2017 fisheries will meet the recovery plan guidance for two to four populations representing the range of life histories displayed by the populations in that region including those specifically identified as needed for recovery of the Puget Sound Chinook ESU (White River and Nisqually). The Sammamish River population may experience some increased risks to the pace of adaptation of the existing local stock given the current status of the natural-origin population. However, the native population has been extirpated and potential improvement in natural-origin production is limited by the existing habitat. Analysis suggests further harvest reductions in 2017 Puget Sound fisheries would not measurably affect the risks to survival or recovery for the population. The population is not essential for recovery of the Puget Sound Chinook ESU (PRA Tier 3), trends in escapement and growth rates are increasing and both the life history and Green River genetic legacy of the population are represented by other populations in the Central/South Sound Region.

The status of the populations in the Hood Canal Region, given their role in recovery of the ESU, is cause for concern. The combination of declining growth rates, low productivity, and low levels of natural-origin escapement suggest these populations are at high risk for survival and recovery. However, the indigenous populations no longer exist and the focus is on a long-term transitional strategy to rebuild one or more locally adapted Chinook populations. The available information indicates further constraints on 2017 Puget Sound fisheries would not measurably affect the risks to survival or recovery of the spawning aggregations within the Mid-Hood Canal population. The general characteristics of the Mid-Hood Canal Rivers population, including genetic lineage, life history, and run timing, are also found in the Skokomish River population and the Hamma Hamma conservation hatchery program should help buffer some demographic risks to the Mid-Hood Canal Rivers population. The proposed actions are consistent with the longer term transitional strategy for recovery of the Skokomish population, the trend in natural escapements is stable, the natural escapement anticipated in 2017 is consistent with that trend, and the co-managers have proposed additional actions as part of the proposed actions to bolster recovery of the population (Unsworth and Parker 2017, Unsworth and Grayum 2016, Grayum and Unsworth 2015, Redhorse 2014, Skokomish and WDFW 2010). Conservation hatchery programs for spring Chinook and late-time fall Chinook were initiated in the Skokomish River in 2014 with further actions taken in 2015 and 2016 to refine the implementation plan for the late-timed program. The fact that growth rates in natural-origin escapement exceed those for recruitment indicates that fisheries may provide some stabilizing influence to abundance and productivity thereby reducing demographic risks. The Skokomish population has been managed subject to a 50% exploitation rate ceiling since 2010. The ceiling has been exceeded every year with virtually all of the overage occurring in the terminal net fishery. Substantial changes in management were made in 2013-2016 but were unsuccessful in achieving the terminal harvest rate objectives. However, the anticipated exploitation rate in 2017 is 47.5%, below the ceiling of 50% which should improve the likelihood that the exploitation rate objective will be met in 2017. The critical status of the Skokomish Chinook population underscores the importance of meeting the exploitation rate

objective such that fisheries do not represent more of a risk than is consistent with a transitional strategy to recovery. As part of the proposed actions, the co-managers will conduct another assessment of fishery management actions affecting achievement of objectives specified by the Plan for the Puyallup management unit (Speaks 2017) which will assess a variety of factors. The co-managers will provide a report on the results to NMFS by mid-February 2018, with a draft of the report exchange between parties in November 2017. The co-managers propose to address any bias found in the performance review through updates to forecasts and/or FRAM model inputs as necessary. Further review and discussion of the results may identify other responses or analysis required in the future. Considering these factors, additional risks associated with exceeding the RER in 2017 should not impede the long-term persistence of the Skokomish Chinook population.

In the Strait of Juan de Fuca Region, both populations are in critical status and both are expected to exceed their RERs in 2017. This is cause for concern given their role in recovery of the ESU. However, impacts from the proposed actions in Puget Sound fisheries are very low (<5%) and analysis suggests further harvest reductions in 2017 Puget Sound fisheries would not measurably affect the risks to survival or recovery for either population. Under the proposed actions, escapement of natural-origin fish in the Elwha and Dungeness are expected to remain below their critical thresholds. When hatchery-origin spawners are taken into account, escapements in the Dungeness more than double exceeding its critical threshold and exceed the rebuilding threshold for the Elwha. The trend in escapement is stable and is positive for growth rate for the Dungeness. The trend in escapement is stable and strongly negative for growth rate for the Elwha which is not surprising given the historically poor conditions in the watershed. The conservation hatchery programs operating in the Dungeness and Elwha Rivers are key components for recovery of these populations and buffer demographic risks and preserve the genetic legacies of the populations as degraded habitat is recovered. Dam removal on the Elwha River was completed in 2014 and a full scale restoration and recovery program is now underway which will substantially change the status and trajectory for that population.

In summary, under the proposed actions, the combined ocean and Puget Sound exploitation rates for the 2017 fishing year for three of the 14 management units and the Upper Skagit population in the ESU (7 of 22 populations) are expected to be under their RER or RER surrogates (**Table 21**). NMFS considers the proposed actions to present a low risk to populations that do not exceed their RERs (NMFS 2004b). For the populations above their RERs or RER surrogates:

- (1) current and anticipated population status in 2017 and stable or positive trends in escapement and growth rate alleviated concerns about additional risk (Lower Skagit, Lower Sauk, and North Fork Stillaguamish, Cedar, Sammamish);
- (2) anticipated impacts from the proposed 2017 Puget Sound fisheries are low and the effect on the population is negligible (North and South Fork Nooksack, Sammamish, Mid-Hood Canal Rivers, Dungeness and Elwha, South Fork Stillaguamish);
- (3) indigenous populations in the watershed have been extirpated and the proposed fisheries and additional actions proposed by the co-managers are consistent with long-term strategies for local adaptation and rebuilding of the remaining populations (Nisqually, Skokomish); and,

(4) populations were in lower PRA tiers and life histories were represented by other healthier populations in the region (Cedar, South Fork Stillaguamish, Sammamish, Puyallup).

Twelve of the 22 populations in the ESU are expected to exceed their critical thresholds for escapement and five of those are expected to exceed their rebuilding thresholds (**Table 21**). Nine populations are expected to be below their critical thresholds (North and South Fork Nooksack, North and South Fork Stillaguamish, Sammamish, Mid-Hood Canal, Skokomish, Dungeness, Elwha). For these populations, the fisheries resulting from implementing the proposed actions in 2017 would not meaningfully affect the persistence of the populations under the recovery strategies in place or the indigenous population has been extirpated and a long-term transition strategy is in place.

Table 21. Summary of factors considered in assessing risk by population in the Puget Sound Chinook ESU.

Region	Population	≤ RER ¹	Population Status ² (Avg/2017)		Escapement Trend ³	Growth Rate Return/Escapement ³		Exploitation Rate in PS fisheries ⁴	Approach consistent with transitional strategy ⁴	PRA Tier
Strait of Georgia	N.F. Nooksack early									1
	S.F. Nooksack early									1
Whidbey/Main Basin	Upper Skagit moderately early									1
	Lower Skagit late									1
	Lower Sauk moderately early									1
	Upper Sauk early									1
	Suiattle very early									1
	Upper Cascade moderately early									1
	N.F. Stillaguamish early									2
	S.F. Stillaguamish moderately early									2
	Skykomish late									2
	Snoqualmie late									3
	Sammamish									3
	Cedar									3
South Sound	Duwamish-Green									2
	White									1
	Puyallup									3
	Nisqually									1
	Mid-Hood Canal									1
	Skokomish									1
Strait of Juan de Fuca	Dungeness									1
	Elwha									1

¹Table 13. NMFS considers fisheries to present a low risk to populations where estimated impacts of the proposed fisheries are less than or equal to the RERs,

² Tables 3

³ Table 4

⁴ Described in text of Section 2.5.1.2 for each MPG in the ESU: Green=low, yellow=moderate, red=high

NMFS noted a particular need for caution for the populations in the Hood Canal Region and Nisqually Chinook. There are only two populations in the Hood Canal Region so both are essential for recovery of the ESU. The Nisqually population is one of two populations in the Central/South Sound Region essential to recovery of the Puget Sound Chinook ESU. Although we concluded that, given the available information, additional risks associated with implementation of the proposed actions in 2017 will not impede the survival and recovery of the ESU, progress of the long-term transitional strategies in these areas should be closely watched given the status of the Skokomish and Nisqually populations, potential long-term effects on survival and recovery suggested by modeling associated with the exploitation rate objective compared with the RER or RER surrogate, and the recent year pattern of exceeding the exploitation rate objective for the Skokomish River population. Continued adaptive management and implementation of the long term transition strategies in these watersheds together with the additional management measures described in the proposed actions will be key to recovery of the populations in those watersheds.

As described in the previous sections, NMFS also considers its trust responsibility to the tribes in evaluating the proposed actions and recognizes the importance of providing tribal fishery opportunity, as long as it does not pose a risk to the species that rises to the level of jeopardy. This approach recognizes that the treaty tribes have a right and priority to conduct their fisheries within the limits of conservation constraints.

