

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

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

NMFS Consultation Number: F/WCR-2016-4418

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

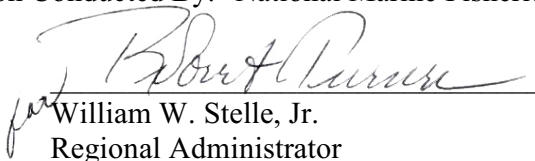
Affected Species and NMFS' Determinations:

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

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

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

Issued by:


William W. Stelle, Jr.
Regional Administrator

Date: June 6, 2016

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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
CPS	Coastal Pelagic Species
CWR	Center for Whale Research
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
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
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
ODFW	Oregon Department of Fish and Wildlife
PBDE	Polybrominated diphenyl ethers
PCB	Polychlorinated biphenyls
PCE	Primary Constituent Element(s)
PFMC	Pacific Fishery Management Council
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
SAS	Smolt to Adult Survival
SUS	Southern United States
USFWS	U.S. Fish and Wildlife Service
VRAP	Viable Risk Assessment Procedure
VSP	Viable Salmonid Populations
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.

1.1 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 action, in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (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 the following three federal actions proposed by NMFS, the Bureau of Indian Affairs (BIA), and the U.S. Fish and Wildlife Service (USFWS):

- (1) The proposed BIA funding of Puget Sound treaty tribes' management, enforcement, and monitoring projects associated with Puget Sound salmon fisheries implemented during May 1, 2016-April 30, 2017.
- (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, 2016-April 30, 2017.
- (3) Two actions associated with the management of the 2016 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 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.

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 three 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 2.11).

1.2 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 and BIA program funding and USFWS Hood Canal Salmon Plan related actions. Since 2014, NMFS has consulted under section 7 of the ESA on 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 two biological opinions for the 2014 and 2015 fishery cycles (May 1, 2014 through April 30, 2016) that considered actions based on this framework including BIA funding of tribal salmon management programs (NMFS 2014a, NMFS 2015c).

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), and from May 2015 to April 2016 (NMFS 2015c). 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 2015c). In this biological opinion, we incorporate by reference NMFS' previous biological opinions and NMFS' previous Southern Resident killer whale and critical habitat analyses regarding the Puget Sound Chinook Resource Management Plan (NMFS 2011a, NMFS Consultation Number: F/NWR/2010/0605; NMFS 2014a, NMFS Consultation Number: F/WCR-

2014-578; NMFS 2015c, NMFS Consultation Number: F/WCR-2015-2433) and also provide a brief summary of the data and information considered in each section of this opinion.

On April 28, 2016, the BIA formally requested consultation on its administration of programs that support tribal management of 2016 Puget Sound salmon fisheries (Shaw 2016). 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 2015-2016 Season (Grayum 2016, Attachment 1) and the List of Agreed to Fisheries for the proposed tribal fisheries which provides specific details about individual anticipated fisheries by location, gear, time and management entity (Bowhay 2016). Grayum (2016, 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 under the proposed action were provided by the Northwest Indian Fisheries Commission under separate cover (James 2016a). Information regarding U.S. Fraser Panel non-tribal commercial fisheries was provided from pre-season model runs using the Fishery Regulation and Assessment Model (FRAM).

This opinion is based on information provided in the letter from the BIA requesting consultation to NMFS and associated documents as described above (Shaw 2016), the Final Environmental Impact Statement on the 2004 Puget Sound Comprehensive Chinook Harvest Management Plan (NMFS 2004c), 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
December 2008 (BO) (affirmed March 1996 (BO))*	until reinitiated	(NMFS 1996)	Snake River spring/summer and fall Chinook and sockeye
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 withdrawn	(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
April 9, 2015 (BO) *	until reinitiated	(NMFS 2015a)	Lower Columbia River coho
April 2012 (BO)*	until reinitiated	(NMFS 2012d)	Lower Columbia River Chinook

* 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.

1.3 Proposed Action

“Action” means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.2). 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). These actions require consultation with NMFS because Federal agencies (BIA, USFWS, NMFS) are funding or authorizing 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.

BIA Funding of Tribal Management, Enforcement, and Monitoring Projects:

The BIA proposes to fund Puget Sound tribal management, enforcement, and monitoring programs in support of the Puget Sound Salmon Management Plan (PSSMP) during the 2016 fishing year from May 1, 2016 through April 30, 2017 (see Shaw 2016; Grayum 2016) for fisheries and associated conservation objectives proposed to occur during this period. This opinion focuses on project funding for programs that may impact listed species under NMFS’ jurisdiction encountered in these fisheries. The 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 that may impact listed species under NMFS' jurisdiction from May 1, 2016 through April 30, 2017. More detailed information about the fisheries is included in the documents provided in the consultation request as described in Section 1.2 above and in Bowhay 2016.

USFWS Authorization of Fisheries Consistent with the Hood Canal Salmon Management Plan:

The USFWS proposes to authorize fisheries that are consistent with the implementation of the Hood Canal Salmon Management Plan (HCSMP 1985) from May 1, 2016 through April 30, 2017. 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, 2016 through April 30, 2017 (see Bowhay 2016 for fisheries proposed to occur during this period).

Fisheries Managed under the U.S. Fraser Panel:

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., 2011, 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 are taken 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.

1.4 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 1) 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.

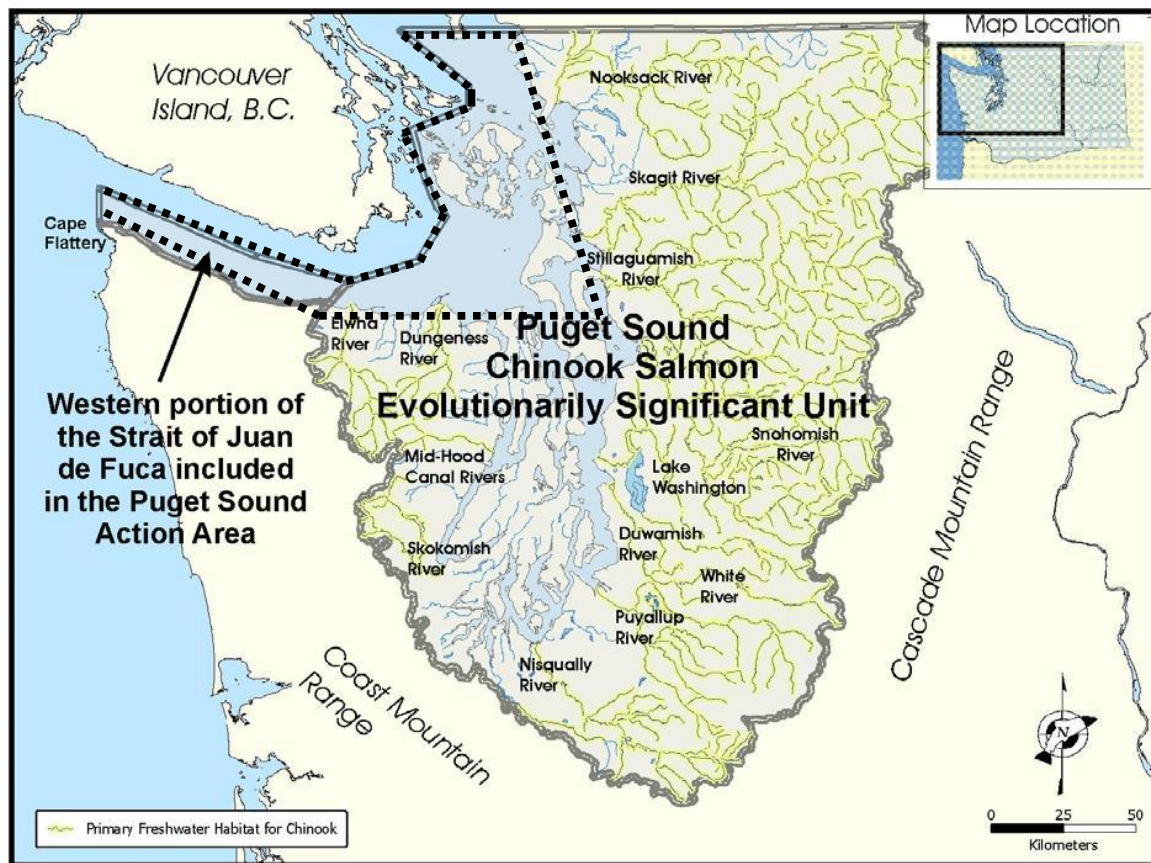


Figure 1. Puget Sound Action Area, which includes the Puget Sound Chinook ESU and the western portion of the Strait of Juan de Fuca in the United States. Dashed area denotes waters in U.S. Fraser Panel jurisdiction.

2. 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.

NMFS has determined that the proposed action is not likely to adversely affect southern green sturgeon, southern eulachon or their critical habitat. The analysis is found in the "Not Likely to Adversely Affect" Determinations Section (Section 2.11).

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "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 is "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, February 11, 2016).

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 PCEs 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 to assess the risk that the proposed action poses to species and critical habitat.* (Section 2.6)
- *Reach jeopardy and adverse modification conclusions.* 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.

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 (PS/GB) bocaccio, canary rockfish, and yelloweye rockfish DPSs. We concluded that the proposed actions are not likely to adversely affect southern green sturgeon, southern eulachon, and their critical habitat (Section 2.11).

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 action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, 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 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.

Climate change and other ecosystem effects

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). 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.

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 and current El Niño conditions are likely to persist. These 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).

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

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 August 15, 2011 (76 FR 50448), and concluded that this species should remain listed as threatened. On February 2, 2015, NMFS announced the initiation of five-year status reviews for 32 listed species of salmon, steelhead, rockfish, and eulachon (80 FR 6695). In December 2015, 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 NWFSC's report will be used by NMFS to inform the new five-year reviews, which will be completed in 2016. In the interim, the draft status review documents generally represent the most recent data on West Coast salmon ESUs. 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;
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

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.

distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity (Table 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).

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 4).

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.

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

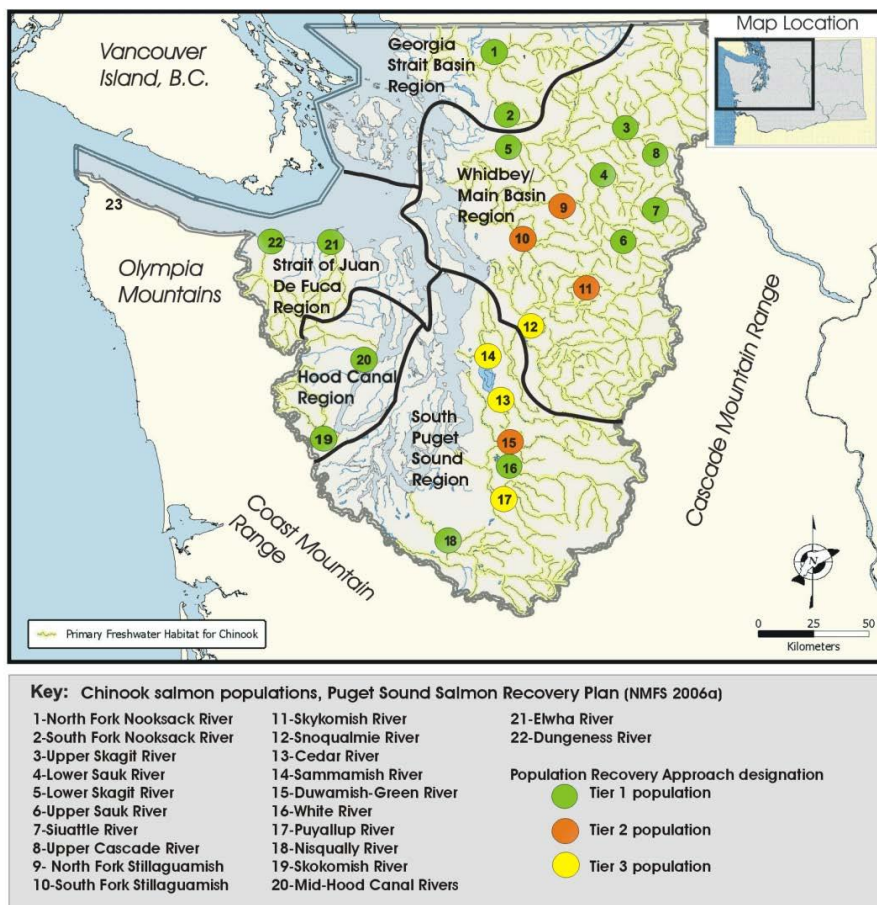
Three of the five regions (Strait of Juan de Fuca, Georgia Basin, and Hood Canal) contain only two populations, both of which must be recovered to viability to recover the ESU (NMFS 2006c). Under the Puget Sound Salmon Recovery Plan, the Suiattle and one each of the early, moderately early, and late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

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 2). 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 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).

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,

Figure 2. Populations of the Puget Sound Chinook salmon ESU, 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, Siattle 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 below their critical thresholds⁵ including both populations in three of the five biogeographical regions: 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).

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) depensatory 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 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 2014 Geometric mean Escapement (Spawners)		NMFS Escapement Thresholds		Recovery Planning Abundance Target in Spawners (productivity) ²	Average % hatchery fish in escapement 1999-2014 (min-max) ⁵
		Natural ¹	Natural-Origin (Productivity) ²	Critical ³	Rebuilding ⁴		
Georgia Basin	Nooksack MU	2,272	268	400	500		
	NF Nooksack	1,810	195⁸ (0.6)	<i>200⁶</i>	-	3,800 (3.4)	85 (63-94)
	SF Nooksack	383	51⁸ (1.6)	<i>200⁶</i>	-	2,000 (3.6)	84 (62-96)
Whidbey/Main Basin	Skagit Summer/Fall MU						
	Upper Skagit River	9,173	8,869 ⁸ (2.0)	967	7,454	5,380 (3.8)	3 (1-8)
	Lower Sauk River	543	538 ⁸ (1.8)	<i>200⁶</i>	681	1,400 (3.0)	1 (0-10)
	Lower Skagit River	1,993	1,917 ⁸ (1.8)	251	2,182	3,900 (3.0)	4 (2-8)
	Skagit Spring MU						
	Upper Sauk River	543	520 ⁸ (1.5)	130	330	750 (3.0)	2 (0-5)
	Suiattle River	331	325 ⁸ (1.2)	170	400	160 (3.2)	2 (0-5)
	Upper Cascade River	309	286 ⁸ (1.1)	170	<i>1,250⁶</i>	290 (3.0)	7 (0-25)
	Stillaguamish MU						
	NF Stillaguamish R.	952	554 (0.8)	300	552	4,000 (3.4)	37 (8-62)
	SF Stillaguamish R.	110	101 (0.7)	<i>200⁶</i>	300	3,600 (3.3)	NA
	Snohomish MU						
	Skykomish River	3,358	1,944 ⁸ (1.3)	1,650	3,500	8,700 (3.4)	34 (15-62)
Snoqualmie River	1,583	1,088 ⁸ (1.3)	400	<i>1,250⁶</i>	5,500 (3.6)	19 (8-35)	
Central/South Sound	Cedar River	844	816 ⁸ (1.9)	<i>200⁶</i>	<i>1,250⁶</i>	2,000 (3.1)	23 (10-36)
	Sammamish River	1,172	184⁸ (0.7)	<i>200⁶</i>	<i>1,250⁶</i>	1,000 (3.0)	83 (66-95)
	Duwamish-Green R.	3,562	1,235 ⁸ (1.0)	835	5,523	-	53 (20-79)
	White River ⁹	1,540	724 ⁸ (0.8)	<i>200⁶</i>	1,100 ⁷	-	44 (27-70)
	Puyallup River ¹⁰	1,570	747 ⁸ (1.1)	<i>200⁶</i>	522 ⁷	5,300 (2.3)	47 (18-76)
	Nisqually River	1,696	591 ⁸ (1.6)	<i>200⁶</i>	1,200 ⁷	3,400 (3.0)	70 (53-85)
Hood Canal	Skokomish River	1,305	334 (0.9)	452	1,160	-	67 (7-95)
	Mid-Hood Canal Rivers ¹¹	175		<i>200⁶</i>	<i>1,250⁶</i>	1,300 (3.0)	38 (5-63)

Strait of Juan de Fuca	Dungeness River	354	106⁸ (0.6)	200 ⁶	925 ⁷	1,200 (3.0)	68 (39-96)
	Elwha River ¹²	1,467	108⁸	200 ⁶	1,250 ⁶	6,900 (4.6)	89 (82-87)

¹ Includes naturally spawning hatchery fish. Nooksack spring Chinook 2014-15 escapements not available.