We also assessed the effects of the action on Puget Sound Chinook critical habitat in the context of the status of critical habitat, the environmental baseline, and cumulative effects, to evaluate whether the effects of the proposed fishing are likely to reduce the value of designated critical habitat for the conservation of listed Puget Sound Chinook salmon. The PBFs most likely to be affected by the proposed actions are (1) water quality, and forage to support spawning, rearing, individual growth, and maturation; and, (2) the type and amount of structure and rugosity that supports juvenile growth and mobility. Fishermen in general actively avoid contact of gear with the substrate because of the resultant interference with fishing and potential loss of gear so would not disrupt juvenile habitat. Derelict fishing gear can affect habitat in a number of ways including barrier to passage, physical harm to eelgrass beds or other estuarine benthic habitats, or occupying space that would otherwise be available to salmon. These impacts have been reduced through changes in state law and active reporting and retrieval of lost gear. Any impact to water quality from vessels transiting critical habitat areas on their way to the fishing grounds or while fishing would be short term and transitory in nature and minimal compared to the number of other vessels in the area participating in activities un-related to the proposed actions. Also these effects would occur to some degree through implementation of fisheries or activities other than the Puget Sound salmon fisheries. Fisheries under the proposed actions will occur within many areas designated as critical habitat in Puget Sound. However, fishing activities will take place over relatively short time periods in any particular area. Other potential effects described in Section 2.4.1.3 are mitigated for under the proposed actions. As discussed in Section 2.2, Rangewide Status of the Species and Critical Habitat, and Section 2.3, Environmental Baseline, of this opinion, critical habitat features in the action area (i.e., forage, water quality, and rearing and spawning habitat) may be affected by forestry; grazing; agriculture; channel/bank

modifications; road building/maintenance; urbanization; sand and gravel mining; dams; irrigation impoundments and withdrawals; river, estuary, and ocean traffic; wetland loss; forage fish/species harvest; and climate change. For the reasons described, we would expect the proposed actions to result in minimal additional impacts to these features although we cannot quantify those impacts because of their transitory nature.

2.7.2 Puget Sound Steelhead

ESA-listed steelhead are caught in tribal and non-tribal marine and freshwater fisheries in the proposed actions that targeting other species of salmon and hatchery-origin steelhead.

NMFS determined that the harvest management strategy that eliminated the direct harvest of natural origin steelhead in the 1990's, prior to listing, largely addressed the threat of harvest to the listed DPS (72 Fed. Reg. 26722, May 11, 2007). In the recent status review, NMFS concluded that the status of Puget Sound steelhead has not changed significantly since the time of listing (NMFS 2017a) and reaffirmed the observation that harvest rates on natural-origin steelhead continue to decline and are unlikely to substantially affect the abundance of Puget Sound steelhead (NWFSC 2015). A key consideration in recent biological opinions was therefore whether catches and catch rates had continued to decline since listing which would reinforce the conclusion that the threat of harvest to the DPS continued to be low.

Under the proposed actions, the expected impact on Puget Sound steelhead in marine fisheries from implementation of the proposed fisheries is expected to be below the level noted in the listing determination during the 2017-2018 season based on similarity of catch patterns and fishing regulations. This expectation is substantiated by the pattern of lower catches in recent years described in Section 2.3.1 and summarized in Table 10 which showed a 46% decline in marine area catches in recent years.

Under the proposed actions, the expected harvest rate in freshwater fisheries is expected to be below that observed at the time of listing. NMFS compared the average harvest rates for a set of five index populations at the time of listing (4.2%) and more recent years (1.6%) and concluded that the average harvest rate had declined by 62% (**Table 11**).

We do not anticipate impacts to steelhead from research test fisheries discussed in this opinion because of the timing, gear and area of the studies relative to the timing and area of steelhead migration in the study areas. However, to be conservative we estimated potential encounters of 14 adults and 2 juveniles just in case encounters were to occur (Section 2.4.2.2). When the research related impacts are added to those resulting from the proposed fisheries, they do not change the conclusion that take associated with the proposed actions continues to be low and well below the levels reported at the time of listing.

Critical habitat is located in many of the areas where Puget Sound recreational and commercial salmon fisheries occur. However, fishing activities will take place over relatively short time periods and thus have a very limited opportunity to impact critical habitat. The PBFs most likely to be affected by the proposed actions are (1) water quality, and forage to support spawning,

rearing, individual growth, and maturation; and, (2) the type and amount of structure and rugosity (NWFSC 2015) that supports juvenile growth and mobility. Fishermen endeavor to keep gear from being in contact or entangled with substrate and habitat features because of the resultant interference with fishing and potential loss of gear. This would result in a negligible effect on the PBFs. Any impact to water quality from vessels transiting critical habitat areas on their way to the fishing grounds or while fishing would be short term and transitory in nature and minimal compared to the number of other vessels in the area (NMFS 2004c).

The environmental baseline for listed steelhead in Puget Sound and their critical habitat includes the ongoing effects of past and current development activities and hatchery management practices. Development activities continue to contribute to the loss and degradation of steelhead habitat in Puget Sound such as barriers to fish passage, adverse effects on water quality and quantity associated with dams, loss of wetland and riparian habitats, and agricultural and urban development activities. Extensive propagation of out-of-basin stocks (e.g., Chambers Creek and Skamania hatchery stocks) throughout the Puget Sound DPS, and increased predation by marine mammals and birds are also sources of concern. Development activities and the ongoing effects of existing structures are expected to continue to have adverse effects similar to those in the baseline. Hatchery production has been modified to some extent to reduce the impacts to ESA-listed steelhead, but is expected to continue at lower levels with lesser impacts. NMFS expects that both Federal and State steelhead recovery and management efforts will provide new tools, data and technical analyses, refine Puget Sound steelhead population structure and viability, and better define the role of individual populations in the DPS. The recovery plan will identify measures necessary to protect and restore degraded habitats, manage hatcheries and fisheries consistent with recovery, and prioritize research on data gaps regarding population parameters. The final recovery plan is anticipated to be completed in 2019.

2.7.3 Puget Sound/Georgia Basin Rockfish

Historic fishery removals were a primary reason for depleted listed rockfish populations, yet the impact of current fisheries and associated bycatch is more uncertain. As detailed in Section 2.3, Environmental Baseline, yelloweye rockfish and bocaccio are caught by anglers targeting halibut, bottom fish and by researchers. To assess if take from the salmon fisheries within the range of the listed rockfish DPSs threatens the viability of each species, in combination with other sources of bycatch in the environmental baseline, we review the population-level impact from all fisheries and research combined. In order to conduct this analysis, we must assess take numbers relative to the overall population of the rockfish DPS of each species.

To assess the effect of these mortalities on population viability, we adopted the methodology used by the PFMC for rockfish species. The decline of West Coast groundfish stocks prompted the PFMC to reassess harvest management (Ralston 1998, 2002). The PFMC held a workshop in 2000 to review procedures for incorporating uncertainty, risk, and the precautionary approach in establishing harvest rate policies for groundfish. The workshop participants assessed best available science regarding “risk-neutral” and “precautionary” harvest rates (Scientific and Statistical Committee 2000). The workshop resulted in the identification of risk-neutral harvest rates of 0.75 of natural mortality, and precautionary harvest rates of 0.5 to 0.7 (50 to 70 percent)

of natural mortality for rockfish species. These rates are supported by published and unpublished literature (Scientific and Statistical Committee 2000; Walters and Parma 1996), and guide rockfish conservation efforts in British Columbia, Canada (DFO 2010; Yamanaka and Lacko 2001). Fishery mortality of 0.5 (or less) of natural mortality was deemed most precautionary for rockfish species, particularly in data-limited settings, and was considered a rate that would not hinder population viability (Scientific and Statistical Committee 2000; Walters and Parma 1996). Given the similar life histories of yelloweye rockfish and bocaccio to coastal rockfish managed by the PFMC, we concluded that this method represented the best available scientific information for assessing the effects of fisheries-related mortality on the viability of the ESA-listed rockfish.

To assess the population-level effects to yelloweye rockfish and bocaccio from the proposed salmon fisheries, and similar to our analysis in section 2.5.3, we calculated the range of total anticipated annual mortalities (**Table 22**).

Table 22. Estimated total annual lethal take for the salmon fisheries and percentages of the listed-rockfish.

Species	Range of Estimated Lethal Take ^a	Abundance Scenario	Range of Percent of DPS Killed
Bocaccio	1 to 77	3,000	0.03 to 2.6
		4,606	0.2 to 1.7
Yelloweye rockfish	2 to 68	40,000	0.005 to 0.017
		47,407	0.004 to 0.014

For yelloweye rockfish and bocaccio, mortalities from the proposed salmon fisheries in the range of the DPSs would be well below the precautionary level as described above (0.5 (or less) of natural mortality) and risk-neutral level (0.75 or less) for each of the abundance scenarios.

Annual natural mortality rate for bocaccio is approximately 8 percent (as detailed in Section 2.3.2) (Palsson et al. 2009); thus, the precautionary level of fishing would be 4 percent and risk-neutral would be up to 6 percent. Lethal takes from the proposed salmon fisheries would be well below the precautionary and risk-neutral levels for each of the abundance scenarios.

Annual natural mortality rates for yelloweye rockfish range from 2 to 4.6 percent (as detailed in Section 2.3.2) (Wallace 2007; Yamanaka and Kronlund 1997); thus, the precautionary range of fishing and research mortality would be 1 to 2.4 percent and risk-neutral would be 1.5 to 3.45 percent. Lethal takes from the salmon fisheries in the DPS would be below the precautionary and risk-neutral level for each of the abundance scenarios.

To assess the population-level effects to yelloweye rockfish and bocaccio from activities associated with the research permits within the environmental baseline, fishery take associated with the proposed actions, and fishery take within the environmental baseline, we calculated the total mortalities for all sources (**Table 23**).

Table 23. Estimated total takes for the salmon fishery and percentages of the listed-rockfish covered in this Biological Opinion in addition to takes within the environmental baseline.

Species	Total Take in Baseline (plus salmon fishery high estimate)	Total Lethal Take in Baseline (plus salmon fishery high estimate)	Abundance Scenario	Percent of DPS Killed (total lethal takes)
Bocaccio	116(+77)	67(+77)	3,000	4.8
			4,606	3.1
Yelloweye rockfish	603(+117)	458(+68)	40,000	1.3
			47,407	1

Lethal takes are most relevant for viability analysis. For yelloweye rockfish and bocaccio, the takes from the salmon fishery, in addition to previously assessed lethal scientific research and fishery bycatch (fishermen targeting bottom fish and halibut) (detailed in Section 2.3, Environmental Baseline), would be within or below the risk-neutral and/or precautionary level for each of the abundance scenarios. Our analysis of potential bycatch for each species uses precautionary assumptions and thus would likely be lower than estimated. These precautionary assumptions include that, of the previously analyzed research projects, the actual take of yelloweye rockfish and bocaccio is well below the permitted take. As an example, since bocaccio were listed in 2010, only 3 fish have been taken in research projects (compared to the permitted take of 58 fish, and 27 mortalities in 2017 alone) within the U.S. portion of the DPS area. An additional precautionary factor is the population estimates that only include the San Juan Island area (WCA 7). Recent ROV surveys and genetic research projects have documented yelloweye rockfish in the Central Sound and Hood Canal, while bocaccio have been documented in Central Sound. We do not yet have population estimates from the recent ROV study, but anticipate them within the next year.

In addition to fishery mortality, rockfish are killed by derelict fishing gear (Good et al. 2010), though we are unable to quantify the number of yelloweye rockfish and bocaccio killed by pre-existing derelict gear or new gear that would occur as part of commercial fisheries within the proposed actions. Despite these data limitations, it is unlikely that mortality associated with derelict gear would cause mortality levels of yelloweye rockfish and bocaccio to exceed the precautionary or risk-adverse levels. This is because: (1) the removal of thousands of nets has restored approximately 650 acres of the benthic habitat of Puget Sound and likely reduced mortality levels for each species; (2) most new derelict gear would become entangled in habitats less than 100 feet deep (and thus avoid most adults); (3) new derelict gear would degrade a relatively small area (up to 0.8 acres of habitat per year), and thus would be unlikely to result in significant additional mortality to listed-rockfish; and (4) the recent and the ongoing program to provide outreach to fishermen to prevent net loss.

Given the threatened status of yelloweye rockfish and the endangered status of bocaccio in the Puget Sound/Georgia Basin DPS, we continue to evaluate whether it is appropriate for us to rely on acceptable mortality levels established using the methods described by Walters and Parma (1996) and the Scientific and Statistical Committee (2000).

We also assessed the effects of the action on yelloweye rockfish and bocaccio critical habitat in the context of the status of critical habitat, the environmental baseline, and cumulative effects to evaluate whether the effects of the proposed fishing are likely to reduce the value of proposed critical habitat for the conservation of each species. The main potential effect of the proposed fishing on listed rockfish critical habitat would be derelict fishing nets. As discussed in Section 2.2, Rangewide Status of the Species and Critical Habitat and Section 2.3, Environmental Baseline, of this opinion, proposed critical habitat features in the action area (i.e., prey resources, water quality, and complex bottom habitats) may be affected by non-point source and point source discharges, hypoxia, oil spills, dredging projects and dredged material disposal activities, nearshore construction projects, renewable ocean energy installations, and climate change. We would expect the proposed fishing to result in minimal additional impacts by the loss of some gill nets to a subset of these features. Thus, the proposed fishing is not likely to reduce the value of critical habitat for the conservation of yelloweye rockfish and bocaccio of the Puget Sound/Georgia Basin DPSs.

In summary, the listed DPSs are at risk with regard to the each of the four VSP criteria, and habitats utilized by listed-rockfish are impacted by nearshore development, derelict fishing gear, contaminants within the food-web and regions of poor water quality, among other stressors. Benefits to habitat within the DPSs have come through the removal of thousands of derelict fishing nets, though nets deeper than 100 feet remain a threat. Degraded habitat and its consequences to ESA-listed rockfish can only be described qualitatively because the precise spatial and temporal impacts to populations of yelloweye rockfish and bocaccio are poorly understood. However, there is sufficient evidence to indicate that listed-rockfish productivity may be reduced because of alterations to habitat structure and function.

Because most adult yelloweye rockfish and bocaccio occupy waters much deeper than surface waters fished by commercial nets, the bycatch of adults in commercial salmon fisheries is likely extremely low to non-existent. However, new derelict gear is a source of potential incidental mortality. The recreational bycatch levels from the 2017/18 salmon fishery season are expected to be quite low, within the risk-neutral or precautionary mortality rates identified for overfished rockfish of the Pacific Coast. Concerns remain about fishery-mortality effects to spatial structure, connectivity and diversity for each species. These concerns are partially alleviated because of the low bycatch rates for each species, and considering that the abundance of each species is likely higher than assessed within our analysis. The structure of our analysis provides conservative population scenarios for the total population of each DPS, and likely overestimates the total mortalities of caught and released fish. Thus taken together, the effects of the proposed actions on ESA-listed rockfish in Puget Sound, in combination with anticipated bycatch from other fisheries and research, their current status, the condition of the environmental baseline, and cumulative effects are not likely to reduce appreciably the likelihood of survival and recovery of yelloweye rockfish and bocaccio.

2.7.4 Southern Resident Killer Whales

This section discusses the effects of the action in the context of the status of the species and designated critical habitat, the environmental baseline, and cumulative effects, and offers our

opinion as to whether the effects of the proposed actions are likely to jeopardize the continued existence of the Southern Residents or adversely modify or destroy Southern Residents' designated critical habitat. We incorporate by reference the previous analyses in the NMFS (2011a), NMFS (2014a), NMFS (2015c), and NMFS (2016b) biological opinions (and therefore the status, environmental baseline, and effects). These previous opinions incorporated the best available information at the time for the relevant sections, and we supplemented this biological opinion with new information available subsequent to the 2016 biological opinion.

The Southern Resident killer whale DPS was listed as endangered under the ESA in 2005 (70 Fed. Reg. 69903, November 18, 2005) and critical habitat was designated in 2006 (71 Fed. Reg. 69054, November 29, 2006). Several factors identified in the final recovery plan for Southern Residents may be limiting recovery. These are quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. It is likely that multiple threats are acting together. For example, disturbance from vessels makes it harder for the whales to locate and capture prey, which can cause them to expend more energy and catch less food. Although it is not clear which threat or threats are most significant to the survival and recovery of Southern Residents, all of the threats are important to address. Based on the natural history of the Southern Residents and their habitat needs, we identified three physical or biological features essential to conservation in designating critical habitat: (1) water quality to support growth of the whale population and development of individual whales, (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.

The Southern Resident killer whale DPS is composed of one small population (consisting of 78 whales as of April 2017) which has had a variable growth rate, is at risk from inbreeding, and has a high extinction risk, depending on the survival rate and probability of catastrophic events. Most of the offspring in recent years were sired by two fathers. Because a small number of males were identified as the fathers of many offspring, a smaller number may be sufficient to support population growth than was previously thought.

Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. The results of these sampling efforts indicate that Southern Residents' diet consists of a high percentage of Chinook. As identified in the previous consultations, any direct effects on the whales from the vessels involved in the proposed fishing, are likely to be minor, and our effects analyses focused on the likely reduction in Chinook prey available to the whales as a result of the proposed fishing. Recently, Ward et al. (2013) and Vélez-Espino et al. (2014b) addressed the relative role of Chinook salmon abundance on the population growth and viability of the Southern Resident killer whales. They found a significant relationship between Chinook salmon abundance and the vital rates of the whales, similar to the relationships analyzed in the previous consultations.

We anticipate that the effects of the proposed fishing action would be a reduction in prey no greater than the reduction contemplated in the previous opinions (NMFS 2011a, NMFS 2014a,

NMFS 2015b, NMFS 2016a). Exploitation rates for the proposed fisheries will be comparable to or lower than exploitation rates planned for the previous years (Speaks 2014, Shaw 2016, also see Section 2.5.1.2). The projected Chinook salmon abundance available to the whales as prey in 2017 (1,670,850 3-5 year old Chinook salmon) is also estimated to be within the range of that estimated previously). This abundance is also within the range of values Ward et al. (2013) analyzed (600,000 to 1.7 million), which indicated a low probability of quasi-extinction and a moderate or higher probability of meeting the ESA downlisting criteria at the upper end of the range.

Although the exploitation rates for the proposed fisheries will be comparable to previous years, and the projected Chinook salmon abundance is within the range previously analyzed, the Southern Resident killer whale status has changed. Current data suggests a downward trend in the Southern Resident population growth over the next 50 years likely due to recent changes in sex and age structure and relatively low fecundity rates. However, during the next decade, the population growth is likely to show some stability or potentially increase slightly. The proposed actions may reduce the rate of growth compared to no proposed actions. In general, the potential for reduced growth rate to have a meaningful effect on population viability depends upon the duration and magnitude of the anticipated reduction. In this case, the duration is short (1 year), continuation of the fishery after that point requires a further ESA approval from NMFS, and the anticipated magnitude is small. In addition, our previous analyses focused on the high end of potential reductions in prey, such that the estimated reductions in growth rate are based on average or maximum reductions in prey from fishing. We note that the predictive models linking salmon abundance and population growth consider long-term model predictions for specific levels of Chinook abundance, incorporating variation over time, and that the influence on population dynamics of the whales is small or uncertain. It is difficult to consider how one year of projected Chinook salmon abundance and fishing will truly influence population growth using these models. We continue to develop a risk assessment framework that should inform our evaluations on the effects of changes in Chinook abundance on Southern Resident killer whales. Informed by these factors, it is NMFS' professional opinion that the anticipated incrementally small decrease in growth rate from one year of proposed fishing is not likely to cause a meaningful change to the viability of the killer whale population and therefore is not likely to reduce, appreciably, the survival and recovery of the species.

2.8 Conclusion

2.8.1 Puget Sound Chinook

After reviewing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed actions, 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 the Puget Sound Chinook salmon ESU or adversely modify its designated critical habitat.