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) and the 2010-2014 Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2010a). North Fork and South Fork Nooksack estimates include years through 2013.

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 1999-2013, Skagit springs, Skagit falls and Skokomish available only for 1999-2014; Snohomish for 1999-2001 and 2005-2014; Lake Washington for 2003-2014; White River 2005-2014; Puyallup for 2002-2014; Nisqually for 2005-2014; Dungeness for 2001-2014; Elwha for 2010-2014.

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 (1990-2014)		Growth Rate ² (1990-2013)	
		NMFS		Recruitment (Recruits)	Escapement (Spawners)
Georgia Basin	NF Nooksack (early)	1.13	increasing	1.04	1.00
	SF Nooksack (early)	1.04	increasing	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)	0.99	stable	0.97	1.00
	Upper Cascade River (moderately early)	1.03	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)	1.01	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)	1.06	increasing	0.93	1.00
Hood Canal	Skokomish River (late)	1.01	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)	1.01	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 fraction of naturally spawning hatchery-origin fish from late- and early run hatchery programs in the White and Puyallup River basin.

Limiting factors

Limiting factors described in SSPS (2007) and reiterated in Ford (2011) and NWFSC (2015) 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, and water quality have been degraded for adult spawning, embryo incubation, and rearing as a result of cumulative impacts of agriculture, forestry, and development.
- 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.
- 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.

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). On August 8, 2011, NMFS conducted a five-year review and concluded that the species should remain listed as threatened (76 Fed. Reg. 50448). 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 3 contains the Puget Sound Steelhead DPS, MPGs, and DIPs for Puget Sound steelhead. On February 2, 2015, NMFS announced the initiation of five-year status reviews for 32 listed species of salmon, steelhead, rockfish, and eulachon. NMFS anticipates that the new five-year reviews will be completed in 2016. In the interim, the draft status review documents generally represent the most recent data on West Coast salmon ESUs. 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.

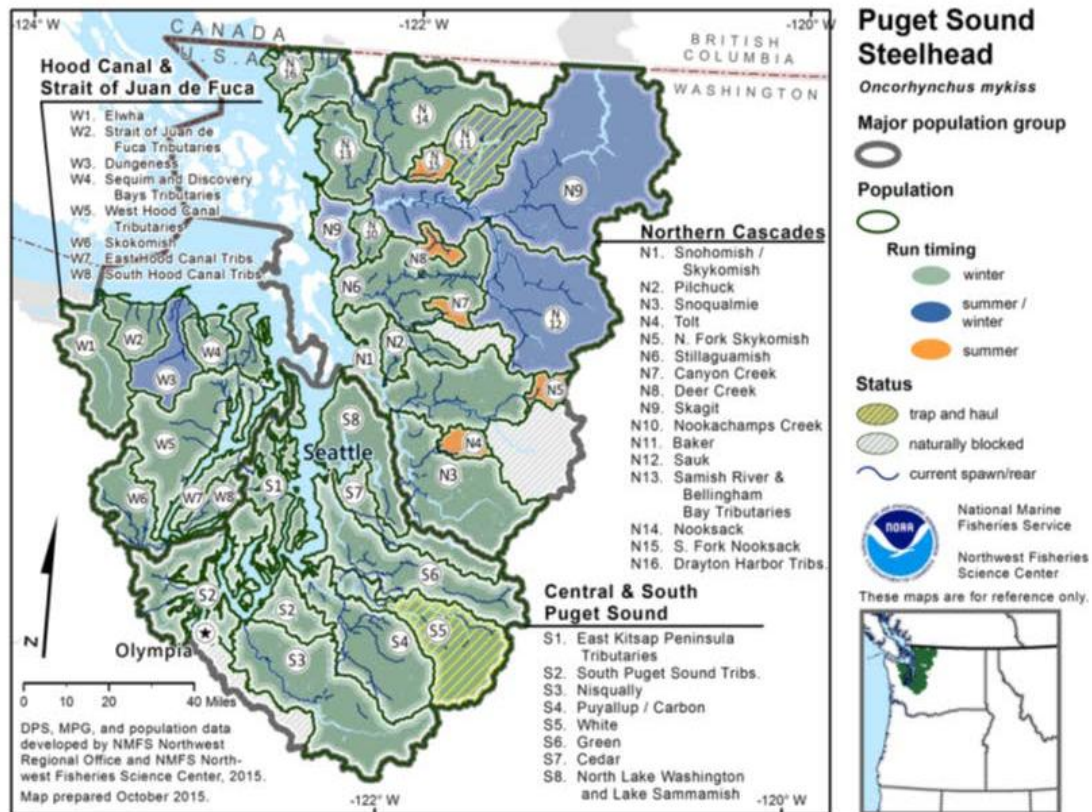


Figure 3. The Puget Sound Steelhead DPS showing MPGs and DIPs. The steelhead MPGs include the Northern Cascades, Central & Sound Puget Sound, and the Hood Canal & Strait of Juan de Fuca.

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). The BRT concluded that low and declining abundance and low and declining productivity were substantial risk factors for the species (Hard et al. 2007). Loss of diversity and spatial structure were judged to be “moderate” risk factors.

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 and occupied spawning habitat.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 4). 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).

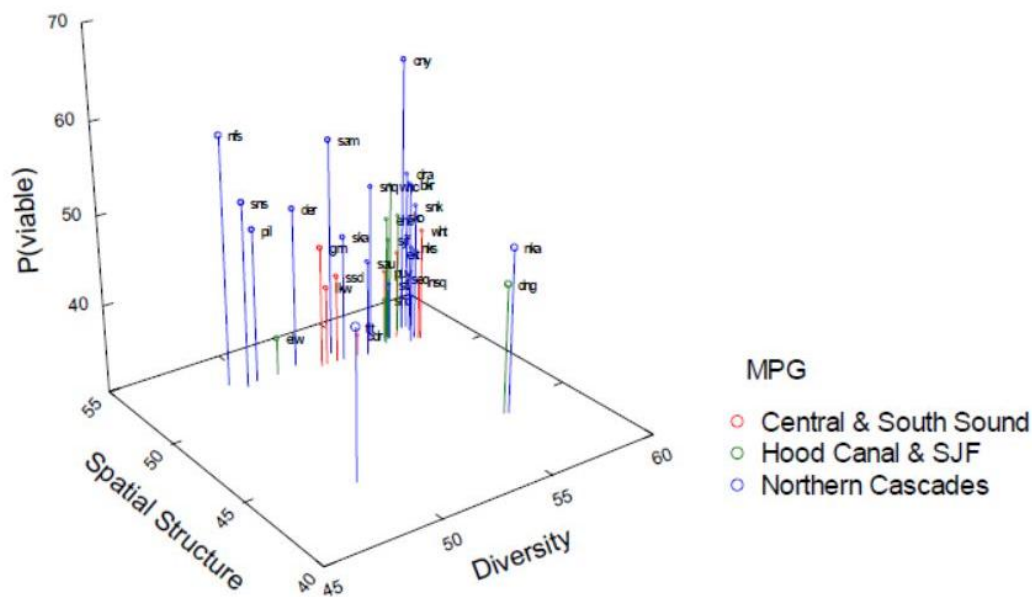


Figure 4. Scatter plot of the probabilities of viability for each of the 32 steelhead populations in the Puget Sound DPS as a function of VSP parameter estimates of influence of diversity and spatial structure on viability (PSSTRT 2013a).

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 (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

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 NOAA's Puget Sound steelhead Technical recovery Team viability report (PSSTRT 2013a) and NOAA'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 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

⁷ The natural Chambers Creek steelhead stock is now extinct.

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 8 of the 16 winter-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 5) 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.

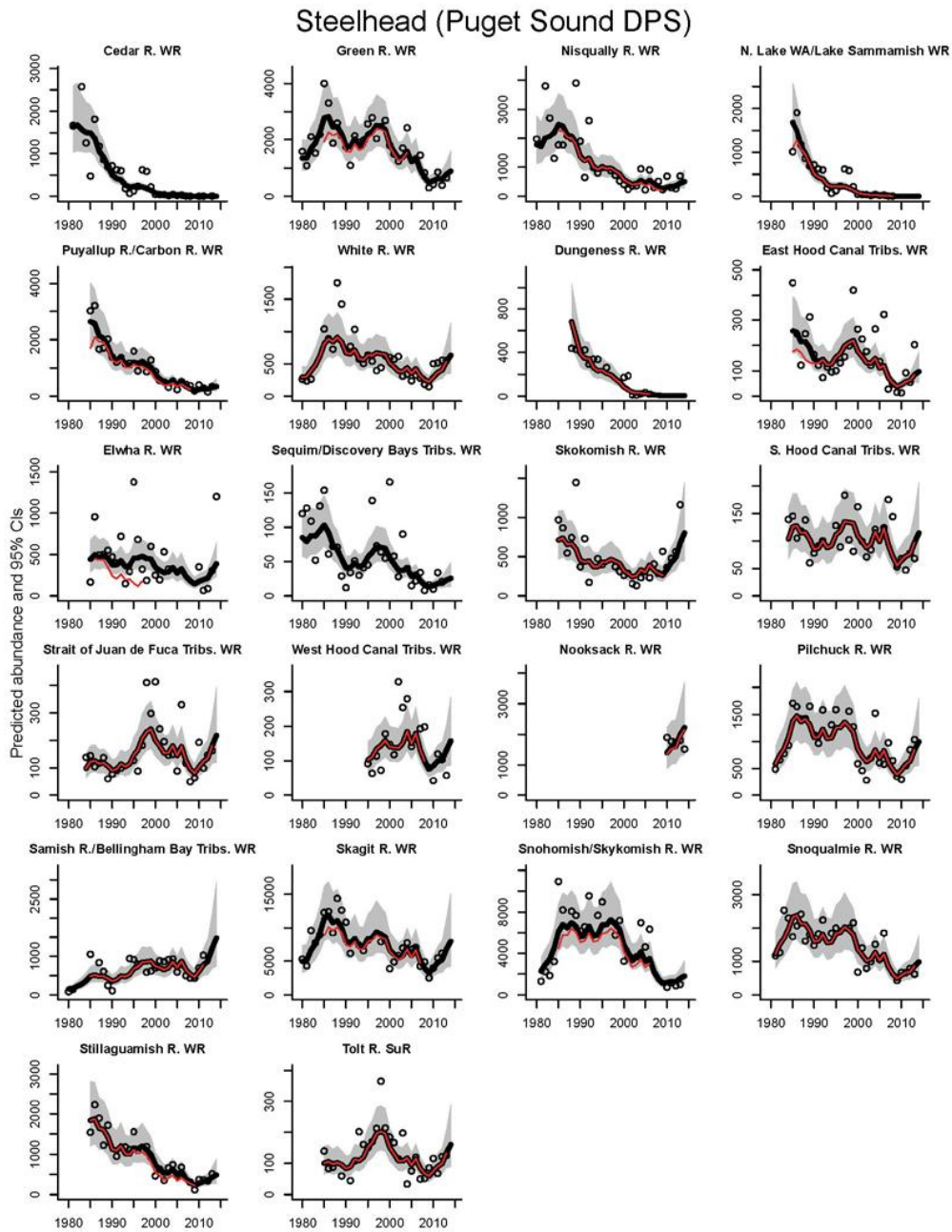


Figure 5. Trends in estimated total (black line) and natural (red line) population spawning abundance of Puget Sound steelhead.

In Figure 5, the circles represent annual raw spawning abundance data and the gray bands represent the 95% confidence intervals around the estimates.

Since 2009, 7 of the 22 populations indicate 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 (NWFSC 2015).

MPG	Run	Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Chang
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)

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

¹¹ Samish River/Bellingham Bays Tributaries, White River, Skokomish River, East Hood Canal Tributaries, and Strait of Juan de Fuca Tributaries winter-run populations with Skagit River and Green River also showing early signs of upward trends.

Strait of Juan de Fuca Tributaries winter-run steelhead populations in the Hood Canal and Strait of Juan de Fuca MPG.

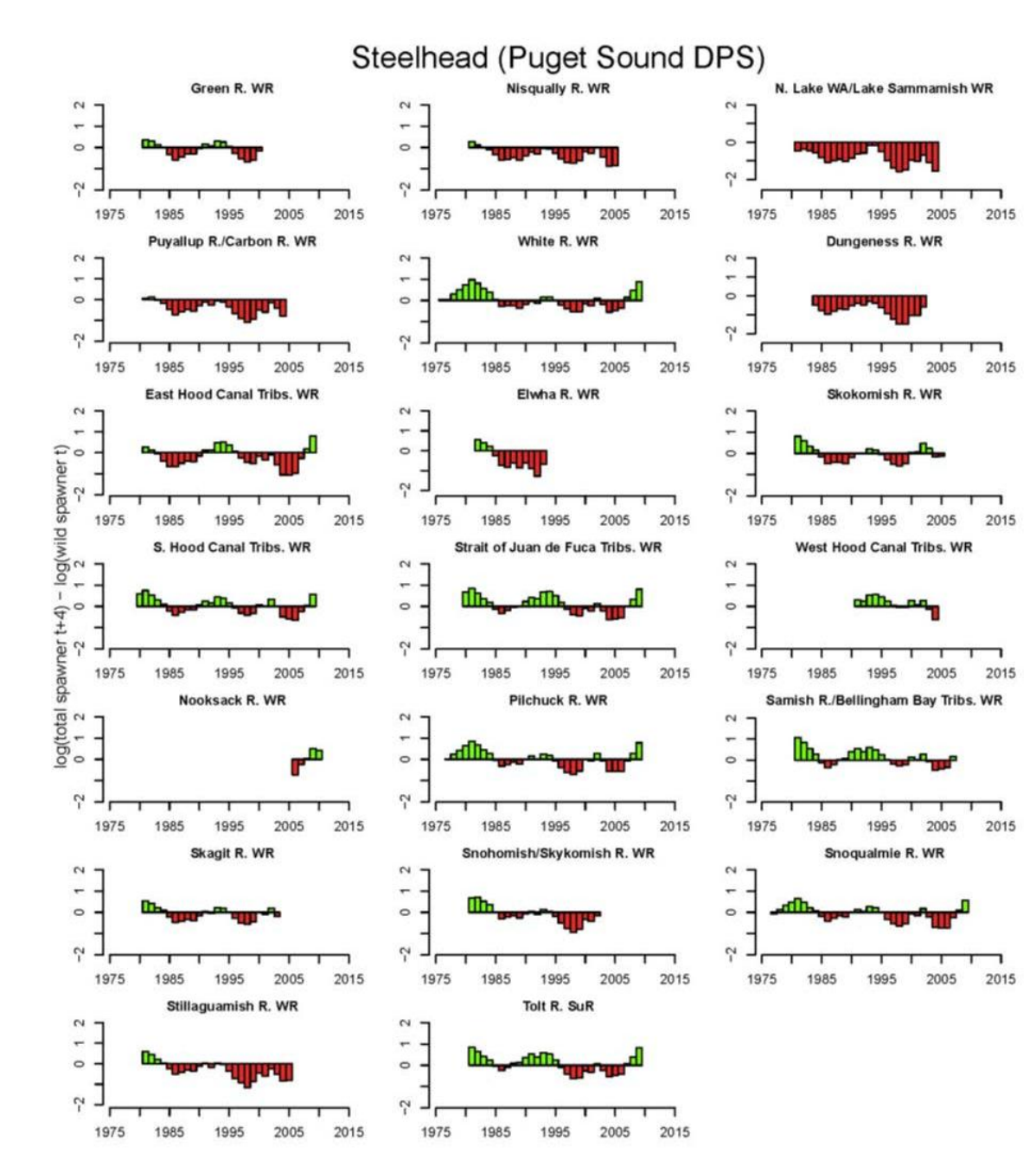


Figure 6. Trends in population productivity of Puget Sound steelhead (NWFSC 2016).

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 have declined overall in the DPS (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 7). Harvest rates on natural-origin steelhead have dropped considerably over the last decade and have been 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).