2.8.2 Puget Sound Steelhead

After reviewing the current status of the listed species, the environmental baseline within the

action area, the effects of the proposed actions, any effects of interrelated and interdependent actions, and cumulative effects, it is NMFS' biological opinion that the proposed actions are not likely to jeopardize the continued existence of the Puget Sound Steelhead DPS or adversely modify proposed designated critical habitat for the Puget Sound Steelhead DPS.

2.8.3 Puget Sound/Georgia Basin Rockfish

After reviewing the current status of yelloweye rockfish and bocaccio within the Puget Sound/Georgia Basin DPSs, the environmental baseline for the action area, the effects of the proposed actions, and the cumulative effects, NMFS concludes that the proposed actions are not likely to jeopardize the continued existence of each species of listed-rockfish or adversely modify designated critical habitat for each species.

2.8.4 Southern Resident KillerWhales

After reviewing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed actions, 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 Southern Resident killer whales or adversely modify its designated critical habitat.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

This incidental take statement specifies the impact of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary or appropriate to minimize impacts and sets forth terms and conditions in order to implement the reasonable and prudent measures.

2.9.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take would occur as follows:

2.9.1.1 Puget Sound Chinook

NMFS anticipates incidental take of listed Puget Sound Chinook to occur in the proposed Puget

Sound salmon and steelhead fisheries from May 1, 2017 through April 30, 2018 through contact with fishing gear. NMFS anticipates Puget Sound salmon fisheries occurring in 2017 together with ocean and Puget Sound fisheries approved under existing consultations will not exceed the exploitation rates summarized in **Table 15** in the column titled Ocean + Puget Sound. These exploitation rates account for landed and non-landed mortality of listed Puget Sound Chinook encountered in the consultation fisheries. Test, research, update and evaluation fisheries that inform fishery management decisions are included as part of the fishery-related mortality summarized in **Table 15**. Exploitation rates are used to define the extent of take for several reasons: (1) they are a direct measure of the take of the listed species that incorporates both the landed and release mortality resulting from implementation of the proposed actions; (2) they are a key parameters used to analyze the effects of the proposed actions; (3) fisheries are designed and managed based on exploitation rates rather than the mortality of individual fish; (4) they can be monitored and assessed; and, (5) they are responsive to changes in abundance over time and therefore a better measure of the effect on the listed species than just enumeration of individual fish.

NMFS anticipates that no more than 10 adult, 60 immature and 30 juvenile Chinook incidental mortalities will occur in the research test fisheries discussed in this opinion from May 1, 2017 through April 30, 2018.

2.9.1.2 Puget Sound Steelhead

NMFS anticipates incidental take to occur in Puget Sound marine and freshwater commercial, recreational and ceremonial and subsistence, from May 1, 2017 through April 30, 2018 through contact with fishing gear.

NMFS anticipates that a maximum of 325 steelhead will be caught in marine area fisheries with an expected catch of 176 based on observations from recent years (**Table 10**). These estimates include an unknown proportion of ESA listed steelhead, unlisted hatchery steelhead, and hatchery and natural-origin fish from Canada.

NMFS also anticipates that the harvest rate on natural-origin steelhead in freshwater treaty and non-treaty fisheries will be no more than 4.2%, with an the expected harvest rate will be 1.6% based on observations from more recent years (**Table 11**). This was calculated as an average across the five Puget Sound winter steelhead populations for which sufficient data are available (i.e., Skagit, Snohomish, Green, Puyallup and Nisqually). That is, the specified harvest rates represent an average across the five winter steelhead populations; it is not an anticipated population specific freshwater harvest rate. Harvest rates are used to define the extent of take for several reasons: (1) they are a direct measure of the take of the listed species that incorporates both the landed and release mortality resulting from implementation of the proposed actions; (2) they are a key parameter used to analyze the effects of the proposed actions; (3) fisheries are generally designed and managed based on harvest rates rather than the mortality of individual fish; (4) they can be monitored and assessed; and, (5) they are responsive to changes in abundance over time and therefore a better measure of the effect on the listed species than just enumeration of individual fish.

NMFS does not have similar estimates of freshwater harvest for other Puget Sound steelhead populations. However, NMFS anticipates that the harvest rates for other populations will be within the range for the five populations discussed above based on the similarity of catch patterns and fishing regulations.

NMFS anticipates that no more than 14 and 2 juvenile steelhead incidental encounters will occur in the research test fisheries discussed in this opinion from May 1, 2017 through April 30, 2018.

2.9.1.3 Puget Sound/Georgia Basin Rockfish

NMFS anticipates that incidental take of ESA listed rockfish would occur by two separate pathways: (1) bycatch of listed-rockfish by anglers targeting salmon, and (2) the indirect effects of lost (derelict) nets. NMFS anticipates that up to 68 yelloweye rockfish, and 77 bocaccio would be killed as bycatch by commercial anglers during the 2017/2018 Puget Sound salmon fishing season that is the subject of this opinion. NMFS anticipates that some minimal take of ESA-listed rockfish would occur as a result of the indirect effects of lost nets in the Puget Sound/Georgia Basin. NMFS estimates that up to 20 gill nets from salmon fisheries may become lost, and of those up to five nets would not be retrieved. If those five nets are lost within rockfish habitat, they would degrade benthic areas potentially used by ESA-listed rockfish. Estimating the specific number of ESA-listed rockfish that may be killed from a new derelict net is difficult to quantify because of several factors, including the location of its loss, the habitat which it eventually catches on, and the occurrence of fish within or near that habitat. The fishery managers for fisheries that are subject of this opinion also track derelict nets through their reporting system and partnership with the Northwest Straits Initiative.

2.9.1.4 Southern Resident Killer Whales

The harvest of Chinook salmon that would occur under the proposed actions could result in some level of harm to Southern Resident killer whales by reducing prey availability. The take estimated for killer whales for a reduction in Chinook prey is within the effects analyzed where the abundance of large (age 3-5) Chinook in the action area as estimated by FRAM during July-September is between 873,766 – 1,747,166 Chinook.²⁶

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed actions, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.2.1 Reasonable and Prudent Measures

“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).

²⁶ Table 1 in Appendix A of NMFS 2011a. The take allowance is the result of the scenario: No Action FRAM abundance w/ 6.6% reduction in abundance from proposed fisheries: 873,766 – 1,747,166 Chinook.

The following reasonable and prudent measures are included in this incidental take statement for the Puget Sound Chinook salmon ESU and Puget Sound steelhead DPS considered in this opinion:

- (1) In-season management actions taken during the course of the fisheries shall be consistent with the level of incidental take established preseason that were analyzed in the biological opinion (see Section 2.5.1.2 and 2.5.2.2) and defined in Section 2.9.1.1 and 2.9.1.2.
- (2) A revised long-term strategy and adaptive management plan shall be developed for Nisqually Chinook by the end of November 2017.
- (3) Catch and other management measures used to control fisheries shall be monitored using best available measures.
- (4) The fisheries shall be sampled for stock composition and other biological information.
- (5) Post season reports shall be provided of take on listed salmon and steelhead in the proposed fisheries and related research studies. Managers shall use results to improve management of Puget Sound Chinook and steelhead to ensure management objectives are met.
- (6) Escapement monitoring for the salmon and steelhead population that are affected by the proposed actions shall be improved using available resources.

The following reasonable and prudent measures are included in this incidental take statement for Southern Resident killer whales:

- (7) NMFS, in consultation with the co-managers, will estimate the observed abundance of Chinook, as defined under Amount or Extent of Take, using postseason information as it becomes available.
- (8) Harvest impacts shall be monitored using the best available measures. Although NMFS is the federal agency responsible for carrying out this reasonable and prudent measure, in practical terms, it is the co-managers that monitor catch impacts.
- (9) All conservation measures that are part of the proposed actions shall be implemented by NMFS in the period specified. NMFS will consult with the co-managers and the Canadian government to implement these measures, as necessary.

NMFS also concludes that the following reasonable and prudent measures are necessary to minimize the impacts to ESA listed Puget Sound/Georgia Basin rockfish

- (10) Derelict gear impacts on listed rockfish shall be reported using best available measures.
- (11) Bycatch of ESA-listed rockfish shall be estimated using best available measures.

2.9.2.2 Terms and Conditions

The terms and conditions described below are non-discretionary, and NMFS, BIA, USFWS or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14) described above. The NMFS, BIA, and USFWS 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 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, the protective coverage for the proposed actions would likely lapse.

The BIA, USFWS and NMFS, to the extent of their authorities, shall:

- 1a. Work with the Puget Sound treaty tribes and WDFW to ensure that in-season management actions taken during the course of the fisheries are consistent with the levels of anticipated take.
- 1b. Work with the Puget Sound treaty tribes and WDFW to complete 2017-2018 preseason annual steelhead fishing plans for all populations (where data are available) prior to implementation of the steelhead fishing season, but no later than December 15, 2017. Preseason fishing plans will include the annual fishing and research test fishing regimes and incidental harvest rates of steelhead in salmon and steelhead fisheries in compliance with the take estimates described in Section 2.9.1.2.
- 1c. In cooperation with the Puget Sound treaty tribes and WDFW as appropriate, ensure that commercial fishers report the loss of any net fishing gear within 24 hours of its loss to appropriate authorities.²⁷
- 1d. The affected treaty tribes and WDFW, when conducting harvest research studies involving electrofishing, will follow NMFS' *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act* (NMFS 2000).
2. The Nisqually Tribe committed as part of the proposed actions to work in close cooperation with NMFS to update the Nisqually Chinook Recovery Plan and Stock Management Plan to describe their proposed long-term strategy and adaptive management plan for Nisqually Chinook by October 2nd, 2017 (Unsworth and Parker 2017). In doing so, managers propose using the HSRG's recovery framework (HSRG 2015) as the template for revising the strategy (pers. comm. C. Ellings, March 15, 2017). NOAA Fisheries supports the principles of the HSRG framework as consistent with the characteristics described above. The framework is designed to achieve four phases of recovery (preservation, recolonization, local adaptation, full restoration). The appropriate phase is determined by the status of the stock in relation to its habitat and other factors (HSRG 2015). Moving from one phase to the next occurs when specific biologically based, quantitative benchmarks are met (HSRG 2015). Each phase may include interim management steps. Consistent with this HSRG (2015) recovery framework, NMFS has identified the following key tasks in revising the long-term strategy and adaptive management plan for Nisqually Chinook. These relate to the discussion about a long-term transition strategy for the Nisqually in Section 2.5.1.1:
 - (a) Inventory the habitat and assess the status of the population relative to the capacity and quality of the available freshwater and estuary environment and the use and distribution of the population within that environment.
 - (b) Determine the benchmarks for abundance, productivity, diversity and spatial structure (VSP) that define the different phases of the strategy for recovery.

²⁷ 1-855-542-3935 (WA Dept of Fish and Wildlife) or 360-733-1725 (Northwest Straits), <http://www.derelictgeardb.org/reportgear.aspx>, or a tribal fishery manager.

- (c) Determine the harvest management approach and response for each phase. Within each phase, align the proposed hatchery strategy (see (g)a. below) with the proposed harvest regime including consideration of the ecosystem conditions. Explain changes in key components from the 2011 NCSMP (e.g., integrated broodstock take).
 - (d) Identify the current phase for the population and the management responses based on the above.
 - (e) Provide the supporting analysis and documentation demonstrating that the proposed strategy will improve the VSP parameters over time to a level that supports the proposed exploitation rate objective.
 - (f) Develop a monitoring program for key components of the framework and identify how results will be applied to adjust management actions to be consistent with the recommended HSRG approach through adaptive management.
 - (g) If the strategy includes a stepping stone/integrated hatchery program:
 - i. In the context of the HSRG framework, define the role and benchmarks for the programs for each phase of recovery.
 - ii. For each phase, scale the programs appropriately to the abundance of natural-origin recruits (NOR) available and describe how NOR abundance will be used to gauge the size of the harvest augmentation program.
 - iii. As progeny from the stepping stone program begin to return, define how pHOS (proportion hatchery origin spawners) will be controlled such that, consistent with HSRG guidelines, the returnees from the program outnumber the returns from the hatchery augmentation program.
3. Work with the Puget Sound treaty tribes and WDFW to ensure that the catch and implementation of other management measures associated with fisheries that are the subject of this opinion are monitored at levels that are comparable to those used in recent years.
 4. Work with the Puget Sound treaty tribes and WDFW to ensure that the fisheries that are the subject of this opinion are sampled for stock composition, including the collection of coded-wire tags and other biological information (age, sex, size) to allow for a thorough post-season analysis of fishery impacts on listed species and to improve preseason forecasts of abundance. This includes:
 - i. ensuring that the fisheries included in this opinion are sampled for contribution of hatchery and natural-origin fish and the collection of biological information (age, sex, and size) to allow for a thorough post-season analysis of fishery impacts on listed Chinook and steelhead species.
 - ii. collecting and analyzing tissues for DNA from summer-run steelhead encountered in 2017-2018 fisheries that are subject of this opinion where feasible.
 - iii. evaluating the potential selective effects of fishing on the size, sex composition, or age composition of listed Chinook and steelhead populations as data become available.

- iv. using the information, as appropriate, together with estimates of total and natural-origin Chinook and wild steelhead encounters and mortalities (summer and winter-run) to report fishery impacts by population.
- 5a. As discussed in the opinion, in most cases for most management units actual exploitation rates are routinely at or below the specified objectives. Management error is such that it is reasonable to expect that management objectives will be exceeded on occasion. However, consistent overages may reflect bias in management procedures and assumptions that need to be corrected. The co-managers have conducted several performance assessments to identify bias and have taken remedial actions to address it. NMFS has identified two populations that required further consideration: Puyallup and Skokomish Chinook.
- i. The BIA and NMFS will work with WDFW and the Puget Sound Tribes to conduct a performance report to assess fishery management actions affecting achievement of objectives specified by the Puget Sound Chinook Harvest Plan for these populations to be provided to NMFS by mid-February 2018, with a draft of the report exchange between parties in November 2017. The report will include:
 - a. a review of past performance as well as recently available information for the 2013, 2014, and 2015 seasons.
 - b. an assessment of forecast error, comparison of pre-season forecasts of exploitation rates with postseason ('validation') FRAM model runs and examine spawning escapement trends for these management units.
 - c. identification of likely fishery management and other causative factors contributing to failures to achieve management objectives.
 - d. post season accounting of the best available information on run sizes, terminal harvest rates, and all pertinent events and observations related to management of the terminal fisheries in 2016 and 2017.
 - ii. The BIA and NMFS will work with the WDFW and the Puget Sound Tribes to address any bias found in this performance review through updates to forecasts and/or FRAM model inputs as necessary.
 - iii. If the report is delayed beyond mid-February or in reviewing the report and after discussion with the WDFW and the Puget Sound Tribes, NMFS and the BIA find the recommended actions regarding model adjustments and forecast updates insufficiently certain to result in meeting management objectives, NMFS and the BIA will work with the co-managers to identify other remedial actions including conservation buffers to the proposed objectives.
- 5b. Work with the affected tribes and WDFW to provide post season reports for the 2017-2018 fishery that include estimates of catch and encounters of listed Chinook in the fisheries that are the subject of this opinion, fishery impacts by population, and other relevant information described in Section 7.5 in the 2010 Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2010a). This includes catch and encounters in the research fisheries discussion in Section 2.5.2.2. The reports will also include escapement estimates for the populations affected by this proposed actions and the results of the work described in reasonable and prudent measure 3.

- 5c. Work with the affected treaty tribes and WDFW, to provide postseason reports for the 2017-18 fishery season on all steelhead DIPs affected by the proposed fisheries as identified in this opinion, where data are available, no later than November 20, 2017 prior to the following winter steelhead season. The postseason report will include:
 - i. identification of compliance with the fishery regimes (including test fisheries) and incidental harvest rate of steelhead mortalities in the tribal salmon and steelhead fisheries described in this opinion;
 - ii. a description of the method used to estimate postseason harvest and a description of any changes to the estimation methodologies used for assessing escapement and/or harvest rates.
- 6a. Work with the affected tribes and WDFW to implement or improve escapement monitoring for all Puget Sound Chinook and steelhead populations that are affected by the proposed actions to improve escapement estimation and to determine and/or augment exploitation rate and harvest rate estimates on natural-origin Chinook and steelhead stocks.
- 6b. For steelhead, coordinate the effort to implement or improve escapement monitoring with NMFS' Viable Salmonid Parameters (VSP) ongoing monitoring inventory endeavor of ESA-listed Puget Sound steelhead. In an effort towards this goal, watershed priorities and monitoring will be identified during the Puget Sound steelhead recovery planning process to secure funding for improvement of steelhead escapement and harvest methodologies.
- 7. NMFS shall confer with the affected co-managers to account for the catch of the fisheries based on postseason reporting and assessment (as described in Section 7 of the 2010 RMP) as the information becomes available. The information will be used to assess consistency with the extent of take specified in the Incidental Take Statement.
- 8a. The co-managers shall monitor catch using measures and procedures that provide reliable accounting of the catch of Chinook.
- 8b. NMFS, in cooperation with the affected co-managers, shall monitor the catch and implementation of other management measures at levels that are comparable to those used in recent years. The monitoring is to ensure full implementation of, and compliance with, management actions specified to control the fisheries within the scope of the action.
- 8c. NMFS, in cooperation with the affected co-managers, shall ensure that any commercial vessel owner or operator participating in the fishery complies with 50 CFR 229.6 and reports all incidental injuries or mortalities of marine mammals that occur during commercial fishing operations to NMFS (or in the case of tribes, voluntary reports). "Injury" is defined in 50 CFR 229.2 as a wound or other physical harm. In addition, any animal that ingests fishing gear, or any animal that is released with fishing gear entangling, trailing, or perforating any part of the body is considered injured and must be reported.
- 9. NMFS will engage in ongoing coordination and communication with Canada's

Department of Fish and Oceans with the goal of ensuring that complementary actions are taken in Canadian fisheries that affect the abundance of Chinook prey available to Southern Resident killer whales

10. NMFS, in cooperation with BIA, the USFWS, WDFW and the Puget Sound tribes, shall minimize take and monitor the number of derelict fishing nets that occur on an annual basis by:
 - a. Derelict Gear Reporting. Requiring all derelict gear to be reported to appropriate authorities within 24 hours of its loss.
 - b. Derelict Gear Accounting and Location. Recording the total number and approximate locations of nets lost (and subsequently recovered) on an annual basis.
 - c. Derelict Gear Prevention. The BIA, USFWS and NMFS in collaboration with the state and tribes, shall continue to conduct outreach and evaluate technologies and practices to prevent the loss of commercial fishing nets, and systems to track nets upon their loss, to better aid their retrieval and other measure necessary to prevent and track lost gear.
11. NMFS in cooperation with BIA, the USFWS, WDFW and the Puget Sound Treaty tribes, shall minimize take and monitor the number of yelloweye rockfish and bocaccio incidentally caught by fishermen targeting salmon, on an annual basis by:
 - a. Monitoring fisheries through fishermen interviews, fish tickets, and phone surveys, as applicable, at levels comparable to recent years.

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 actions on listed species or critical habitat or regarding the development of information (50 CFR 402.02). NMFS believes the following conservation recommendations are consistent with these obligations, and therefore should be implemented by the BIA, USFWS and NMFS in cooperation with the Puget Sound treaty tribes.