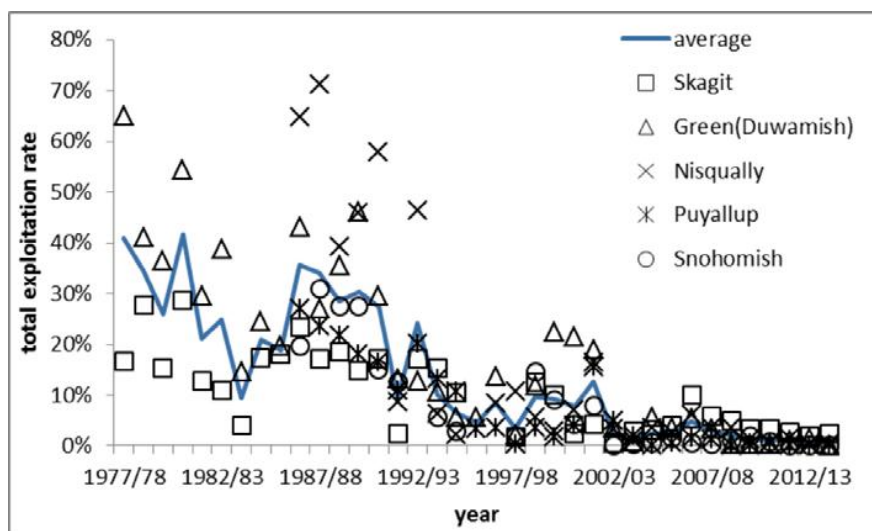


Figure 7. Total harvest rates on natural steelhead in Puget Sound rivers (WDFW 2010 in NWFSC 2015).

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 unlikely to substantially reduce spawner abundance or general productivity for most Puget Sound steelhead populations (NWFSC 2015). 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.

¹² Green River and Nisqually River populations.

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:

- 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.
- Widespread declines in adult abundance (total run size), despite significant reductions in harvest over the last 25 years.
- Threats to diversity posed by use of two hatchery steelhead stocks (Chambers Creek and Skamania) inconsistent with wild stock diversity throughout the DPS.
- Declining diversity in the DPS, including the uncertain, but likely weak, status of summer run fish in the DPS.
- 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.

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 and canary rockfish are listed under the ESA as threatened, and bocaccio are listed as endangered (75 Fed. Reg. 22276, April 28, 2010). These DPSs include all yelloweye rockfish, canary rockfish, and bocaccio found in waters of the Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca east of Victoria Sill (Figure 8). Yelloweye rockfish, canary rockfish, and bocaccio are 3 of 28 species of rockfish in Puget Sound (Palsson et al. 2009). On February 2, 2015, NMFS announced the initiation of five-year status reviews for 32 listed species of salmon, steelhead, rockfish, and eulachon. We issued

the 5 year review on May 5, 2016 and recommended canary rockfish of the Puget Sound/Georgia Basin be declassified as a DPS and de-listed as a threatened species under the ESA. We made this recommendation because new genetic data for canary rockfish in the Puget Sound/Georgia Basin provides strong evidence that they are not discrete from coastal fish (Ford 2015, NMFS 2016a). Because they are not discrete, in accordance with the DPS policy, we determined that they no longer meet the criteria to be considered a DPS. New genetic data reveals that canary rockfish of the Puget Sound/Georgia Basin are part of the larger population occupying the Pacific Coast. Canary rockfish were declared overfished in 2000 and a rebuilding plan was put in place in 2001. The Pacific Fishery Management Council determined the population to be “rebuilt” under the Magnuson-Stevens Fishery Conservation Act in 2015 (Thorson and Wetzel 2015). We will proceed with a proposed rule to delist Puget Sound/Georgia Basin canary rockfish which will go out for public comment. Nonetheless, Puget Sound/Georgia Basin canary rockfish are for the time being listed as threatened and continue to be treated as such in this biological opinion. Status review documents generally represent the most recent data on the listed Puget Sound rockfish species. 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.



Figure 8. ESA-listed rockfish DPSs.

The life histories of yelloweye rockfish, canary 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 these three species is similar, with important differences noted below.

Rockfish fertilize their eggs internally and the young are extruded as larvae. Yelloweye rockfish, canary 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 (Tagal et al. 2002), 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 and canary rockfish 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 and canary rockfish, 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, canary 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 canary rockfish and 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 canary rockfish is at least 84 years (Love et al. 2002), although 60 to 75 years is more common (Caillet et al. 2000). They reach 50% maturity at sizes around 16 inches (40 cm) and ages of 7 to 9 years. 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, canary 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 each listed rockfish species. 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, canary 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 study conducted by NMFS and WDFW is now underway to provide population and demographic information in the Puget Sound. The study is surveying listed rockfish habitats by Remotely Operated Vehicle (ROV) in Hood Canal, the South Sound and Central Sound. The survey is designed to provide abundance estimates for listed rockfish in three habitat strata based on high, medium, and low probability of presence and will be completed by the end of 2016.

Catches of yelloweye rockfish, canary 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). Canary rockfish occurred in 6.5% of the North Sound recreational harvests during the 1960s and then declined to 1.4% and to 0.6% during the subsequent two periods (Palsson et al. 2009). During the 1960s, canary rockfish were 3.1% of the Puget Sound proper rockfish harvest and then declined to 1% in 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, canary 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 three 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 canary rockfish and 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, canary 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 ESA-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 canary rockfish or bocaccio in Puget Sound proper, each species has been historically present there, observed in recent ROV surveys, and reported caught in recent recreational fisheries. The lack of detected canary rockfish and 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, canary rockfish, or bocaccio within Puget Sound proper.

Table 8. WDFW population estimates for yelloweye rockfish, canary 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	Canary Population Estimate		Percent Standard Error	
	North Sound	Puget Sound proper		
Bottom Trawl	16,100	Not detected	260.6 (variance)	NA
Drop Camera	2,751	Not detected	89.3	NA
Remotely Operated Vehicle	1,697 (San Juan Basin)		100	
Total Population Estimate	20, 548		Na	
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, canary 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 action 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.

Canary Rockfish Abundance and Productivity

Historically, the South Sound may have been a population stronghold for the DPS, but it appears to be greatly depleted (Drake et al. 2010b). Natural annual mortality ranges from 6 to 9% (Methot and Stewart 2005; Stewart 2007). Life history traits suggest an intrinsically slow growth

rate and low rates of productivity for this species, specifically its age at maturity, long generation time, and its maximum observed age (84 years) (Love et al. 2002).

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, canary 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 (McElhane 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 (McElhane 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, canary 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. The severe reduction of fish in these basins may eventually result in a contraction of the DPS' range (Drake et al. 2010b). 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.

Canary Rockfish Spatial Structure and Connectivity

Canary rockfish were present in each of the major basins in the 1970s (Moulton and Miller 1987) and have been documented in a genetics study conducted in 2014 and 2015 in the Central and Sound Sound. The ability of adults to migrate hundreds of kilometers could allow the DPS to re-establish spatial structure and connectivity in the future under favorable conditions (Drake et al. 2010b).

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 (WDFW 2011b). 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. Though there is limited genetic data for the ESA-listed rockfish DPSs, the unique oceanographic features and relative isolation of some of its basins may have led to unique adaptations, such as timing of larval release (Drake et al. 2010b).

Yelloweye Rockfish Diversity

Yelloweye rockfish size and age distributions have been truncated (Figure 9). 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). Since these fish were observed several years ago, they are likely bigger. (Pacunski et al. 2013 did not report a precise size for these fish thus we are unable to provide a precise estimate of their likely size now). As a result, the reproductive burden may be shifted 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).

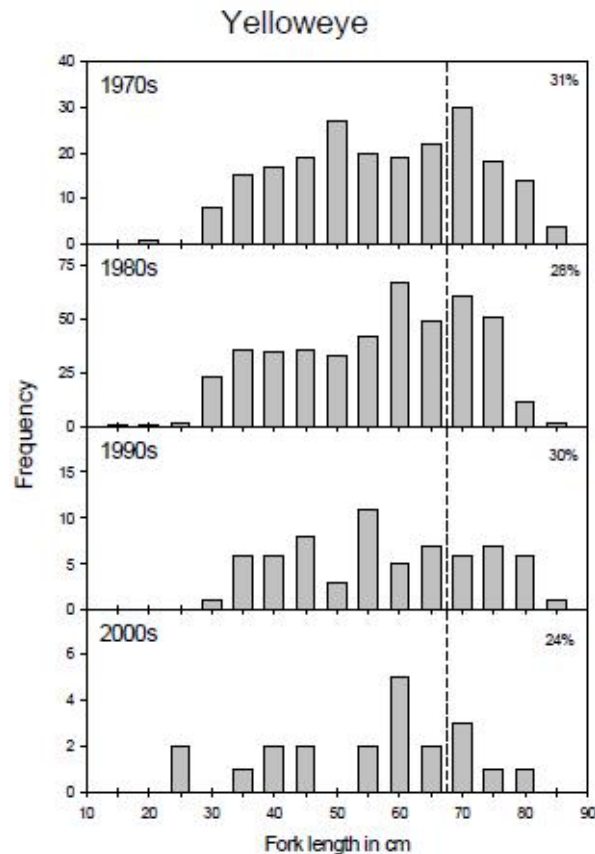


Figure 9. Yelloweye rockfish length frequency distributions (cm) binned within four decades. The vertical line depicts the size at which about 30% of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for later decades (figure from Drake et al. 2010b).

Canary Rockfish Diversity

Canary rockfish size and age distributions have been truncated (Figure 10). As a result, the reproductive burden may be shifted to younger and smaller fish. The population of canary rockfish in the 1970s exhibited a broad range of sizes. However, by the 2000s there were far fewer size classes represented and no fish greater than 21.65 inches (55 cm) were recorded in the recreational data (Drake et al. 2010b). Although some of this truncation may be a function of the overall lower number of sampled fish, the data in general suggest few older fish remain in the population. This shift could alter the timing and condition of larval release that may be mismatched with habitat conditions within the range of the DPS, potentially reducing the viability of offspring (Drake et al. 2010b).

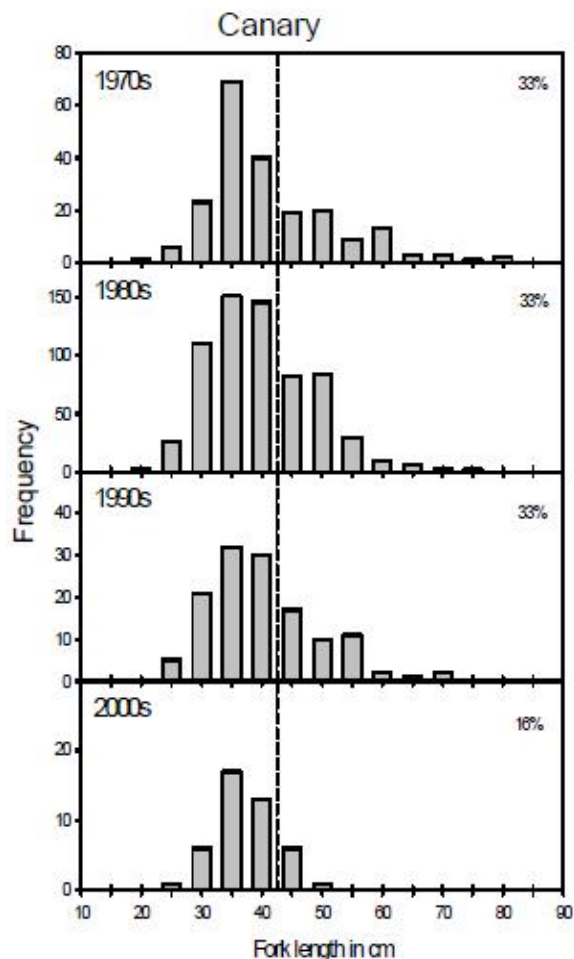


Figure 10. Canary rockfish length frequency distributions (cm) binned within four decades. The vertical line depicts the size at which about 30% of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for later decades (figure from Drake et al. 2010b).

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 11). 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).

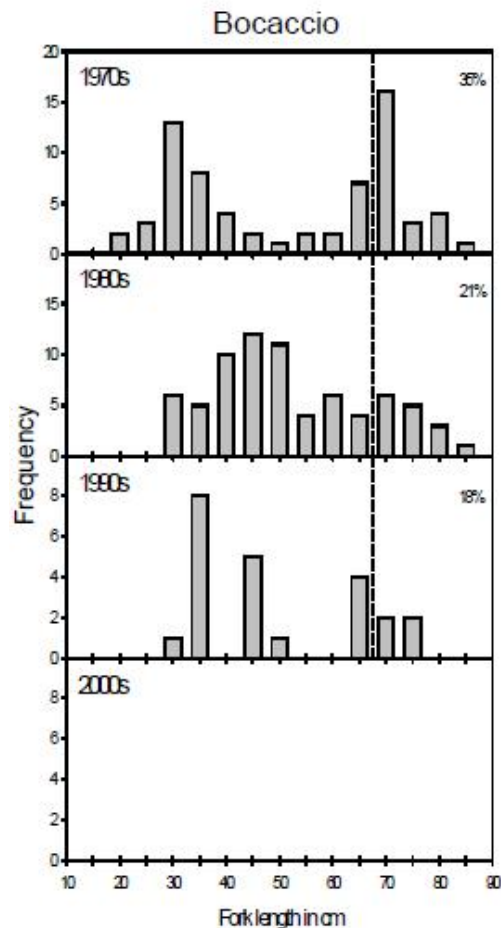


Figure 11. Bocaccio length frequency distributions (cm) binned within four decades. The vertical line depicts the size at which about 30% of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for later decades (figure from Drake et al. 2010b).

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 last 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.

Several factors, both population- and habitat-related, have caused the DPS of canary rockfish to decline to the point that NMFS has listed them as threatened. The general outlook in terms of all five criteria (habitat, spatial structure, diversity, abundance, and productivity) is that the DPS is likely to become 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, canary 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 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). On January 26, 2016, NMFS announced the initiation of a five-year status review of Southern Resident killer whales. The public comment period ended April 25, 2016. Limiting factors described in the final recovery plan for Southern Resident killer whales include quantity of prey (subsequent data collection and analysis indicated a strong preference for Chinook salmon) (NMFS 2008g, 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 2015c) incorporated the best available information at the time for the relevant sections, and here we supplement with new information available subsequent to the 2015 biological opinion.

Updates to Abundance, Productivity, and Trends

NMFS has continued to fund the Center for Whale Research (CWR) to conduct the annual census of the Southern Resident population, and census data are now available through July 2015. Between the July 2014 census count of 78 whales and July 2015, two whales died (a pregnant adult female from J pod and an L pod calf), and five whales were born (3 from J pod and 2 from L pod). As of March 2016, four additional calves were born and there was one calf death, bringing the number of whales to 84.

The Southern Resident killer whale population has 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 is weak evidence of a decline in fecundity rates through time for reproductive females. This decline is linked to fluctuations in abundance of Chinook prey, and possibly other factors (NWFSC unpubl.). In contrast to the increasing number of reproductive females, there has been a general decline in post-reproductive females. A decline in this life stage is concerning as a couple of studies (Brent et al. 2015, Franks et al. 2016) have suggested that this post-reproductive lifespan is an important component in the life history of killer whales. Brent et al. (2015) found that post-reproductive females lead groups through salmon foraging areas and that this leadership is especially evident and important during times of low salmon abundance. They further suggest older female killer whales likely improve the fitness of their offspring by transferring ecological knowledge (Brent et al. 2015).

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 have continued the satellite tagging project that began in 2011. The researchers working on the satellite tagging project use location data from satellite tags deployed on Southern Residents to find out more about their winter migration and the extent of their geographic range. This work was also recommended by an independent science panel that evaluated the available science about Southern Residents, their feeding habits, and the potential effects of salmon fisheries on the abundance of Chinook salmon available to Southern Residents (Hilborn et al. 2012). Results of the satellite tagging from 2012-2016, indicate the limited occurrence along the outer coast by J pod and extensive occurrence in inland waters, particularly in the northern Georgia Strait. Because J pod spent very little time in coastal waters during tag deployments, we know less of their coastal distribution than we do for K and L pods. J pod has also only been detected on one of seven passive acoustic recorders positioned along the outer coast; they do not appear to travel to Oregon or California like K and L pods do (Hanson et al. 2013). Detection rates of K and L pods on the passive acoustic recorders indicate the whales occur with greater frequency off Columbia River and Westport and are most common in March (Hanson et al. 2013). Satellite-linked tag deployments on K and L pod individuals have also provided more data on the whales' movements in the winter (NWFSC unpubl. data). These data indicate that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months.

The satellite tagging project has also allowed for the collection of prey and fecal samples in the winter months. Successful satellite tagging continues through the present, with anticipated collection of more prey samples. Preliminary analysis of prey remains sampled indicated that most prey samples were Chinook salmon, with a smaller number of steelhead, chum, and halibut. One hypothesis as to why killer whales primarily consume Chinook salmon even when they are not the most abundant salmon is because of their relatively high energy content (Ford and Ellis 2006). Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (kcal/kg) (O'Neill et al. 2014). For example, in order for a killer whale to obtain the total energy value of one Chinook

salmon, they would need to consume approximately 2.7 coho, 3.1 chum, 3.1 sockeye, or 6.4 pink salmon (O'Neill et al. 2014).

Updates to Limiting Factors

As described in the previous biological opinions (NMFS 2011a, NMFS 2014a, NMFS 2015c), 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 2008g).

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 2015c).

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 salmon management 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 Chinook, with an overall average of 88% Chinook across the timeframe and monthly proportions as high as >90% Chinook (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). Recently, 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 found that salmonids made up to over 98% of the inferred diet, of which almost 80% were Chinook salmon. They also found evidence of prey shifting at the end of summer towards coho salmon for all years analyzed (coho salmon contributed to over 40% of the diet in late summer). Chum, sockeye, and steelhead made up relatively small contributions to the sequences (less than 3% each).

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. in review). 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). 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. in review).

In April 2015, NMFS hosted a 2-day SRKW health workshop to assess the causes of decreased survival and reproduction in the killer whales. Following the workshop, a list of potential action items generated during the workshop was then reviewed and prioritized. A Priorities Report (http://www.westcoast.fisheries.noaa.gov/publications/protected_species/marine_mammals/killer_whales/srkw_healthpriority_dec2015.pdf) provides a prioritized list of the recommended action items to better understand what is causing decreased reproduction and increased mortality in this population of whales. The report also provides prioritized opportunities to establish important baseline information on SRKW and reference populations to better assess negative impacts of future health risks, as well as positive impacts of mitigation strategies on SRKW health.

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. Houghton et al. (2015) found that the noise levels killer whales receive are largely determined by the speed of the vessel. Thus, to reduce noise exposure to the whales, they had recommended reduced vessel speeds. In 2011, NMFS announced final regulations to protect killer whales in Washington State from the effects of various vessel activities (76 FR 20870). NMFS is currently using the 5 years of data from monitoring groups and several years of data from the NWFSC acoustic tagging program to evaluate the effectiveness of these regulations.

2.2.2 Status of Critical Habitat

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

For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they

provide to each listed species they 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 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).

Primary constituent elements (PCE) 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 PCEs 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

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).

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 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). The CHART completed a draft report on the designation of critical habitat for Puget Sound steelhead in 2012 (NMFS 2012a; Appendix B). 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. The total number of miles designated for the DPS in the final rule differ slightly from those identified in the proposed rule. Numerous minor edits were made to maps and distribution data to better reflect the areas occupied by Puget Sound steelhead. 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). As described further in the Section 4(b)(2) report (NMFS 2012b), NMFS could not identify “specific areas” within the marine and ocean range that meet the definition of critical habitat. Instead, the CHARTs considered the adjacent marine areas in Puget Sound when designating steelhead freshwater and estuarine critical habitat. More information on Puget Sound steelhead critical habitat designation 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.

Primary constituent elements (PCE) 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 PCEs 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 to protect and restore habitat throughout Puget Sound 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 on habitat, including primarily critical habitat, is 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 all three species of rockfish in 2014 under section 4(a)(3)(A) of the ESA (79 FR 68041, November 13, 2014). The specific areas designated for canary rockfish and bocaccio are the same and include 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 canary rockfish and 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 all three 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, canary 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, canary rockfish, and bocaccio fall into major categories reflecting key life history phases.

Adult canary rockfish and 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 canary rockfish and 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 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; 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, canary 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.

2.2.2.1 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).

2.3 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 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 is planning 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. Future consultations will incorporate information from the recovery planning process as it becomes available.

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.

2.3.1 Puget Sound Chinook and Steelhead

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 2008e) and the Pacific Coast Salmon Plan effects on Lower Columbia River Chinook (NMFS 2012c). The University of Washington Climate Impacts Group recently 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)

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) and 2015 (Grayum and Unsworth 2015, Shaw 2015). 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 2012 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	Total Exploitation Rate
Nooksack early	82%	5%	26%
Skagit spring	55%	12%	26%
Skagit summer/fall	58%	21%	50%
Stillaguamish	56%	8%	18%
Snohomish	44%	14%	25%
Lake Washington	56%	17%	38%
Duwamish-Green River	47%	27%	48%
White River	14%	13%	15%
Puyallup River	39%	33%	54%
Nisqually River	22%	55%	71%*
Skokomish River	24%	45%	59%*
Mid-Hood Canal rivers	57%	10%	25%
Dungeness River	85%	6%	41%
Elwha River	87%	5%	40%

*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 our Federal Register Notice (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 affect the abundance and overall productivity of Puget Sound steelhead (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 2010c). An annual average of 102 (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 2014/2015 time period (NMFS 2015b). 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 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 six year period from 2009 to 2014, 28 steelhead were encountered in 2,481 net sets estimated at 5 steelhead per year (Henry 2015). 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 108 (range 22 – 202) 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 2014/2015 time period (Kraig 2016). Three natural-origin steelhead were landed in 2010/2011 as a result of illegal retention (WDFW and PSIT 2011). From April 2014 to March 2015, the steelhead catch estimate for marine recreational fisheries¹⁴ was 22 fish (WDFW and PSIT 2016). The majority of steelhead were caught in Marine Catch Area 9. All steelhead were identified as marked hatchery fish (WDFW and PSIT 2016). Applying a catch-and-release mortality rate of 10 percent,¹⁵ an average estimated 11 natural-origin steelhead mortalities have occurred annually from 2008/2009 to 2014/15. This also demonstrates a declining trend (45% decrease in incidental harvest) in non-treaty recreational fisheries since 2001.

In summary, at the time of listing, during the 2001/02 to 2006/07 seasons, an average of 325 steelhead were encountered 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 212 steelhead were encountered in marine treaty and non-treaty commercial, ceremonial and subsistence, and recreational fisheries (i.e., 102 treaty marine; 2 non-treaty commercial; 108 non-treaty recreational) for the most recent time period (2007/2008 to 2014/2015) (Table 10). Since not all fish in marine area fisheries are sampled for

¹⁴ Marine Catch Areas 6, 8-1, 9 and 10 for recreational fisheries.

¹⁵ An annual average of 108 *0.10 = 10.8 or 11 natural-origin steelhead mortalities in non-treaty recreational fisheries.

marks, this annual estimate includes both encounters (fish that will be caught and released) and incidental mortality of 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 decline by 35% in recent years.

Table 10. Marine area harvest on natural-origin steelhead from 2001/02 to 2006/07 and 2007/08 to 2014/15 time periods.

Time Period	Marine Catch			Total
	Treaty commercial & C&S	Non-Treaty Commercial	Non-Treaty Recreational	
2001/02 to 2006/07	126	1	198	325
2007/08 to 2014/15	102	2	108	212

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 five Puget Sound summer run populations, four out of the twenty-five winter run populations, and one out of the five summer/winter run populations (Marshall 2014). Data are currently insufficient to provide a full run reconstruction of natural-origin steelhead populations needed to assess exploitation or 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 a subset of Puget Sound 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 2010c) (Table 11). Average harvest rates on the same subset of watersheds for natural-origin steelhead demonstrated a reduction to 1.8% in Puget Sound fisheries during the 2007/2008 to 2014/2015 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 57% in recent years.

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 2015c; WDFW and PSIT 2016).

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	1.22 ^c	0.99 ^c	1.04 ^c	0.54 ^c	0.79 ^c
Avg HRs 2007-15	3.73	1.12	1.54	0.48	2.02
Total Avg HR	1.8% total average harvest rate across all populations from 2007-08 to 2014-15				
Total average HR 2001-02 to 2013-15	2.93				

^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.

^c Preliminary catch estimates; subject to change.

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 abundance in the DPS (NWFSC 2015). NMFS also evaluated the 2014-15 Puget Sound Chinook Harvest plan and found that it met the requirements of section 7 of the ESA for incidental impacts on listed steelhead, and that fisheries managed consistent with the terms of the harvest plan would not jeopardize the survival and recovery of the DPS (NMFS 2014a).

As described in the Status of Puget Sound Steelhead (Section 2.2.1.2), NMFS convened a technical recovery team that identified historic populations and developed viability criteria for a steelhead recovery plan (PSSTRT 2013a, 2013b). In May 2013, NMFS convened a recovery

team to lead Puget Sound Steelhead Recovery Planning. NMFS plans to publish the draft Puget Sound Steelhead Recovery Plan for public comment in 2018. 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.

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 2014b). 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. No steelhead have been observed in the fishery. 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.

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 protocols¹⁶ 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

¹⁶ 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.

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).

There are currently 14 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 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 are 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 functions to rebuild native stock winter-run steelhead abundances in the Dewatto, Duckabush, and South Fork Skokomish river watersheds, and 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.

Five programs produce "early winter" (previously "Chambers Creek lineage") unlisted steelhead for harvest in recreational and tribal fisheries: (1) Dungeness River; (2) Nooksack River; (3) Stillaguamish River; (4) Skykomish River; and (5) Snoqualmie River. Three other harvest augmentation programs propagate unlisted summer-run fish derived from Columbia River, Skamania stock that has become localized to their Puget Sound release sites. The operational status of these Skamania summer-run programs beyond the 2016 release year remains uncertain. The early winter and Skamania summer steelhead stocks reared and released as smolts through the nine 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 hatchery steelhead poses a genetic risk to natural-origin steelhead (NMFS 2016b). Of particular importance to this harvest evaluation is that early winter steelhead have been artificially selected to return 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. Early winter and summer steelhead hatchery programs are isolated programs, where hatchery-origin adults return before the majority of the natural-origin run to reduce the genetic risk. The earlier return timing for the hatchery-origin steelhead minimizes hatchery-origin and natural-origin stock overlap and co-occurrence during the in-river migration and spawning periods. This temporal and spatial separation in adult return and spawn timing provides protection to the later-returning natural-origin steelhead populations in harvest areas when and where fisheries directed at early winter steelhead occur (Crawford 1979).

On March 3, 2016, NMFS announced that we were releasing an FEIS that 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. On April 15, 2016, NMFS announced the release of the FEIS (NMFS 2016b) for five HGMP on early winter steelhead programs and signed a Record of Decision (ROD).

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 2014c) to about 1,504,750 annually (Appendix A in NMFS 2016b). Hatchery programs propagating unlisted winter steelhead account for the majority of hatchery-origin steelhead smolt releases (531,600) and a total of 841,600 unlisted smolts released annually (including 310,000 summer steelhead) in the Puget Sound DPS (Appendix A in NMFS 2016b).

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 2005b). 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 2005b). 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 2005b, 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. 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 Elwha¹⁷ 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 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

¹⁷ 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.

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.

2.3.2 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. WDFW has estimated that the biomass of benthic bottom fishes in Puget Sound is 220 million pounds (WDFW 2010).

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, including one canary rockfish (within a net) (NRC 2010). Because habitats deeper than 100 feet (30.5 m) are most readily used by adult yelloweye rockfish, canary rockfish, and bocaccio, there is an unknown but potentially significant impact from deepwater derelict gear on rockfish habitats within Puget Sound.

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, canary 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 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 ESA-listed rockfish that use waters in Canada and the San Juan area. In 2010, the Washington State Fish and Wildlife Commission formally adopted regulations that ended the retention of rockfish by recreational anglers in Puget Sound and closed fishing for bottom fish in all waters deeper than 120 feet. On July 28, 2010, WDFW enacted the following package of regulations by emergency rule for the following non-tribal commercial fisheries in Puget Sound in order to protect dwindling rockfish populations:

- 1) Closure of the set net fishery,
- 2) Closure of the set line fishery,

- 3) Closure of the bottom trawl fishery,
- 4) Closure of the inactive pelagic trawl fishery,
- 5) Closure of the inactive bottom fish pot fishery.

As a precautionary measure, WDFW closed the above commercial fisheries westward of the ESA-listed rockfish DPSs' 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, 138 canary rockfish, and 43 bocaccio annually (all of these fish would be released). Some released fish are expected to survive; thus, of the total takes, we authorized a subset of lethal take of up to 75 yelloweye rockfish, 79 canary rockfish, and 25 bocaccio annually (consultation number F/NWR/2012/1984). Recreational and commercial halibut fishermen can incidentally catch listed rockfish. In 2014 we assessed the bycatch associated with the halibut fishery in Puget Sound. We estimated that up to 265 yelloweye rockfish, 31 canary rockfish, and 10 bocaccio would be caught annually in the 2014, 2015, and 2016 fishing seasons. Of these, it is anticipated that all caught listed rockfish would be killed (consultation number 2014/F/WCR/403). After the 2014 fishery, it was reported that 7 yelloweye rockfish and one canary rockfish were incidentally caught in the commercial halibut fishery (James 2015a) though there is uncertainty if all bycatch is being identified.

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.¹⁸ 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).

2.3.3 Southern Resident Killer Whales

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

Previous Harvest Actions

In the past harvest opinions (NMFS 2011a, NMFS 2014a, NMFS 2015c), 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.

2.3.4 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

¹⁸ 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-ac/permitt-ed-permis-eng.htm>)

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 9 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 2012-2016 (Dennis 2016).

Species	Life Stage	Production/Origin	Total Take	Lethal Take
Puget Sound Chinook	Juvenile	Natural	432,471	12,149
		Listed hatchery intact adipose	78,382	4,023
		Listed hatchery clipped adipose	115,921	11,891
	Adult	Natural	883	52
		Listed hatchery intact adipose	145	11
		Listed hatchery clipped adipose	2,693	87
Puget Sound steelhead	Juvenile	Natural	70,223	1,326
		Listed hatchery intact adipose	103	2
		Listed hatchery clipped adipose	9,050	175
	Adult	Natural	1,357	30
		Listed hatchery clipped adipose	40	5
PS/GB Bocaccio	Adult	Natural	48	26
PS/GB Canary Rockfish	Adult	Natural	110	58
PS/GB Yelloweye Rockfish	Adult	Natural	97	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.

2.4 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 action and are later in time, but still are reasonably certain to occur.

2.4.1 Puget Sound Chinook

2.4.1.1 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 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).

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%	23%
Whidbey/Main Basin	Skagit Spring	Upper Sauk River	46%	38%
		Suiattle River	50%	41%
		Upper Cascade		38-41%
	Skagit Summer/Fall	Upper Skagit River	54%	60%
	Lower Skagit River	36%	51%	
	Lower Sauk River	33%	49%	
Stillaguamish	N.F. Stillaguamish River	45%	30%	
	S.F. Stillaguamish River	28%	18%	
Snohomish	Skykomish River	24%	18%	
	Snoqualmie		18%	
South Sound	Lake Washington	Sammamish ^a		30%
	Green-Duwamish	Cedar ^a		30%
		Duwamish-Green	62%	46%
	White	White ^b		23%
	Puyallup	Puyallup ^c		33-46%
Nisqually	Nisqually ^d		33%	
Hood Canal	Mid-Hood Canal	Mid-Hood Canal ^e		18-23%
	Skokomish	Skokomish	36%	33%
Strait of Juan de Fuca	Dungeness	Dungeness ^b		23%
	Elwha	Elwha ^b		23%

^aUses North Fork Stillaguamish RER as a surrogate for the Cedar (30%) and the Sammamish given similarity of current abundance and escapement trends.

^b Uses Nooksack early Chinook as surrogate.

^c Uses the Skokomish (33%) as surrogate.

^d Uses range including Skokomish (33%) and Green Rivers fall Chinook as surrogates

^e Uses range including Nooksack early Chinook (23%) and South Fork Stillaguamish (18%) as surrogates.