- (1) As discussed in Section 2.5.1.2, preseason abundance expectations still present challenges for terminal area management for the Puyallup and Skokomish populations in maximizing harvest and achieving management objectives. Improvements in inseason management tools including inseason abundance updates could be valuable in addressing these issues and have value for fisheries beyond those in the terminal area. The BIA, USFWS, and NMFS in collaboration WDFW and the Puget Sound treaty tribes should conduct a workshop(s) to explore and identify methods to update abundance inseason that would be useful for managing fisheries for these populations, particularly in terminal areas, to better achieve management objectives.
- (2) The BIA, USFWS, and NMFS in collaboration with WDFW and the Puget Sound treaty tribes should continue to evaluate improvement in gear technologies and fishing techniques in treaty tribal and U.S. Fraser Panel fisheries to reduce impacts on listed

species without compromising data quality used to manage fisheries.

- (3) The BIA, USFWS, and NMFS in collaboration with WDFW and the Puget Sound treaty tribes, should continue to evaluate the potential selective effects of treaty tribal and U.S. Fraser Panel fishing on the size, sex composition, or age composition of salmon populations.
- (4) The BIA, USFWS, and NMFS in collaboration with the WDFW and the Puget Sound treaty Tribes, should continue to collect data on steelhead populations where insufficient data exist and improve upon catch accounting for all steelhead populations as resources become available.
- (5) The BIA, USFWS, and NMFS in collaboration with the WDFW, and the Puget Sound treaty tribes, should implement the recommendations for the prevention, retrieval and investigation of gear modifications of gill nets used in Puget Sound treaty tribal and U.S. Fraser Panel salmon fisheries reported in Gibson (2013).
- (6) The BIA, USFWS, and NMFS in collaboration with the WDFW, and the Puget Sound treaty tribes, should continue to assess best available and precautionary methods to estimate listed rockfish bycatch in the tribal and U.S. Fraser Panel salmon fisheries in Puget Sound.
- (7) The BIA, USFWS, and NMFS in collaboration with the WDFW, and the Puget Sound treaty tribes should explore inclusion of environmental variables into preseason forecasts and use of inseason management to improve their performance and utility in management.

2.11 Reinitiation of Consultation

This concludes formal consultation for the impacts of programs administered by the Bureau of Indian Affairs that support Puget Sound tribal salmon fisheries, salmon fishing activities authorized by the U.S. Fish and Wildlife Service, and fisheries authorized by the U.S. Fraser Panel in 2016.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) the amount or extent of incidental taking specified in the incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to 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.

2.12 “Not Likely to Adversely Affect” Determinations

NMFS does not anticipate the proposed actions will take southern green sturgeon or southern eulachon which occur in the action area or adversely affect their critical habitat.

Green Sturgeon

Individuals of the southern DPS of green sturgeon are unlikely to be caught in Puget Sound salmon fisheries. Most marine area fisheries use hook-and-line gear to target pelagic feeding

salmon near the surface and in mid-water areas. Net gear that is used in terminal and nearshore areas throughout the action area is fished at the surface. Green sturgeon are bottom oriented, benthic feeders. NMFS is not aware of any records or reports of green sturgeon being caught in Puget Sound salmon fisheries. Any contact of the gear with the bottom would be rare and inadvertent. Given their separation in space and differences in feeding habitats, and the nature and location of the salmon fisheries, NMFS would not expect green sturgeon to be caught in or otherwise affected by the proposed fisheries or there to be any effect on the physical or biological factors (PBFs) of the critical habitat, making any such effects discountable. The proposed salmon fisheries therefore are not likely to adversely affect green sturgeon or its designated critical habitat.

Eulachon

Eulachon in the listed southern DPS are primarily a marine, pelagic species that spawn in the lower reaches of coastal rivers and whose primary prey is zooplankton (Drake et al. 2010a). They are typically found “in near-benthic habitats in open marine waters” of the continental shelf between 20 and 150 m depth (Hay and McCarter 2000). In Puget Sound the species is found on occasion in several rivers including the Elwha, the Puyallup, the Nisqually, the Little Quilcene, and the Snohomish, as well as rivers in the San Juan Islands (W. Palsson, WDFW, unpubl. data). Since 1888, the states of Washington and Oregon have maintained a commercial and recreational fishery for eulachon. In the commercial fishery, eulachon were caught using small-mesh gillnets (i.e., ≤ 2 inches) and small mesh dipnets (although small trawl gear is legal, it is rarely used). However, in 2010, following the listing of eulachon under the ESA, the states of Washington and Oregon permanently closed the commercial and recreational eulachon fishery. In 2014 the states of Washington and Oregon adopted a limited-opportunity recreational and commercial fishery on eulachon in the Columbia River as well as the Cowlitz and Sandy Rivers. Eulachon also have been taken as bycatch in pink shrimp trawl gear off of the coast of Oregon, Washington and California (Hannah and Jones 2007) and in Puget Sound (W. Palsson, pers. comm., WDFW, Fish Biologist). Salmon fisheries in the northern Puget Sound areas use nets with large mesh sizes (i.e., >4 inches) and hook and line gear designed to catch the much larger salmon species. The gear is deployed to target pelagic feeding salmon near the surface and in mid-water areas. Encounters of eulachon in salmon fisheries would be extremely unlikely given the general differences in spatial distribution and gear characteristics. NMFS is not aware of any record of eulachon caught in either commercial or recreational Puget Sound salmon fisheries. Given all of the above, NMFS would not expect eulachon to be caught or otherwise affected by the proposed fisheries, making any such effects discountable. The proposed salmon fisheries therefore are not likely to adversely affect eulachon or its designated critical habitat.

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

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

This analysis is based, in part, on descriptions of EFH for Pacific coast groundfish (PFMC 2014a), coastal pelagic species (PFMC 2011), and Pacific coast salmon (PFMC 2014b) contained in the Fishery Management Plans developed by the Pacific Fishery Management Council and approved by the Secretary of Commerce. This section is NMFS’ Magnuson-Stevens Fishery Conservation and Management Act (MSA) consultation on the three federal actions considered in the above sections of the opinion (see Section 1.3).
Essential Fish Habitat Affected by the Project.

3.1 Essential Fish Habitat Affected by the Project

The action area is described in section 1.4. It includes areas that are designated EFH for various life stages of Pacific Coast salmon, Pacific Coast groundfish, and coastal pelagic species managed by the PFMC.

Marine EFH for Chinook, coho and Puget Sound pink salmon in Washington, Oregon, and California includes all estuarine, nearshore and marine waters within the western boundary of the EEZ, 200 miles offshore. Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable man-made barriers, and longstanding, naturally-impassable barriers (i.e., natural waterfalls in existence for several hundred years). Designated EFH within the action area includes the major rivers and tributaries, and marine waters to the east of Cape Flattery in the hydrologic units identified for Chinook, coho salmon and Puget Sound pink salmon. In those waters, it includes the areas used by Chinook, coho and pink adults (migration, holding, spawning), eggs and alevins (rearing) and juveniles (rearing, migration). A more detailed description and identification of EFH for salmon is found in Appendix A to Amendment 18 to the Pacific Coast Salmon Plan (PFMC 2014b).

Essential fish habitat for groundfish includes all waters, substrates and associated biological communities from the mean higher high water line, or the upriver extent of saltwater intrusion in

river mouths, seaward to the 3500 m depth contour plus specified areas of interest such as seamounts. A more detailed description and identification of EFH for groundfish is found in the Appendix B of Amendment 19 to the Pacific Coast Groundfish Management Plan (PFMC 2014a).

Essential fish habitat for CPS is defined based on the temperature range where they are found, and on the geographic area where they occur at any life stage. This range varies widely according to ocean temperatures. The east-west boundary of CPS EFH includes all marine and estuary waters from the coasts of California, Oregon, and Washington to the limits of the EEZ (the 200-mile limit) and above the thermocline where sea surface temperatures range between 10° and 26° centigrade. The southern boundary is the U.S./Mexico maritime boundary. The northern boundary is more changeable and is defined as the position of the 10° C isotherm, which varies seasonally and annually. In years with cold winter sea surface temperatures, the 10° C isotherm during February is around 43° N latitude offshore, and slightly further south along the coast. In August, this northern boundary moves up to Canada or Alaska. Assessment of potential adverse effects on these species EFH from the proposed actions is based, in part, on this information. A more detailed description and identification of EFH for coastal pelagic species is found in Amendment 8 to the Coastal Pelagic Species Fishery Management Plan (PFMC 2011).

3.2 Adverse Effects on Essential Fish Habitat

3.2.1 Salmon

The PFMC assessed the effects of fishing on salmon EFH and provided recommended conservation measures in Appendix A to Amendment 18 of the Pacific Coast Salmon Plan (PFMC 2014b). The PFMC identified five fishing-related activities that may adversely affect EFH including: (1) fishing activities; (2) derelict gear effects; (3) harvest of prey species; (4) vessel operations; and (5) removal of salmon carcasses and their nutrients from streams. Of the five types of impact on EFH identified by the PFMC for fisheries, the concerns regarding gear-substrate interactions, removal of salmon carcasses, redd or juvenile fish disturbance and fishing vessel operation on habitat are also potential concerns for the salmon fisheries in Puget Sound. However, the PFMC recommendations for addressing these effects are already included in the proposed actions.

Fishing Activities

Most of the harvest related activities in Puget Sound occur from boats or along river banks, with most of the fishing activity in the marine and nearshore areas. The gear fishermen use include hook-and-line, drift and set gillnets, beach seines, and to a limited extent, purse seines. The types of salmon fishing gear that are used in Puget Sound salmon fisheries in general actively avoid contact with the substrate because of the resultant interference with fishing and potential loss of gear. Possible fishery-related impacts on riparian vegetation and habitat would occur primarily through bank fishing, movement of boats and gear to the water, and other stream side usages. The proposed fishery implementation plan includes actions that would minimize these impacts if they did occur, such as area closures. Also these effects would occur to some degree through implementation of fisheries or activities other than the Puget Sound salmon fisheries (i.e.,

recreational boating and marine species fisheries). Therefore, the proposed fisheries would have a negligible additional impact on the physical environment.

Derelict Gear

When gear associated with commercial or recreational fishing breaks free, is abandoned, or becomes otherwise lost in the aquatic environment, it becomes derelict gear. In commercial fisheries, trawl nets, gillnets, long lines, purse seines, crab and lobster pots, and other material, are occasionally lost to the aquatic environment. Recreational fisheries also contribute to the problem, mostly via lost crab pots.

Derelict fishing gear, as with other types of marine debris, can directly affect salmon habitat and can directly affect managed species via “ghost fishing.” Ghost fishing is included here as an impact to EFH because the presence of marine debris affects the physical, chemical, or biological properties of EFH. For example, once plastics enter the water column, they contribute to the properties of the water. If debris is ingested by fish, it would likely cause harm to the individual. Another example is in the case of a lost net in a river. Once lost, the net becomes not only a potential barrier to fish passage, but also a more immediate entanglement threat to the individual.

Derelict gear can adversely affect salmon EFH directly by such means as physical harm to eelgrass beds or other estuarine benthic habitats; harm to coral and sponge habitats or rocky reefs in the marine environment; and by simply occupying space that would otherwise be available to salmon. Derelict gear also causes direct harm to salmon (and potentially prey species) by entanglement. Once derelict gear becomes a part of the aquatic environment, it affects the utility of the habitat in terms of passive use and passage to adjacent habitats. More specifically, if a derelict net is in the path of a migrating fish, that net can entangle and kill the individual fish.

Due to recent changes in state law, additional outreach and assessment efforts (i.e. Gibson 2013), and recent lost net inventories (Beattie and Adicks 2012; Beattie 2013; James 2015) it is likely that fewer nets will become derelict in the upcoming 2017/18 fishing season compared to several years and decades ago. In 2014, an estimated 13 nets became derelict, and 12 of them were recovered (James 2015), in 2013 an estimated 15 nets became derelict, 12 of which were recovered (Beattie 2013), and in 2012 eight nets were lost, and six were recovered (Beattie and Adicks 2012). From June 2012 to February 2016 a total of 77 newly lost nets were reported, and only 6 of these were reported by commercial fishermen (Drinkwin 2016). Based on this new information we estimate that a range of five to 20 gill nets may be lost in the 2017/2018 fishing season, but up to 75% of these nets would be removed within days of their loss and have little potential to damage proposed rockfish critical habitat.

Harvest of Prey Species

Prey species can be considered a component of EFH (PFMC 2014b). For Pacific salmon, commercial and recreational fisheries for many types of prey species potentially decrease the amount of prey available to Pacific salmon. Herring, sardine, anchovy, squid, smelt, groundfish, shrimp, crab, burrowing shrimp, and other species of finfish and shellfish are potential salmon prey species that are directly fished, either commercially or recreationally. The proposed actions

does not include harvest of prey species and will have no adverse effect on prey species.

Vessel Operation

A variety of fishing and other vessels on the Pacific Coast can be found in freshwater streams, estuaries, and the marine environment within the action area. Vessels that operate under the proposed actions range in size from small single-person vessels used in streams and estuaries to mid-size commercial or recreational vessels. Section 4.2.2.29 of Appendix A to Amendment 18 of the Pacific Coast Salmon Plan (PFMC 2014b) regarding Vessel Operations provides a more detailed description of the effects of vessel activity on EFH. Any impact to water quality from vessels transiting critical habitat areas on their way to the fishing grounds or while fishing would be short term and transitory in nature and minimal compared to the number of other vessels in the area. Also these activities would occur to some degree through implementation of fisheries or activities other than the Puget Sound salmon fisheries, i.e., recreational boating and marine species fisheries.

Removal of Salmon Carcasses

Salmon carcasses provide nutrients to stream and lake ecosystems. Spawning salmon reduce the amount of fine sediment in the gravel in the process of digging redds. Salmon fishing removes a portion of the fish whose carcasses would otherwise have contributed to providing those habitat functions.

The PFMC conservation recommendation to address the concern regarding removal of salmon carcasses was to manage for spawner escapement levels associated with MSY, implementation of management measures to prevent over-fishing and compliance with requirements of the ESA for ESA listed species. These conservation measures are basic principles of the harvest objectives used to manage salmon fisheries. Therefore, management measures to minimize the effects of salmon carcass removal on EFH are an integral component of the management of the proposed fisheries.

3.2.2 Groundfish

As described in Section 2.4.3 of this opinion, NMFS believes that the proposed actions would have the following adverse effects on the EFH of groundfish.

Habitat Alteration

Lost commercial fishing nets would adversely affect groundfish EFH. As described in section 2.4.3.4, most nets hang on bottom structure that is also used by rockfish and other groundfish. This structure consists of high-relief rocky substrates or boulders located on sand, mud or gravel bottoms (Good et al. 2010). Derelict nets alter habitat suitability by trapping fine sediments out of the water column. This makes a layer of soft sediment over rocky areas, changing habitat quality and suitability for benthic organisms (Good et al. 2010). Nets can also cover habitats used by groundfish for shelter and pursuit of food, rendering the habitat unavailable. Using the most common derelict net size reported by Good et al. (2010), if up to 20 nets were initially lost and five were not retrieved they would degrade approximately damage up to 35,000 square feet

(0.8 acre) of habitat (assuming an average of 7,000 square feet) of benthic habitat.

Reduction in Groundfish Prey and Entanglement

Most nets hang on bottom structure that is also attractive to rockfish and other groundfish species. This structure consists of high-relief rocky substrates or boulders located on sand, mud or gravel bottoms (Good et al. 2010). The combination of complex structure and currents tend to stretch derelict nets open and suspend them within the water column, in turn making them more deadly for marine biota (Akiyama et al. 2007, Good et al. 2010) and thus result in a decrease of groundfish prey and entanglement of various species of groundfish.

3.2.3 Coastal Pelagic

The proposed actions would not have an adverse effect on coastal pelagic EFH. Commercial and recreational fisheries targeting salmon would not appreciably alter habitats used by coastal pelagic species. Any derelict gear would occur in benthic habitats, not pelagic habitats.

3.3 Essential Fish Habitat Conservation Recommendations

Pursuant to Section 305(b)(4)(A) of the MSA, NMFS is required to provide EFH conservation recommendations to Federal agencies regarding actions which may adversely affect EFH.

NMFS is not providing any EFH conservation recommendations for salmon EFH because the proposed actions includes adequate measures to mitigate for the potential adverse effects from salmon fishing. We provide the following conservation recommendations to minimize the adverse effects to groundfish EFH; consistent with the terms and conditions described for rockfish in Section 2.8.4 of the opinion:

Derelict Gear Reporting

The BIA, USFWS and NMFS, in collaboration with the state and Puget Sound treaty tribes, should encourage commercial fishers to report derelict gear lost in marine areas within the Action Area to appropriate authorities within 24 hours of its loss.

Derelict Gear Accounting & Locations

The BIA, USFWS and NMFS, in collaboration with the state and Puget Sound treaty tribes, should track the total number and approximate locations of nets lost (and subsequently recovered) in marine areas within the Action Area and account for them on an annual basis.

Derelict Gear Prevention

The BIA, USFWS and NMFS, in collaboration with the Washington Department of Fish and Wildlife, and Puget Sound treaty tribes, should implement the recommendations for the prevention, retrieval and investigation of gear modifications of gill nets used in Puget Sound salmon fisheries reported in Gibson (2013).

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2 above, approximately 0.8 acre of

designated EFH for Pacific coast groundfish species.

3.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, BIA, USFWS and NMFS must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.5 Supplemental Consultation

The BIA, NMFS and USFWS must reinitiate EFH consultation with NMFS if the proposed actions is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR 600.920(l)).

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this consultation are the applicants and funding/action agencies listed on the first page. Other interested users could include the agencies, applicants, and the American public. Individual copies of this opinion were provided to the BIA, NMFS, USFWS and the applicants. This opinion will be posted on the Public Consultation Tracking System web site (<https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts>). The format and naming adheres to conventional standards for style

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion [*and EFH consultation, if applicable*] contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA [*and MSA implementation, if applicable*], and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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Appendix A

Viable Risk Assessment Procedure

Viability Risk Assessment Procedure

NMFS analyzes the effects of harvest actions on populations using quantitative analyses where possible and more qualitative considerations where necessary. The Viable Risk Assessment Procedure (VRAP) is an example of a quantitative risk assessment method that was developed by NMFS and applied primarily for analyzing harvest impacts on Puget Sound and Lower Columbia River tule Chinook. VRAP provides estimates of population-specific exploitation rates (called Rebuilding Exploitation Rates or RERs) that are designed to be consistent with ESA-related survival and recovery requirements. Proposed fisheries are then evaluated, in part, by comparing the RERs to rates that can be anticipated as a result of the proposed harvest plan. Where impacts of the proposed plan are less than or equal to the RERs, NMFS considers the harvest plan to present a low risk to that population (the context and basis of NMFS' conclusions related to RERs is discussed in more detail below). The results of this comparison, together with more qualitative considerations for populations where RERs cannot be calculated, are then used in making the jeopardy determination for the ESU as a whole. A brief summary of VRAP and how it is used to estimate an RER is provided below. For a more detailed explanation see NMFS (2000) and NMFS (2004).

The Viable Risk Assessment Procedure:

- quantifies the risk to survival and recovery of individual populations compared with a zero harvest scenario;
- accounts for total fishing mortality throughout the migratory range of the ESU;
- explicitly incorporates management, data, and environmental uncertainty; and
- isolates the effect of harvest from mortality that occurs in the habitat and hatchery sectors.