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 thresholds¹⁹

¹⁹ After taking into account uncertainty, the critical threshold is defined as a point below which: (1) depensatory 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.²⁰ 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.

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 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 action. 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 risk²¹ 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.

Populations are also at increased risk if actual exploitation rates exceed exploitation rate ceilings that are part of the proposed action. In most cases for most management units actual exploitation rates are routinely at or below the specified objectives (see for example Table 13). Management error is such that it is reasonable to expect that management objectives will be exceeded on

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.

²⁰ 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.

²¹ When compared to a population otherwise at or above its critical threshold.

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 2012 based on work completed in late 2014. Based on that information, in March 2015, NMFS identified four populations that required further consideration including Skagit summer/fall, Puyallup, Nisqually, and Skokomish Chinook (Table 14). The co-managers subsequently provided a Management Performance Assessment for each of these populations that reviewed past performance, by comparing preseason and post season estimates of exploitation rate, factors that contributed to the observed overages, and remedial actions (Graham and Unsworth 2015). Major issues identified in the report were better estimation methods for preseason forecasts and projected terminal harvest rates, improved inseason estimates of terminal abundance, higher than projected catches in terminal areas, and increased impacts in Alaskan and Canadian fisheries. Although Canadian fisheries contributed substantially to the overages in some years, the most consistent contributor to the overages was the terminal fishery. While we do not have final exploitation rates for the most recent years, we do have the terminal harvest rates for those years for the four terminal area fisheries. Since the terminal area fisheries were the primary contributor to the overages in the years for which we have exploitation rates, the terminal harvest rates are reasonable proxies for the exploitation rates in the more recent years assuming the proportion of catch in the preterminal fisheries has not changed dramatically. In 2016, the tribes provided a draft report that assessed the efficacy of the remedial actions for 2015, including post season accounting of run sizes, terminal harvest rates, and other pertinent information related to management of the terminal fisheries for the four populations (James 2016b). Results for each of the terminal areas is discussed in more detail in the Effects on the Species section for each of the relevant regions.

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	
		Actual	Objective	Actual	Objective	Actual	Objective
Georgia Basin	Nooksack early	5%	7% SUS	6%	8%	6%	7%
Whidbey/ Main Basin	Skagit spring	21%	38%	31%	38%	24%	38%
	Skagit summer/fall	45%	50%	66%	50%*	34%	50%
	Stillaguamish	15%	25%	19%	25%	14%	25%
	Snohomish	21%	21%	17%	15% SUS*	23%	21%*
Central/South Sound	Lake Washington	10%	20% SUS	16%	20% SUS	16%	20% SUS
	Duwamish-Green R	8%	15% /5800	7%	15% /5800	10%	15% /5800
	White River	18%	20% SUS	10%	20% SUS	13%	20% SUS
	Puyallup River	56%	50%	49%	50%	61%	50%
	Nisqually River	67%	65%	67%	65%	58%	56%
Hood Canal	Mid-Hood Canal R.	11%	12% PTSUS	8%	12% PTSUS	11%	12% PTSUS
	Skokomish River	55%	50%	54%	50%	58%	50%
Strait of Juan de Fuca	Dungeness River	6%	10% SUS	5%	10% SUS	4%	10% SUS
	Elwha River	7%	10% SUS	5%	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. Both management units have exceeded both their total and SUS objectives in recent odd years. The Snohomish was below its SUS objective in 2012 (11% v 15%) although preseason fisheries were designed to meet the total exploitation rate objective and northern fishery impacts were higher than anticipated.

Shorten this section, reference additional info provided as follow up to our questions for Skokomish and the assessment repo

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.²² 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.

2.4.1.2 Effects on the Species

Effects of the Proposed Actions on listed species occur through implementation of the proposed tribal Puget Sound salmon fisheries, the U.S. Fraser Panel 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, 2016 through April 30, 2017 are summarized in Table 15. Exploitation rates are reported by management units and escapements by populations based on

²² 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 2015c).

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 (Shaw 2016). Thus, Table 13 represents the sum of fishing-related mortality anticipated under the proposed action together with that evaluated under the existing PFMC and PST consultations. Documentation provided for the proposed BIA funding action states that “Individual treaty tribes may conduct additional ceremonial and subsistence fisheries not detailed in this agreement, consistent with provisions of the Puget Sound Salmon Management Plan.” (Bowhay 2016). The impacts of these fisheries are not assessed in Table 13 because we do not have an estimate of the associated harvest. These fisheries would be sporadic; responding to important unanticipated cultural circumstances for tribal communities, such as funerals, and overall impacts are expected to be low (James 2016c). The fisheries could be considered on a case by case basis at the time to determine if the anticipated take would fall within the impacts evaluated in this opinion. If not, the take of those fisheries would not be exempted as part of this opinion, However, NMFS will work with the tribes to evaluate proposed ceremonial and subsistence fisheries if and when they are proposed.

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 13 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%).²³ All of the population specific RERs are shown in Table 13.

NMFS’ critical and rebuilding escapement thresholds represent natural-origin spawners. 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.

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.

²³ 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 2016 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	32.3%	4.9%	37.1%	23%	
Whidbey/ Main Basin	Skagit spring	18.8%	11.2%	30.0%	38-41%	
	Skagit summer/fall	29.9%	10.0%	39.9%	49-60%	
	Stillaguamish	12.2%	7.0%	19.2%	18-30%	
	Snohomish	16.2%	3.4%	19.7%	18%	
Central/South Sound	Lake Washington	26.9%	10.5%	37.4%	30%	
	Duwamish-Green R	26.9%	7.8%	34.6%	46%	
	White River	5.1%	13.2%	18.3%	23%	
	Puyallup River	26.9%	21.2%	48.1%	33-46%	
	Nisqually River	22.4%	25.6%	48.0%	33%	
Hood Canal	Mid-Hood Canal R.	18.6%	4.2%	22.8%	18-23%	
	Skokomish River	18.6%	26.2%	44.8%	33%	
Strait of Juan de Fuca	Dungeness River	65.6%	2.3%	67.9% ³	23%	
	Elwha River	65.9%	2.3%	68.2% ³	23%	
Escapement			Natural (HOR+NOR)	NOR	Critical	Rebuilding
Georgia Basin	Nooksack Management Unit			226		500
	NF Nooksack (early)			91	200	-
	SF Nooksack (early)			135 ²	200	-
Whidbey/ Main Basin	Upper Skagit River (moderately early)		11,453	11,017	967	7,454
	Lower Sauk River (moderately early)		571	571	200	681
	Lower Skagit River (late)		2,382	2,382	251	2,182
	Upper Sauk River (early)		980	980	130	330
	Suiattle River (very early)		491	491	170	400
	Upper Cascade River (moderately early)		334	334	170	1,250
	NF Stillaguamish R. (early)		355	186	300	552
	SF Stillaguamish R. (moderately early)		121	63	200	300
	Skykomish River (late)			2,061	1,650	3,500
Snoqualmie River (late)			775	400	1,250	
Central/South Sound	Cedar River (late)		1,350	1,198	200	1,250
	Sammamish River (late)		1,502	140 ¹	200	1,250
	Duwamish-Green R. (late)		4,049	1,975	835	5,523
	White River (early)		1,488	714	200	1,100
	Puyallup River (late)		1,039	275	200	522
	Nisqually River (late)		1,367	604	200	1,200
Hood Canal	Mid-Hood Canal Rivers (late)		336	208 ¹	200 ³	1,250
	Skokomish River (late)		1,443	410	452	1,160
Strait of Juan de Fuca	Dungeness River		328	84	200	925
	Elwha River		2,782	153	200	1,250

Source: Chin2716_STTFinal_TreatyOnly_PuySkokSkagitNTFraserNetAddon.xlsm (L. Lavoy, pers. comm., May 18, 2016). Model output escapements adjusted to reflect natural-origin (NOR) or natural (hatchery-origin (HOR)+NOR) escapement as closely as possible using FRAM 2716 inputs, pre-season forecasts or post-season data from previous years.

¹Information not available to directly assess 2016 natural origin escapement. Previous post-season reports indicate NOR Chinook contribute approximately 62% (Mid-Hood Canal) to natural escapement since 2004. Sammamish escapement based on 2006-2015 contribution to Lake Washington natural-origin escapement.

² C. James, pers. comm, May 2, 2016. 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.

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. 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 action in the action area described in Section 1.4.

Natural-origin average escapement is below the critical escapement threshold for both populations (Table 3), indicating additional risk to both populations in this Region. When hatchery-origin spawners are included, average spawning escapement of both populations 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=195, North Fork average NOR+HOR=1,810; Table 3) and the hatchery fish retain the native profile of North Fork Nooksack early Chinook. Total natural escapement to the South Fork Nooksack is also higher (South Fork average NOR=51, South Fork average NOR+HOR=396; Table 3). However, most of the additional spawners are strays from the North Fork Nooksack population and do not retain the South Fork Nooksack early Chinook native profile and, therefore, likely do not provide the same buffer against risk.

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 2016 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). Returns in 2015 comprised primarily jacks likely due to poor ocean conditions. Approximately 400 spawners from the South Fork program were transported upstream in 2015 to augment naturally spawning Chinook. Few redds were observed perhaps due in part to the large number of pink salmon spawning concurrently and the large number of jacks in the supplemental spawners, so at this time it is unclear whether they were successful in spawning.

Productivity (recruits/parent spawners) is 0.6 for the North Fork and 1.6 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. 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 2008-2012 averaged 26% (total) and 5% (southern U.S. (SUS)) (Table 9), higher than the RER but below the SUS exploitation rate ceiling of 7% in place during that time. Eighty-two 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 37.1%, well above the RER for the management unit of 23%, although the exploitation rate in the proposed action area alone (Puget Sound) is expected to be very low, i.e., 4.9% (Table 15). Under the proposed action, 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 2016 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 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. Since 1997, there have been limited ceremonial and subsistence fisheries in the lower river in May. 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 2016 as part of the proposed action (Shaw 2016). The proposed extension of the in-river ceremonial and subsistence (C&S) fishery in 2016 to June 15 would rely on inseason monitoring and an assessment of impact to the population (Grayum 2016, Shaw 2016). Under the proposed action virtually all of the harvest on Nooksack early Chinook in SUS fisheries would occur in tribal treaty fisheries. If the proposed action were not to occur in 2016, we estimate that an additional 8 and 12 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 Alaskan and Canadian fisheries, outside U.S. jurisdiction. Under the proposed action, the exploitation rate on Nooksack early Chinook within the action area is expected to be very low (4.9%). The managers propose actions to minimize impacts to Nooksack early Chinook and past patterns indicate exploitation rates under the proposed action are likely to be lower than anticipated (Tables 9 and 14). Virtually all 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 2016 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 further constraints to fisheries occurring in 2016 would 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).

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). Productivity is 1.1 or more for eight 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, trends in 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 2008-2012 ranged between 18 and 50% (total) and 8 to 21% (SUS)(Table 9). About 50% of the harvest occurred in Alaska and Canadian fisheries.

In 2015, NMFS identified that the Skagit summer/fall management unit exceeded its exploitation rate objective in some recent years and, as discussed in section 2.4.1.1 were called out for further consideration. Estimates of total exploitation rate for Skagit summer/fall Chinook are available from 2003 to 2012 (Table 14). The exploitation rate ceiling of 50% was exceeded in three of

those ten years; first in 2007 and more substantially in 2009 and 2011 (Grayum and Unsworth 2015). Exploitation rates in the other years have generally been substantially less than 50% ranging from 34% to 46% (Table 14).

The 2015 performance assessment (Grayum and Unsworth 2015) concluded that overages in pre-terminal fisheries in Alaska and Canada contributed substantially to these deviations, but that overestimates in preseason forecasts contributed to target harvest rates in the Skagit River terminal net fisheries that were too high (Grayum and Unsworth 2015). The terminal fisheries are complicated as they must be divided between numerous fisheries implemented by three separate treaty tribes. Fisheries are therefore planned around expected catches (number of fish) for each fishery rather than using effort controls (e.g., time, area and gear type management) to achieve target harvest rates. When abundance turns out to be lower than expected preseason and catches are not reduced accordingly, harvest rates can be too high. The result of these management challenges has primarily been that the Lower Sauk summer Chinook population did not meet its low abundance threshold of 400 Chinook spawners.

Given the circumstances, remedies focused on improving preseason forecasts and evaluating possible inseason run size update tools. In response to higher than anticipated Chinook encounters inseason in tribal terminal fisheries, in 2015, tribal managers implemented Chinook non-retention measures, closed some fisheries and restructured other species fisheries to reduce Chinook encounters. Overall, catch and terminal harvest rates were lower and abundance higher in 2015 than anticipated preseason. Escapement for the Lower Sauk population in 2015 just exceeded its low abundance threshold (406). This outcome combined with similar preliminary results in 2013 and 2014 (Grayum and Unsworth 2015) is promising. However, continued monitoring of the fishery and post season reporting are required to ensure exploitation rate ceilings continue to be met, evaluate the efficacy of the new forecast model, and explore additional opportunities to improve management outcomes. Managers developed a new model for 2016 to improve accuracy and transparency of risk and to better account for the dynamic nature of preterminal fisheries in forecasting preseason abundance (Kairis et al. 2016, Ruff 2016).

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 2016. 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, Skagit summer/fall; representing six populations) and the North Fork Stillaguamish 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 South Fork Stillaguamish population and the populations in the Snohomish Management Unit are within 1.7% or less of meeting their RERs. The exploitation rates in 2016 Puget Sound fisheries are expected to be very low to low across the four management units (3.5%-11.2%)(Table 15). If the proposed action were not to occur in 2016, we estimate that an additional 5 natural-origin spawners would return to the South Fork Stillaguamish River and would not provide substantive

benefits by providing sufficient additional spawners to significantly change its status or trends from what would occur without the fisheries.

In summary, the effects of the proposed actions in 2016 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 well relative to abundance criteria and RERs, representing a diversity of healthy populations in the region as a whole. The stable escapement trends 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 by a small amount for the Snohomish Management Unit. In addition, the late life history type exhibited by the Snohomish populations is also represented by the Lower Skagit River which is expected to be well below its RER. 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 three 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 2). 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.

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.

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). When hatchery-origin spawners are taken into account, current average escapement for the Nisqually and White Rivers also exceeds their rebuilding thresholds. Productivity is 1.0 or more for four of the six populations (Table 3). Natural escapement trends are increasing or stable for four of the six populations (Table 4). Growth rates for recruitment and escapement are declining 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. These reductions have led to higher escapements than would otherwise have occurred. The combination of declining growth rates and a declining trend in natural escapement suggest that the Puyallup population may be at higher risk for survival and recovery than other populations in the region, at least over the longer term. However, total spawning escapement remains strong when compared to its rebuilding threshold (Table 3). Average observed exploitation rates during 2008-2012 ranged between 15 and 71% (total) and 13 to 55% (SUS)(Table 9), above the RERs for three of the five management units (Table 14). Overall, a larger proportion of the harvest of these populations occurs in SUS fisheries than for populations in other regions of Puget Sound; 14 to 56% 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 to provide greater assurance that the fisheries would meet the overall exploitation rate limit.

The post season estimates of total exploitation rate for Puyallup Chinook exceeded the exploitation rate ceiling of 50% every year from at least 2003 to 2010 and 2012 (Grayum and Unsworth 2015). 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. Managers have 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. In 2011, the total exploitation rate did not exceed the objective and the tribal net fishery also matched its preseason expected rate. Although total exploitation rate estimates are not available, from 2013 to 2015, post season estimates of terminal harvest rates were below preseason expectation. In 2016, tribal managers have reduced the 1 day of directed Chinook fishing from 12 hours to six. Continued implementation of these management actions in 2016 provide reasonable assurance that target terminal area harvest rates and likely the total exploitation rate objective will not be exceeded, but close monitoring and post season reporting will be required to assess compliance.

Estimates of total exploitation rate for Nisqually Chinook are available from 2003 to 2012. Target exploitation rates have been exceeded in all but one of these ten years. 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). 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). From 2010 to 2012 post season estimates of the total exploitation rate were two to three percentage points too high but harvest rate estimates for the terminal area net fisheries were over by 3.6% to 10.7%. Terminal harvest rates also exceeded preseason expectations in 2013 and 2014.