The result of applying the VRAP to an individual population is an RER which is the highest allowable ("ceiling") exploitation rate that satisfies specified risk criteria related to survival and recovery. Calculation of RERs depend on the selection of two abundance-related reference points (referred to as critical and rebuilding escapement thresholds (CET and RET²⁸⁴)), and two risk criteria that define the probability that a population will fall below the CET and exceed the RET. Considerations for selecting the risk criteria and thresholds are discussed briefly here and in more detail in NMFS 2000.

The selection of risk criteria for analytical purposes is essentially a policy decision. For jeopardy determinations, the standard is to not "...reduce appreciably the likelihood of survival and recovery ..." (50 CFR 402.2). In this context, NMFS used guidance from earlier biological opinions to guide the selection of risk criteria for VRAP. NMFS' 1995 biological opinion on the operation of the Columbia River hydropower system (NMFS 1995) considered the biological requirements for Snake River spring/summer Chinook to be met if there was a high likelihood, relative to the historic likelihood, that a majority of populations were above lower threshold levels²⁹⁵ and a moderate to high likelihood that a majority of populations would achieve their

²⁸⁴ Also referred to in previous opinions as the Upper Escapement Threshold.

²⁹⁵ The Biological Requirements Work Group defined these as levels below which uncertainties about processes or

recovery levels in a specified amount of time. High likelihood was considered to be a 70% or greater probability, and a moderate-to-high likelihood was considered to be a 50% or greater probability (NMFS 1995). The Cumulative Risk Initiative (CRI) has used a standard of 5% probability of absolute extinction in evaluating the risks of management actions to Columbia River ESUs. The different standards of risk, i.e., 50% vs. 5%, were based primarily on the thresholds that the standard was measured against. The CRI threshold is one of absolute extinction, i.e., 1 spawning adult in a brood cycle. The Biological Requirements Work Group (BRWG 1994) threshold is based on a point of potential population destabilization, i.e., 150-300 adult spawners, but well above what would be considered extinction. In fact, several of the populations considered by the BRWG had fallen below their thresholds at some point and rebounded, or persisted at lower levels. Since the consequences to a species of the CRI threshold are much greater than the consequences of the BRWG thresholds, the CRI standard of risk should be much higher (5%). Scientists commonly define high likelihood to be $\geq 95\%$. For example, tests of significance typically set the acceptable probability of making a Type I error at 5%. The basis of the VRAP critical threshold is more similar to the BRWG lower threshold in that it represents a point of potential population destabilization. However, given the uncertainties in the data, especially when projected over a long period of time, and the different risk to populations represented by the two thresholds, we chose a conservative approach both for falling below the critical threshold, i.e., 5%, and exceeding the recovery threshold, i.e., 80%.

The risk criteria were chosen within the context of the jeopardy standard. They measure the effect of the proposed actions against the baseline condition, and require that the proposed actions not result in a significant negative effect on the status of the species over the conditions that already exist. We determined that the risk criteria consistent with the jeopardy standard would be that: (1) the percentage of escapements below the critical threshold differs no more than 5% from that under baseline conditions; *and* (2) the viable threshold must be met 80% of the time, *or* the percentage of escapements less than the viable threshold differs no more than 10% from that under baseline conditions. Said another way, these criteria seek to identify an exploitation rate that will not appreciably increase the number of times a population will fall below the critical threshold and also not appreciably reduce the prospects of achieving recovery. For example, if under baseline conditions, the population never fell below the critical threshold, escapements must meet or exceed the critical threshold 95% of the time under the proposed harvest regime.

As described above, VRAP uses critical escapement and rebuilding escapement thresholds as benchmarks for calculating the RERs. Both thresholds represent natural-origin spawners. The CET represents a boundary below which uncertainties about population dynamics increase substantially. In cases where sufficient stock-specific information is available, we can use the population dynamics relationship to define this point. Otherwise, we use alternative population-specific data, or general literature-based guidance. NMFS has provided some guidance on the range of critical thresholds in its document, *Viable Salmonid Populations* (McElhaney et al.

population enumerations are likely to become significant, and below which qualitative changes in processes are likely to occur (BRWG 1994). They accounted for genetic risk, and some sources of demographic and environmental risk.

2000). The VSP guidance suggests that effective population sizes of less than 500 to 5,000 per generation, or 125 to 1,250 per annual escapement, are at increased risk. For the Lower Columbia River tule analyses, we generally used CETs corresponding to the Willamette/Lower Columbia River TRT's quasi-extinction thresholds (QET): 50/year for four years for 'small' populations, 150/year for four years for medium populations, and 250/year for four years for large populations (McElhany et al. 2000).

The RET may represent a higher abundance level that would generally indicate recovery or a point beyond which ESA type protections are no longer required. The RET could also be an estimate of the spawners needed to achieve maximum sustainable yield or for maximum recruits, or some other designation. It is important to recognize, though, that the RET is not an escapement goal but rather a threshold level that is expected to be exceeded most of the time ($\geq 80\%$). It should also be noted that, should the productivity and/or capacity conditions for the population improve, the RET should be changed to reflect the change in conditions. There is often some confusion about the relationship between rebuilding escapement thresholds used in the VRAP analysis, and abundance related recovery goals. The RET are generally significantly less than recovery goals that are specified in recovery plans. VRAP seeks to analyze a population in its existing habitat given current conditions. As the productivity and capacity of the habitat improves, the VRAP analysis will be adjusted to reflect those changes. Thus the RET serves as a step in the progression to recovery, which will occur as the contributions from recovery action across all sectors are realized.

There are two phases to the VRAP process for determining an RER for a population. The first, or model fitting phase, involves using data from the target population itself, or a representative indicator population, to fit a spawner-recruit relationship representing the performance of the population over the time period analyzed. Population performance is modeled as:

$$R = f(S, \mathbf{e}),$$

where S is the number of fish spawning in a single return year, R is the number of adult equivalent recruits,³⁰⁶ and \mathbf{e} is a vector of environmental, density-independent indicators of annual survival.

Several data sets are necessary for this: a time series of natural spawning escapement, a time series of total recruitment by cohort, and time series for the environmental correlates of survival. In addition, one must assume a functional form for f , the spawner-recruit relationship. Given the data, one can numerically estimate the parameters of the assumed spawner-recruit relationship to complete the model fitting phase.

The data are fitted using three different models for the spawner recruit relationship: the Ricker (Ricker 1975), Beverton-Holt (Ricker 1975), and Hockey stick (Barrowman and Meyers 2000).

³⁰⁶ Equivalently, this could be termed "potential spawners" because it represents the number of fish that would return to spawn absent harvest-related mortality.

The simple forms of these models can be augmented by the inclusion of environmental variables correlated with brood year survival. The VRAP is therefore flexible in that it facilitates comparison of results depending on assumptions between production functions and any of a wide range of possible environmental co-variables. Equations for the three models are as follows:

$$\begin{aligned} R &= (aSe^{-bS})(M^c e^{dF}) && \text{[Ricker]} \\ R &= (S/[bS + a])(M^c e^{dF}) && \text{[Beverton-Holt]} \\ R &= (\min[aS, b])(M^c e^{dF}) && \text{[hockey stick]} \end{aligned}$$

In the above, M is the index of marine survival and F is the freshwater correlate.

The second, or projection phase, of the analysis involves using the fitted model in a Monte Carlo simulation to project the probability distribution of the near-term future performance of the population assuming that current conditions of productivity continue. Besides the fitted values of the parameters of the spawner-recruit relationships, one needs estimates of the probability distributions of the variables driving the population dynamics, including the process error (including first order autocorrelation) of the spawner-recruit relationship itself and each of the environmental correlates.³¹⁷ Also, since fishing-related mortality is modeled in the projection phase, one must estimate the distribution of the deviation of actual fishing-related mortality from the intended ceiling. This is termed “management error” and its distribution, as well as the others, is estimated from available recent data.

For each of a stepped series of exploitation rates the population is repeatedly projected for 25 years. From the simulation results we computed the fraction of years in all runs where the escapement is less than the critical escapement threshold and the fraction of runs for which the final year’s escapement is greater than the rebuilding escapement threshold. Exploitation rates for which the first fraction is less than 5% and the second fraction is greater than 80% (or 10% from baseline) satisfies the identified risk criteria are thus used to define the population specific ceiling exploitation rates for harvest management.

Finally, the population-specific RERs must be made compatible with the exploitation rates generated from the FRAM model for use in fishery management planning. The VRAP and the FRAM model were developed for different purposes and are therefore based on different data sources and use different approaches to estimate exploitation rates. The VRAP uses long-term population intensive data to derive a RER for a single population. The FRAM uses fishery intensive data to estimate the effects of southern U.S. West Coast fishing regimes across the management units (populations or groups of populations) present in those fisheries. Because the

³¹⁷ Actual environmental conditions may vary from the modeled 25-year projections due to such things as climate change, restoration actions, development, etc. However, it is difficult to anticipate exactly how conditions might be different for a specific population which is the focus of the VRAP analysis. Incorporation of the observed uncertainty in each of the key parameters in the VRAP analysis, the use of high probabilities related to abundance thresholds and periodic revision of the RERs on a shorter time frame (e.g., 5-10 years) in the event that conditions have changes serve to mitigate this concern.

FRAM model is used for preseason planning and to manage fisheries, it is necessary to ensure that the RERs derived from VRAP are consistent with the management unit exploitation rates that we estimated by the FRAM model. To make them compatible, the RERs derived from VRAP are converted to FRAM-based RERs using linear or log-transform regressions between the exploitation rate estimates from the population specific data and post season exploitation rate estimates derived from FRAM.

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