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. Post seasons estimates of terminal harvest rates in the gillnet fishery were at or below preseason expectations in 2011, 2012, and 2014. 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. Continued implementation of management actions for the gillnet fishery coupled with improved changes and closer monitoring of the tangle net fishery were intended to provide additional assurance that target terminal area harvest rates would not be exceeded in 2015. 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. Given this is a relatively new fishery, over time additional data and experience should result in more precision in terminal harvest rates for this fishery. Postseason assessment of the terminal harvest rate in the 2015 gillnet and C&S fishery met preseason expectations. The expected combined gillnet and tangle net terminal harvest rate for 2015 was 26 percent. The post-season preliminary combined terminal harvest rate estimate is 30 percent because of the greater than expected impacts in the tangle net fishery. The Nisqually Tribe does not propose implementing the tangle net fishery in 2016 (Bowhay 2016)

Natural-origin spawning escapements in 2016 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. 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 are positive for the Cedar, Sammamish and White River; negative for the Duwamish-Green, Puyallup and Nisqually populations. Growth rates for escapement reflect the same pattern except for the Nisqually which is stable. In response to

recent declines in escapements due to poor freshwater survival and unanticipated changes in spawning distribution, tribal managers have chosen to manage 2016 fisheries that impact the Green River population very conservatively as they investigate potential causes of the declines and consider whether changes in harvest strategy are appropriate (Grayum 2016). Although spawning escapement is anticipated to be above the level that would initiate the minimum fishing regime, the managers are proposing fisheries that are as restrictive as the minimum fishing regime for the Green River Chinook population, i.e., no Chinook directed fisheries, limiting pre-terminal fisheries, later start dates for fisheries directed on other species (Bowhay 2016, Grayum 2016). As a result, the total exploitation rate in 2016 is expected to be below its RER and the rate in Puget Sound fisheries is low (7.8%)(Table 15) indicating the risk to the population from the proposed action is low.

Exploitation rates in 2016 for three 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, Puyallup, and Nisqually) (Table 15). The Cedar, Sammamish and Puyallup populations are in PRA Tier 3 and the life histories of these populations are represented by other populations in the region. Exceeding the surrogate RERs for the Sammamish, Cedar, and Puyallup populations may result in some increased risk for the pace of adaptation of the local population. However, 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 2016 fisheries when hatchery spawners are taken into account. 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 2016 we estimate that an additional 17 natural-origin spawners would return to the Sammamish population. The number of recruits produced per spawner remains low indicating that habitat conditions are limiting the populations' ability to grow (Sammamish = 0.7, Puyallup = 1.1, Table 3). The low productivity of the watersheds given the much higher level of overall escapement (Tables 3 and 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 25.6% for a total exploitation rate of 48.8% for the 2016 fishing season (Table 15). This rate exceeds its surrogate RER of 33%. 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 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 to 50 percent in 2016 represents another step in a long term transitional strategy designed to reduce rates over time in concert with improvements in habitat and adjustments in hatchery operations (NCSMP 2011, Nisqually Watershed Council 2011, PSIT and WDFW 2010a, SSPS 2007, Turner 2016). The indigenous 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. Then again 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 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 2015c). 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. As part of the proposed action, the Puget Sound tribes have described a revised strategy based on the existing objectives and limiting factors (Grayum 2016). The new strategy no longer proposes controlling hatchery strays but emphasizes (1) maximizing the number of adult Chinook on the spawning grounds to spawn naturally in order to optimize future NOR abundances by managing to achieve at least 1,200 natural spawners; (2) continuing the integrated stepping stone program using 105 of the returning 2016 NOR spawners; (3) implementing a 50% exploitation rate ceiling and a low

abundance threshold of 700, and (4) a commitment to update the Nisqually Chinook Recovery Plan and Stock Management Plan to describe in more detail a revised long-term strategy and adaptive management plan for Nisqually Chinook that can be relied on in the future by the end of September 2016 (Grayum 2016).

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 managers are using a recovery framework developed by the Hatchery Science and Review Group (HSRG 2015, Troutt 2016a, Troutt 2016b) as the template for their new transitional strategy and many of the components listed in the previous paragraph are anticipated to be components of that 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. NMFS' concerns centered around: (1) alignment of the proposed harvest strategy with the existing hatchery approach, (2) application of the general guidance of the recovery framework to the specific circumstances of the Nisqually watershed, e.g., definition and basis for the escapement target to "optimize future NOR abundances", (3) the need for biologically based benchmarks and management actions for moving from one phase of the recovery framework or one interim management step to the next, (4) better understanding of the capacity, fish use and fish distribution of the Nisqually System, inclusive of the estuary and freshwater habitats from which benchmarks and objectives can be developed, (5) explanation of the need for and role of the stepping stone and integration hatchery programs given the intent of the approach is to maximize escapement into the system, (6) supporting analysis and documentation demonstrating that the proposed strategy will improve the VSP parameters over time to a level that supports the exploitation rate objective and harvest level, and (7) a detailed monitoring and adaptive management programs for key components of the strategy (Bishop 2016a, Bishop 2016b, James 2016b, Turner 2016).

After further discussion with NMFS, the managers decided to incrementally reduce the exploitation rate for Nisqually Chinook in 2016 from 52% to 50% to further reduce risk to the population while constructing the new transition strategy. The 2010 Puget Sound Chinook Harvest Plan on which the proposed BIA action is based included a final reduction to 47 percent for Nisqually Chinook that was to be implemented in 2014. The exploitation rate objective of 52 percent was implemented as an interim management objective in 2014 because of some complexities related to estimates of exploitation rates and until the primary harvest management model (FRAM) was updated²⁴ and because of challenges with implementation of the weir at the

²⁴ Analyses in 2013 concluded that exploitation rates predicted by FRAM during pre-season modeling result in lower rates when estimated using actual CWT recoveries; a more direct measure of exploitation rate (McHugh et al. 2013). Application of the results of this analysis indicated that the actual exploitation rate under the 56% exploitation rate objective implemented at the time (in 2013) was in fact already likely less than or equal to 47 percent. Based on the analytical results, NMFS agreed to consider the FRAM-based objective of 52% for 2014 as part of the proposed action. Work is currently ongoing to update the FRAM base period data which should ensure that fishery exploitation rates as estimated by FRAM are comparable to CWT-based estimates and to biologically

time (NMFS 2015c, Grayum and Anderson 2014). The RER surrogate for Nisqually Chinook is 33 percent (Table 13), consistent with the analysis in the Nisqually recovery plan (NCSMP 2011). NMFS' analysis indicates that a 52 percent exploitation rate without a revised transitional strategy in place would result in less than a 30 percent probability of recovery; less than half of the probability of recovery under the 33 percent exploitation rate. 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 the time, an incremental reduction in the exploitation rate beginning in 2016 is consistent with a gradual transition approach, provides an initial reduction in risk for the population and for a meaningful tribal fishery in 2016, and time to develop a substantive alternative transition strategy that addresses NMFS' concerns described above and 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 2016 is well above its critical threshold, and managers have further reduced the exploitation rate in 2016 to reduce risks while revising the necessary substantive long-term transitional strategy by September 2016. Therefore, the additional risks associated with exceeding the RER in the 2016 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 2016. Therefore, implementation of the proposed 2016 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

based exploitation rate ceilings. The ceiling of 47% will be re-instated as the management objective when the FRAM upgrade is complete (Redhorse 2014).

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 2016 Puget Sound fisheries would not measurably affect the risks to survival or recovery for either 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 2). 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 Hoodspout 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).

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 action in 2016 (Grayum 2016, Shaw 2016). 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 at least partially responsible for the recent increase in escapement observed in the Hamma Hamma River. From 2008 to 2012, on average 60% of the Chinook salmon spawning in the Hamma Hamma River were of hatchery origin (WDFW and PSTIT 2009; WDFW and PSTIT 2010, WDFW and PSTIT 2011, WDFW and PSTIT, 2012). 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 (Jones 2006, 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 2008-2012 were 25 and 59% 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 57 and 24% of the harvest of the Mid Hood Canal and Skokomish rivers populations (Table 9).

Under the proposed actions, escapement for the Skokomish population is expected to be below its critical threshold and the escapement for Mid-Hood Canal Rivers population is expected to be just above its critical threshold (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 2016 Puget Sound salmon fisheries under the proposed action is expected to be low (4.2%; Table 15). If Puget Sound salmon fisheries closed in 2016 we estimate that no additional spawners would return to the Mid-Hood Canal population but and approximately 150 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 2016 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 2016 under the proposed action from Puget Sound salmon fisheries is 26.2% with a total exploitation rate in 2016 of 44.8%. 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 33 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 consistently exceeded the management objective of 50% 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 2012 (Grayum and Unsworth 2015). The ceiling was exceeded each year from 2010 to 2012 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, 2014 and 2015. 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 18 days in 2015 including a three week closure during the peak of the Chinook run and reductions during the coho directed fishery to minimize Chinook by-catch. Additional actions were taken by restructuring the Skokomish River tribal net fishery for both Chinook and coho in time and area to better target hatchery-origin fish. Despite these changes, the terminal area harvest rate continues to exceed preseason projections resulting in a high likelihood of exceeding the exploitation rate objective (James 2016b). As was the case in 2014, the return in 2015 was substantially less than the preseason forecast and compounded by extremely poor marine survival conditions. The postseason estimate of terminal harvest rate was 31% compared to a preseason expectation of 21% for tribal net fisheries in the Skokomish River.

Work on improving abundance forecasts continues. In the interim, tribal managers will further restrict the fishery with one objective being greater certainty of meeting the harvest management objectives. Compared with 2015, the number of days during the Chinook management period in 2016 will be further reduced from 18 to 9 days with additional delays in the coho fishery. The lower Skokomish River will be closed during the Chinook management period and the coho fishery opening delayed a week later than in 2015 (Bowhay 2016, James 2016c). 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. Impacts on Skokomish River Chinook may be further minimized by reduced tribal fishing planned in adjacent marine areas. Changes proposed in the fishery for 2016 are substantial. The proposed action also includes close monitoring of the fishery and reporting are ensure these actions are effective in meeting the management objective.

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) that was initiated in 2014 and as discussed above, has been developed further as part of the proposed action in 2016. The plan for late-timed fall Chinook is an addendum to the draft Skokomish Recovery Plan (Skokomish and WDFW 2010) to complement the measures described there and for the 2008 settlement agreement as described previously. 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 rate for 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 2). 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). 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 by either population in terms of natural-origin production (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 2008-2012 were 41 and 40% (total) and 6 and 5% (SUS) for the Dungeness and Elwha River populations, respectively (Table 9), both well above the RERs (Table 13). However, eighty-five 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 (Tables 3 and 13). Total exploitation rates for both populations are expected to substantially exceed their RER surrogates and this is a concern given the challenges to the populations from other sectors. However, almost all of the harvest occurs outside the jurisdiction of the co-managers (Tables 9 and 15) and exploitation rates in 2016 Puget Sound salmon fisheries are expected to be less than 3% (Table 15). If Puget Sound salmon fisheries closed in 2016 we estimate that only an additional 1 and 2 natural-origin spawners would return to the Dungeness and Elwha escapements, respectively. Therefore, further constraints on 2016 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.

2.4.1.3 Effects on Critical Habitat

Critical habitat is located in many of the areas where the fisheries under the proposed action would occur. However, fishing activities will take place over relatively short time periods in any particular area. The PCEs 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 2015b) it is likely that fewer nets will become derelict in the upcoming 2016/17 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 2015b), 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 2016/2017 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.

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 action. The proposed action will not affect the ability of critical habitat to remain functional or to retain the current ability for the PCEs to become functionally established and to serve the intended conservation role for the species.

2.4.2 Puget Sound Steelhead

2.4.2.1 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 reinforced 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 at the time of listing to catches in more recent years and concluded that catch had declined by an average of 35% (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 57% (Table 11).

Available information continues to be quite 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) and reaffirmed the observation that harvest rates on natural-origin steelhead continue to decline and are unlikely to substantially affect the abundance and overall productivity 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 under the proposed action. Under the proposed action, the expected catch was characterized as the same as what occurred during the 2014/15 season. In this supplemental analysis, NMFS therefore also considered how the terminal harvest rates under the proposed

action compared to the rates at the time of listing and in more recent years, i.e., Do the terminal harvest rates under the proposed action continue to be low?

The proposed action includes all Puget Sound tribal marine and freshwater fisheries²⁵ directed at Chinook, chum, coho, pink, and sockeye salmon which encounter listed summer, winter, and summer/winter steelhead populations. The proposed action also includes Puget Sound non-treaty U.S. Fraser Panel fisheries implemented under the Pacific Salmon Treaty directed at sockeye and pink salmon. Tribal fisheries would be implemented from May 1, 2016 to April 30, 2017 in various salmon marine catch reporting areas (Areas) 4, 4B, 5, 6, 6C, 6D, 7, 7A, 7B, 7C, 7D, 8, 8A, 8D, 9A, 10, 10A, 10E, 11, 11A, 12, 12A, 12B, 12C, 12D, 13 and 13A-K (Figure 12) (Bowhay 2016). The proposed action also includes non-tribal salmon fisheries implemented under the U.S. Fraser Panel from May 1, 2016 up to August 30, 2016 in Areas 7 and 7A.

²⁵ Tribal ceremonial and subsistence and commercial net fisheries, which includes U.S. Fraser Panel fisheries implemented under the Pacific Salmon Treaty.

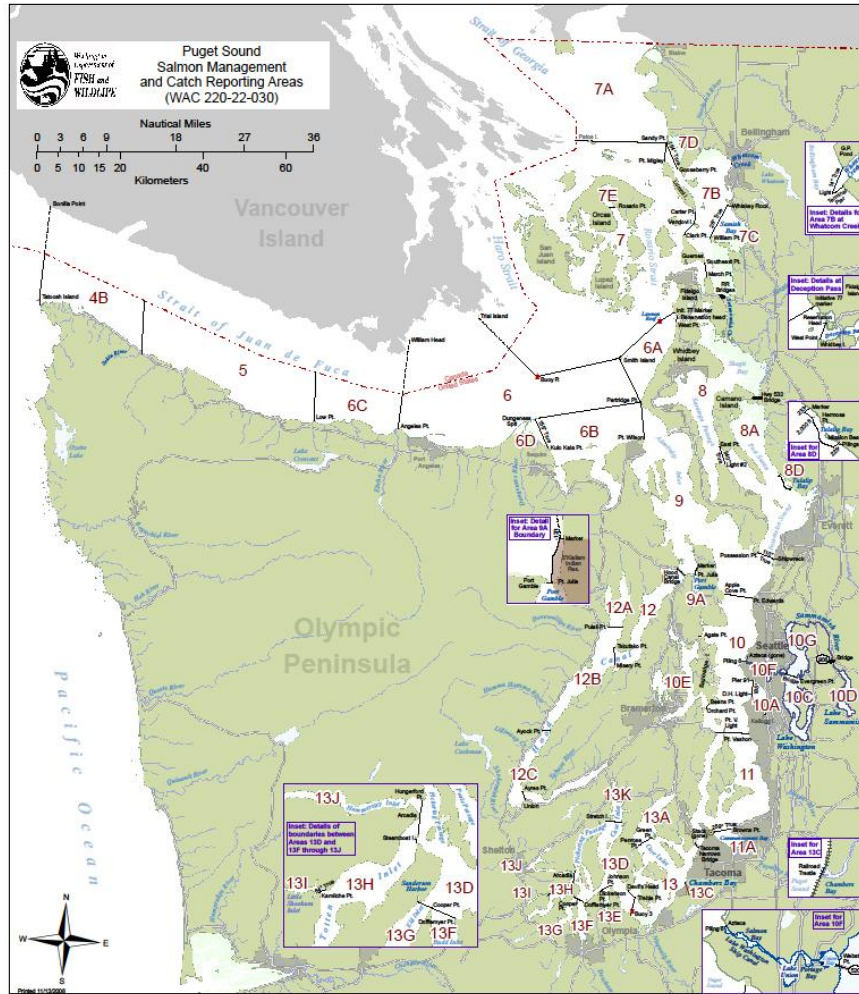


Figure 12. Puget Sound Commercial Salmon Management and Catch Reporting Areas (WAC 220-22-030).

2.4.2.2 Effects on Species

Marine Area Harvest Impacts

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 qualitative 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 caught in marine area fisheries. Nonetheless, it provides some useful perspective about the likely impact of marine area fisheries.

The expected catch of steelhead in marine area fisheries under the proposed action is 129 (Table 16). This compares to estimates of catch at the time of listing and in more recent years of 325 and 212 (Table 10). The resulting harvest rate is 0.58% ($129/22,361=0.0058$). This represents a very conservative (high) estimate of the actual harvest rate resulting from marine fisheries.

Table 16. 2014/15 tribal incidental catch and mortalities in marine and terminal fisheries, DIP escapement (where applicable), and harvest rates (pre-terminal marine areas calculated by DPS abundance and terminal freshwater areas calculated by DIP abundance) (WDFW and PSIT 2016).

Marine Area or Management Unit	Tribal Catch		DIP Escapement Estimate	Harvest Rate (%)	
	Total Encounters ¹	Total Mortality		DIP ²	DPS ³
<i>Marine and Adjacent Terminal Area Harvest Impacts</i>					
Total Marine & Adjacent Terminal Area Catch	205	129	--	--	0.58
<i>Terminal Area Harvest Impacts⁴</i>					
Skagit	173	77	8,644	0.89	--
Snohomish	8	1	2,914	0.03	--
Green	24	2	1,622	0.12	--
Puyallup	0	0	926	0.00	--
Nisqually	1	1	1,126	0.09	--
Total Tribal Terminal	206	81	15,232	1.14	--

Average Tribal Harvest Rate for Five Terminal Management Units⁵	0.23
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¹ Includes natural-origin and hatchery-origin listed and unlisted fish.

² Harvest rate is calculated by the percentage of the amount of total mortality based on the DIP escapement estimate for the 2014/15 fishery season (WDFW and PSIT 2016).

³ Harvest rate is calculated by the percentage the amount of total mortality based on the annual average abundance estimate of 22,361 for Puget Sound steelhead (NMFS 2015).

⁴ Terminal areas include the five management units analyzed at time of listing for Puget Sound steelhead: Skagit River, Snohomish River, Green River, Puyallup River, and Nisqually River winter-run steelhead.

⁵ Average tribal harvest rates calculated for five terminal management units; $1.137/5 = 0.227$.

Terminal Area Harvest Impacts

Under the proposed action, the expected catch was characterized as the same as what occurred during the 2014/15 season. In this supplemental analysis, NMFS therefore considers how the terminal harvest rates under the proposed action compared to the rates at the time of listing and in more recent years.

Skagit Management Unit

For the Skagit River, the total kelt²⁶ adjusted natural-origin harvest mortality in the steelhead-directed fishery, C&S fishery, test fishery and incidental mortality in the spring Chinook and sockeye fisheries was 77 fish from July 1, 2014 to June 30, 2015. A portion of the steelhead impacts in Skagit River are attributed to release mortalities from a tangle-net fishery.²⁷ Seventy-seven steelhead mortalities represent 0.89% of the total Skagit River steelhead natural-origin abundance of 8,644 during the 2014-15 fishery season (Table 16).

Snohomish Management Unit

For the Snohomish River, eight steelhead were encountered with one natural-origin steelhead mortality. One steelhead mortality represents 0.03% of the total Snohomish River natural-origin abundance of 2,914 during the 2014-15 fishery season (Table 16).

Green River Management Unit

A winter steelhead fishery in the Duwamish/Green River targeted at hatchery steelhead occurred from November 1, 2015 to December 31, 2015. Two natural-origin steelhead were incidentally harvested. Two steelhead mortalities represent 0.12% of the 1,622 total average natural-origin steelhead abundance in the Green River during the 2014-15 fishery season (Table 16).

Puyallup River Management Unit

A Puyallup tribal fishery directed at chum salmon occurred in November and December 2015. Incidental steelhead mortality was zero. The proposed action anticipates similar impacts for the 2016-17 fishery season. Therefore, no analysis is provided for incidental effects to steelhead in the Puyallup River chum fishery.

²⁶ A steelhead that has already spawned and typically moving out of the river system. An 8.6% kelt adjustment rate is used to determine overall impacts to Skagit River steelhead.

²⁷ An 18.5% release mortality rate is used for the Skagit River fishery.

Nisqually River Management Unit

The Nisqually tribal fishery directed at coho salmon occurred in November 2015. The Nisqually tribal fishery directed at winter chum salmon occurred from November 23, 2015 to December 29, 2015. Incidental steelhead mortality was one natural-origin steelhead combined in both the coho and winter chum salmon fisheries. One steelhead mortality represents a 0.09% terminal harvest rate based on the estimated Nisqually River steelhead escapement of 1,126 fish during the 2014-15 season (WDFW and PSIT 2016) (Table 16).

In summary, the expected average harvest rate in terminal area fisheries for the five index populations for the proposed action is 1.1% (Table 16). This compares to similar estimates at the time of listing and in more recent years of 4.2% and 1.8%, respectively (Table 11).

Summary

NMFS has previously reported that the catch of steelhead in marine and terminal area fisheries has declined. NMFS considers the effect of marine area fisheries by comparing expected catch under the proposed action to similar estimates at the time of listing and in more recent years, and by calculating a conservative estimate of the associated harvest rate. The expected catch under the proposed action is 129 compared to catches at the time of listing and in more recent years of 325 and 212. The associated harvest rate is 0.58%.

NMFS previously reported that average harvest rate from terminal area fisheries for five index populations averaged 4.2% at the time of listing and 1.8% in more recent year. Under the proposed action, the comparable average harvest rate for the five populations is 1.1%.

Steelhead Harvest Research

Two harvest research projects are proposed during the 2016-17 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.

Pacific Salmon Commission (PSC)

A PSC Chum Technical Committee has received funding from the Southern Endowment Fund (SEF) 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 2016 steelhead fishery season. The fall chum research proposal is summarize here and incorporated by reference (Van Will and Patton 2015).

The proposed study will use one purse seine vessel two days per week for five weeks during October and November in Area 5 (U.S. territory). There is the potential to encounter small numbers of non-listed and ESA-listed Puget Sound natural and hatchery steelhead during implementation of the study. Any steelhead encounters would be dip-netted from the purse seine and released alive while still in the water. Anticipated steelhead encounters would be no more than 10 steelhead, released in-water, alive with minimal handling (dip net).

Because steelhead encounters in pre-terminal areas such as Area 5 may be a combination of ESA-listed natural-origin, ESA-listed hatchery-origin, and non-listed natural-origin or hatchery-

origin steelhead and are not sampled for marks (Section 2.4.1), it is not possible at this time to assign harvest encounters to a specific population(s). 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. This research impact is considered to have very low negligible effects on natural-origin steelhead abundance, productivity, spatial structure, and diversity and is unlikely to impede the adjacent Hood Canal and Strait of Juan de Fuca MPG or the Puget Sound Steelhead DPS as a whole from reaching viability.

Muckleshoot Indian Tribe

The Muckleshoot Indian Tribe (MIT) proposes to implement a research test fishery to collect information on the feasibility and potential impacts of a directed ceremonial and subsistence and commercial warm water fishery in the Lake Washington Basin. The MIT warm water test fishery proposal is summarize here and incorporated by reference (MIT 2016).

The MIT proposed warm water test fishing study area is divided into five zones (Figure 13). The test fishery will occur during times and in places and using gear designed to avoid encountering steelhead (MIT 2016). Nonetheless the MIT warm water test fishery may impact up to three Puget Sound adult steelhead.

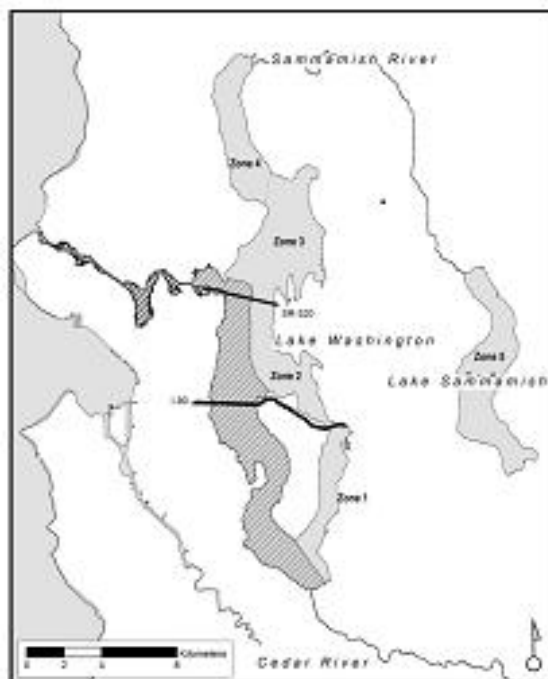


Figure 13. Muckleshoot Indian Tribe proposed warm water test fishery zones (1-5) and exclusion areas (cross-hatched) that will not be fished in order to minimize the potential for adult steelhead encounters (MIT 2016).

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 steelhead 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 17). No estimates were available for the North Lake Washington/Lake Sammamish winter-run DIP for the 2010-2014 time period.

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 Puget Sound steelhead. Based on steelhead abundance data from (NWFSC 2015), three steelhead is approximately 75% of the natural-origin abundance for the Cedar River winter-run DIP for the 2010-2014 time period resulting in potentially large negative effects to its abundance, productivity, spatial structure, and diversity. However, there is a very small to zero potential impact for this test fishery to interact with adult steelhead in Lake Washington (MIT 2016). Current data from the MIT suggests that natural-origin steelhead have already been extirpated from the Lake Washington watershed (MIT 2016).

The 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 steelhead is 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. Precautionary measures such as important exclusion zones, timing of the fishery, immediate reporting, careful release measures for encounters, and close research monitoring by Tribal 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 MIT warm water research test fishery proposal are largely negative on the population level, but these effects are considered rare and unlikely to prevent the Central and South Puget Sound MPG or the Puget Sound DPS as a whole from reaching viability.

Other studies resulting in Puget Sound steelhead encounters and mortality associated with harvest-related research and monitoring activities, which may be proposed before expiration of this biological opinion and have broader applicability to stock assessment, recovery planning, and harvest management (e.g., escapement estimates, stock composition, migration timing, etc.), will be evaluated under steelhead harvest research. As part of the proposed action, additional research that has broader applicability to stock assessment, recovery planning and harvest management may be authorized under this biological opinion if take does not exceed a level equivalent to a 1% harvest rate for any Puget Sound steelhead DIP, unless special circumstances allow for lower or higher impact rates.²⁸ Any special circumstances would be discussed by co-managers and NOAA Fisheries staff prior to implementation of any research study. If steelhead harvest research is proposed that is not previously described in this section before expiration of this biological opinion, co-managers will submit proposals to NOAA Fisheries to obtain authorization for monitoring and research studies under the 1% cap at least 30 days in advance of starting field work.

2.4.2.3 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 PCEs 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

²⁸ Special circumstances would be considered in light of the status and abundance levels of the individual Puget Sound steelhead DIPs.

resultant interference with fishing and potential loss of 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 (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 directly 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 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. The proposed actions will not affect the ability of critical habitat to remain functional or to retain the current ability for the PCEs to become functionally established and to serve the intended conservation role for the species.

2.4.3 Puget Sound/Georgia Basin Rockfish

We first assess the general effects of proposed fisheries on individual yelloweye rockfish, canary 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, canary rockfish, and bocaccio. The only areas within the ESA-listed rockfish DPS where hook and line fisheries may occur are in Area 6 (part of this area is outside of the rockfish DPS area) within the Strait of Juan de Fuca and limited C&S fisheries in Area 9. 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). There may be greater injury to listed rockfish caught by fishermen targeting salmon by trolling with downriggers/outriggers because the fish may not trigger the release mechanism and be dragged for a period of time prior to being reeled in.

Recent research has found that short term (48 hours) survival for recompressed yelloweye rockfish was 95.1 %, while 77.8% of canary rockfish survived (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 PFMC recently 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 (Supplemental GMT Report 2 2014).

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

We make the assumption that for the 2016/17 fishing season, ESA-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 and canary 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 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 fishermen targeting salmon that incidentally catch rockfish for us to partition mortality rates for each depth range, as done by the PFMC. To estimate mortalities

by fishermen 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 ESA-listed rockfish given that most fishermen may 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 tribal salmon fishers in the Puget Sound use purse seines and gill nets (PSIT and WDFW 2010a, Bowhay 2016). 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 much of 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, canary 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, canary rockfish and bocaccio are unlikely to be caught in beach seines because the seines are generally not used along kelp areas where juvenile canary rockfish, and bocaccio tend to be found in appreciable numbers (WDFW 2010). If adult or juvenile yelloweye rockfish, canary 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.

2.4.3.1 Bycatch Estimates and Effects on Abundance

Given the nature of the tribal salmon fisheries described above, we do not anticipate that any adult or juvenile yelloweye rockfish, canary rockfish, or bocaccio will be incidentally caught by actively fished nets. However, it is likely that some gill nets would become derelict gear near rockfish habitat and potentially kill some ESA-listed rockfish, though we are unable to quantify the number of fish killed from new derelict nets.

The limited hook and line fisheries in Areas 6 and 9 have the potential to catch listed rockfish but the number of fish caught, if any, would be a very small amount. We base this analysis on WDFW data for the recreational salmon fishing trips that have occurred in recent years. The WDFW has estimated listed rockfish caught by recreational anglers targeting salmon in the same areas as the tribal hook and line fisheries. The WDFW estimates vary, but range from 4 to 111 yelloweye rockfish, 18 to 312 canary rockfish, and 2 to 132 bocaccio annually caught by recreational anglers targeting salmon (WDFW 2011a; 2014b). For perspective, from 2010 to 2015 WDFW estimated there are approximately 415,000 recreational fishing trips targeting salmon annually within the Puget Sound (WDFW 2016). We do not know the number of anticipated tribal hook and line fishing trips in Puget Sound but the number is likely a fraction of the number of annual recreational trips. To be conservative – we assume that the number of fishing trips would be no more than 10% of the recreational fishing trips targeting salmon from 2010 to 2015, but the actual fraction of tribal hook and line trips will likely be much lower than this estimate because the proposed action is composed predominantly of harvest using nets. For simplicity and to err on the side on conservativeness, we also estimate that bycatch of listed rockfish is no more than 10% of the annual bycatch estimated in the recreational sector in recent years.

2.4.3.1.1 Yelloweye Rockfish

The average annual estimated bycatch of yelloweye rockfish from salmon anglers ranges from 4 (WDFW 2014b) to 111 (WDFW 2011a) fish. We estimate that no more than 10% of these bycatch rates would occur in the fisheries within the proposed action (0 to 11 yelloweye rockfish) (Table 19). These fish will be released, and using recent PFMC methodology we

estimate that 56% will 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	0	11 (6)	56%	40,000	0	0.015
				47,407	0	0.013

2.4.3.1.2 Canary rockfish

The average annual estimated bycatch of canary rockfish from salmon anglers ranges from 18 (WDFW 2015) to 312 (WDFW 2011a) fish. We estimate that no more than 10% of these bycatch rates would occur in the fisheries within the proposed action (2 to 17 canary rockfish) (Table 20). These fish will be released, and using recent PFMC methodology we estimate that 53% will likely perish from barotrauma and related hooking injuries and/or predation induced by injury.

Table 19. Canary 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)
Canary Rockfish	2 (1)	31 (17)	53%	15,000	0.0007	0.11
				20,548	0.0005	0.09

2.4.3.1.3 Bocaccio

The average annual estimated bycatch of canary rockfish from salmon anglers ranges from 2 (WDFW 2014b) to 132 (WDFW 2015) fish. We estimate that no more than 10% of these bycatch rates would occur in the fisheries within the proposed action (0 to 7 bocaccio) (Table 21). These fish will be released, and using recent PFMC methodology we estimate that 53% will 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	0	13 (7)	53%	3,000	0	0.2
				4,606	0	0.17

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, canary rockfish and

bocaccio killed by pre-existing derelict gear or new gear that would occur as part of commercial fisheries addressed in the proposed action. 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 2016/17 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, canary rockfish and bocaccio mortalities will occur from new derelict gill nets, and that any additional mortality would not induce additional risk to any population.

2.4.3.2 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, canary 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 canary rockfish and bocaccio, which are better able to recolonize habitats due to the propensity of some individuals to travel long distances.

2.4.3.3 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, canary rockfish, and bocaccio. The loss of fish that are reproductively mature, or nearly so, would hinder the demographic diversity (and productivity) of each species.

2.4.3.4 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 canary rockfish and bocaccio and critical habitat in some waters deeper than 98 feet (30 m) for each listed rockfish. For all three 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 action.

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 (Snohomish County MRC 2010). 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 14).



Figure 14. 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, canary 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 (Northwest Straits Initiative 2011), 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 2016/17 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 2015b), 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 six to 20 gill nets may be lost in the 2016/2017 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 canary rockfish and bocaccio), they would damage a fraction of the area proposed for listed rockfish and not degrade the overall condition of critical habitat.

2.4.4 Southern Resident Killer Whales

2.4.4.1 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, 2016-April 30, 2017 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, and 2015 biological opinions (NMFS 2011a, NMFS 2014, NMFS 2015) 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, 2016-April 30, 2017 fishing season is similar to the effects previously analyzed in the 2011, 2014, and 2015 biological opinions (NMFS 2011a, NMFS 2014a, NMFS 2015c), 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 years (Speaks 2014a, Shaw 2016, also see section 2.4.1.2); 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 pre-season Fishery Regulation and Assessment Model (FRAM)²⁹ run is 1,243,352 (compared to 1,431,940 in 2015), which is within the range of Chinook salmon abundance 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 2016 pre-season 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 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 2016 pre-season forecast of Canadian fall, coastal Washington fall, Puget Sound fall and Columbia River tule and bright stocks is 1.44 million (PFMC 2016; Table 1-1). We also note that the 2016 forecast of all Canadian and southern U.S. Chinook stocks within the migratory range of Southern Resident killer whales is 2.61 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 2016, using multiple abundance indices, is in the range of values analyzed in the previous opinions (NMFS 2011a, NMFS 2014a) and in the recent analysis (Ward et al. 2013).

Based on the previous analyses, the whale population is expected to grow during the period of the proposed fishing action, particularly if Chinook abundance is within the range of long-term

²⁹ 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.

averages as projected for 2016. Although the proposed action may result in a small decrease in the rate of growth of the population when compared to the growth rate without the action, the anticipated decrease in growth would be less than previously anticipated, 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 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.

2.4.4.2 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 2.4.4.1 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 PCE 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 2015c), and that they would not adversely modify their critical habitat.

2.5 Cumulative Effects

Cumulative effects” are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

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 2008g). 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 PCEs, 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.

2.6 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we will add the effects of the action (Section 2.4) to the environmental baseline (Section 2.3) and the

cumulative effects (Section 2.5), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species.

2.6.1 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 2.3.1 and 2.4.1. 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 22 which may help navigate the complexities of the narrative.

Both Chinook populations in the Georgia Basin Region are 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 very low (<5 percent), and our analysis indicates that further harvest reductions in 2016 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 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 or stable for both populations. The conservation hatchery programs are key components in recovery of the Nooksack early Chinook populations and should buffer demographic and genetic. 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 action are likely to be lower than anticipated.

For the Whidbey/Main Basin Region, the effects of the proposed actions in 2016 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 positive 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 by a small amount in 2016 for the Snoqualmie, Skykomish, and South Fork Stillaguamish populations. The Snoqualmie, Skykomish, and South Fork Stillaguamish populations are PRA Tier 2 and 3 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 2016 Puget Sound fisheries are expected to be very low to low across the four management units (3.5-11.2%)(Table 15). 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. In the Effects Section, NMFS evaluated observations that exploitation rate limits for Skagit summer/fall Chinook had been exceeded in some recent years. For 2003 to 2012 the exploitation ceiling of 50% was exceeded in three of ten years but in the other years was actually substantially less than the 50% ceiling ranging from 34% to 46%. Opportunities for reducing the deviation observed in terminal area fisheries that are part of this proposed action focus on forecasting and inseason update models. Since 2013, catch and terminal harvest rates were lower and abundance higher than anticipated preseason indicating the improvements may have been effective. The Skagit summer/fall populations are among the healthiest in the Region and it does not appear that the occasional management errors that have been observed have compromised the long term viability of the populations.

For the Central/South Sound Region, implementation of the proposed 2016 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). The Green and White River populations are expected to meet their RERs under the proposed actions indicating low risk of the proposed actions to those populations. Most populations in the region are doing well relative to abundance criteria (Table 22). Given the extirpated status of the indigenous Chinook population, the trend in overall escapements and growth rate for natural-origin escapement, the escapement anticipated in 2016, the further reduction in exploitation rate managers will take in 2016 to reduce risks while revising the necessary substantive long-term transitional strategy described in Section 2.4.1.2 (Central/South Sound Region), and the additional actions being taken by the co-managers as part of the proposed action described in Section 2.4.1.2, the additional risks associated with exceeding the RER in the 2016 fishing year should not impede the survival and recovery 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 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 natural-origin population has been extirpated, and potential improvement in natural-origin production is limited by the existing habitat. The population is not essential for recovery of the Puget Sound Chinook ESU (PRA Tier 3), and both the life history and Green River genetic legacy of the population are represented by other healthier populations in the Central/South Sound Region. 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). Actions taken in recent years in both the Puyallup and Nisqually and corresponding results provide reasonable assurance that the exploitation rate ceilings will not be exceeded in 2016. The tangle net fishery in the Nisqually is not planned for 2016; however, careful monitoring and post season reporting for the Puyallup and Nisqually fisheries will be required.

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 2016. Therefore, implementation of the proposed 2016 fisheries will meet the recovery plan guidance of 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 2016 Puget Sound fisheries would not measurably affect the risks to survival or recovery for either 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 2016 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 2016 is consistent with that trend, and the co-managers have proposed additional actions as part of the proposed action to bolster recovery of the population (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. Significant changes in management were made in 2013, 2014 and 2015 but were unsuccessful in achieving the terminal harvest rate objectives. More extensive measures are proposed for 2016, providing greater assurance that the management objective will be met in 2016. 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. The proposed action also includes close

monitoring of the fishery and reporting requirements to ensure management actions are effective in meeting the management objectives. Considering these factors, additional risks associated with exceeding the RER in 2016 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 2016. 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 and analysis suggests further harvest reductions in 2016 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 2016 fishing year for four of the 14 management units in the ESU (9 of 22 populations) are expected to be under their RER or RER surrogates (Table 22). Three more populations are close to their RERs. 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 2016 and stable or positive trends in escapement and growth rate alleviated concerns about additional risk (Skykomish, Snoqualmie, Cedar);
- (2) anticipated impacts from the proposed 2016 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 (South Fork Stillaguamish, Sammamish, Puyallup).

Fourteen of the 22 populations in the ESU are expected to exceed their critical thresholds and four of those are expected to exceed their rebuilding thresholds (Table 17). Eight populations are expected to be below their critical thresholds (North and South Fork Nooksack, North and South

Fork Stillaguamish, Sammamish, Skokomish, Dungeness, Elwha). For these populations, the fisheries would not meaningfully affect the persistence of the populations under the recovery strategies in place.

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 2016 are not likely to measurably affect the survival and recovery of the populations, progress in these areas should be closely watched given the status of the populations, potential long-term effects on survival and recovery suggested by modeling associated with the exploitation rate ceiling, and the recent year pattern of exceeding the exploitation rate ceiling. Continued adaptive management and implementation of the long term transition strategies in these watersheds together with the additional management measures described in the proposed action 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 limited 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.

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/2016)	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	Red	Red	Green	Yellow	Green		1
		S.F. Nooksack early	Red	Red	Green	Green	Green		1
Whidbey/Main Basin		Upper Skagit moderately early	Green	Green	Yellow	Red	Yellow	Green	1
		Lower Skagit late	Green	Yellow	Yellow	Red	Green		1
		Lower Sauk moderately early	Green	Yellow	Yellow	Red	Green		1
		Upper Sauk early	Green	Green	Green	Red	Yellow		1
		Suiattle very early	Green	Yellow	Yellow	Red	Yellow		1
		Upper Cascade moderately early	Green	Yellow	Green	Red	Yellow		1
		N.F. Stillaguamish early	Green	Green	Yellow	Red	Yellow	Green	2
		S.F. Stillaguamish moderately early	Red	Red	Red	Red	Green		2
		Skykomish late	Red	Yellow	Yellow	Red	Green		2
		Snoqualmie late	Red	Yellow	Yellow	Red	Green		3
South Sound		Sammamish	Red	Red	Yellow	Green	Green		3
		Cedar	Red	Yellow	Green	Green	Green		3
		Duwamish-Green	Green	Yellow	Red	Red	Green		2
		White	Green	Yellow	Green	Green	Yellow		1
		Puyallup	Red	Green	Red	Red	Red		3
		Nisqually	Red	Yellow	Green	Red	Red	Yellow	1
Hood Canal		Mid-Hood Canal	Red	Red	Yellow	Green	Green		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 and 12

³ Table 4

⁴ Described in text of Section 2.4.1.2 for each MPG in the ESU: Green=low, yellow=moderate, red=high

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 PCEs 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 action. 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 action 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 action to result in minimal additional impacts to these features although we cannot quantify those impacts because of their transitory nature.

2.6.2 Puget Sound Steelhead

ESA-listed steelhead are caught in tribal and non-tribal marine and freshwater fisheries in the proposed action 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 (Ford 2011, NWFSC 2015) and reaffirmed the observation that harvest rates on natural-origin steelhead continue to decline and are unlikely to substantially affect the abundance and overall productivity 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 reinforced 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 at the time of listing (325) to catches in more recent years (212) and concluded that catch had declined by an average of 35% (Table 10). The expected catch of steelhead in marine area fisheries under the proposed action is 129 (Table 16) thus confirming that catch continues to be low. To provide further perspective, NMFS then compared estimated catches under the proposed action to a conservative minimum estimate of the abundance of the Puget Sound steelhead DPS, thus providing an outside and very conservative (high) estimate of what the harvest rate of the marine fisheries could be. The resulting harvest rate was 0.58% ($129/22,361=0.0058$).

To assess the effects of terminal (freshwater) fisheries, NMFS compared the average harvest rates for a set of five index populations at the time of listing (4.2%) and more recent years (1.8%) and concluded that the average harvest rate had declined by 57% (Table 11). The expected average harvest rate for the five index populations under the proposed action is 1.1% (Table 16).

Impacts from tribal research test fisheries are anticipated to be 13 fish representing 0.06% of the total annual average abundance estimate of 22,361 for Puget Sound steelhead (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 action continue 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. The PCEs 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 PCEs. 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). 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. NMFS convened a technical recovery team to identify historic populations and develop viability criteria for a steelhead recovery plan. These reports are currently being finalized. 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 recovery plan is anticipated to be completed in 2019.

2.6.3 Puget Sound/Georgia Basin Rockfish

Bycatch in fisheries may be a primary limiting factor for listed-rockfish. As detailed in Section 2.3, Environmental Baseline, yelloweye rockfish, canary 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. However, 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.

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, canary 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 listed-rockfish.

To assess the population-level effects to yelloweye rockfish, canary rockfish, and bocaccio from the proposed salmon fisheries we calculated the range of total anticipated annual mortalities (Table 23).

Table 22. Estimated total annual 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	0 to 7	3,000	0 to 0.2
		4,606	0 to 0.17
Canary Rockfish	1 to 17	15,000	0.0007 to 0.11
		20,548	0.005 to 0.09
Yelloweye rockfish	0 to 6	40,000	0 to 0.015
		47,407	0 to 0.013

For yelloweye rockfish, canary 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) 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 and research mortality would be 4 percent. Lethal takes from the proposed salmon fisheries would be well below the precautionary level for each of the abundance scenarios.

Annual natural mortality rates for canary rockfish ranges from 6 to 9 percent (as detailed in Section 2.3.2) (Methot and Stewart 2005; Stewart 2007); thus, the precautionary level of fishing and research mortality would be 3 to 4.5 percent. Lethal takes from the proposed salmon fisheries would be well below the precautionary level 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. Lethal takes from the salmon fisheries in the DPS would be below the precautionary level for each of the abundance scenarios.

To assess the population-level effects to yelloweye rockfish, canary rockfish, and bocaccio from activities associated with the research permits within the environmental baseline, fishery take associated with the proposed action, and fishery take within the environmental baseline, we calculated the total mortalities for all sources (Table 24).

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 plus high estimate)	Abundance Scenario	Percent of DPS Killed (total lethal takes)
Bocaccio	101(+13)	61(+7)	3,000	2.2
			4,606	1.5
Canary rockfish	279(+31)	168(+17)	15,000	1.2
			20,548	0.9
Yelloweye rockfish	514(+11)	388(+6)	40,000	1.0
			47,407	0.8

Lethal takes are most relevant for viability analysis. For yelloweye rockfish, canary rockfish, and bocaccio, the takes from the salmon fishery, in addition to previously assessed lethal scientific research and fishery bycatch (detailed in Section 2.3, Environmental Baseline), would be within or below the 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.

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, canary rockfish and bocaccio killed by pre-existing derelict gear or new gear that would occur as part of commercial fisheries within the proposed action. Despite these data limitations, it is unlikely that mortality associated with derelict gear would cause mortality levels of yelloweye rockfish, canary 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 canary rockfish, and the endangered status of bocaccio in the Puget Sound/Georgia Basin DPS, we are evaluating within recovery planning 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, canary 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, canary rockfish, and bocaccio of the Puget Sound/Georgia Basin DPSs.

In spring of 2013, NMFS appointed a recovery team to assist in the development of a recovery plan for listed rockfish of the Puget Sound/Georgia Basin. The recovery plan will identify measures necessary to protect and restore degraded habitats, manage fisheries consistent with recovery, and prioritize research on data gaps regarding listed rockfish habitat usage and population parameters. A draft recovery plan is expected to be released for public review and comment in 2016. The ongoing recovery planning process, which includes state and tribal representatives, will identify protective measures to address impacts from all sources of bycatch. The increased use of descending devices is an important component of fisheries management, as well as studying the long-term survival of released rockfish. The recovery team is assessing the need for potentially establishing RCAs and will include a framework for these evaluations in the recovery plan.

In summary, the three listed DPSs are at risk with regard to 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 listed-rockfish can only be described qualitatively because the precise spatial and temporal impacts to populations of yelloweye rockfish, canary 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, canary rockfish and bocaccio occupy waters much deeper than surface waters fished by commercial nets, the bycatch of adults in commercial salmon fisheries is likely low to non-existent. However, new derelict gear is a source of potential incidental mortality. The recreational bycatch levels from the 2016/16 salmon fishery season, in combination with anticipated bycatch from other fisheries and research, their current status, the condition of the environmental baseline, and cumulative effects would not threaten the survival and recovery of yelloweye rockfish, canary rockfish and bocaccio. 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. Within this analysis, all of the calculated bycatch levels were well below the 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.

2.6.4 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 action 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) and NMFS (2014a) 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 2014 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 81 whales as of April 2015) 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. Recent analyses show a general decline in post-reproductive females and an increase in reproductive females since the beginning of the annual censuses. Although there has been an increase in reproductive females, the probability of a reproductive female between the ages of 21 to 27 giving birth has decreased over time.

As identified in the previous consultations, any direct effects on the whales from the fishing vessels, 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). Exploitation rates for the proposed fisheries will be comparable to or lower than exploitation

rates planned for the previous years (Speaks 2014a, Shaw 2016, also see section 2.4.1.2). The projected Chinook salmon abundance available to the whales as prey in 2016 (1,431,940 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. Corresponding impacts to Chinook salmon are also anticipated to be within the range of what was previously analyzed.

Based on the previous analyses, the whale population is expected to grow (at a slightly reduced rate) during the period of the proposed fishing action, because the Chinook abundance projected for 2016 is within the range of long-term averages. 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, however both the salmon analysis and modeling for the whales project out over longer time frames (25-30 years) and if the action were to continue into the future, similar to the one year action considered in this opinion, the conclusions would be the same. 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.

2.7 Conclusion

2.7.1 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 action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the Puget Sound Chinook salmon ESU or adversely modify its designated critical habitat.

2.7.2 Puget Sound Steelhead

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent

actions, and cumulative effects, it is NMFS' biological opinion that the proposed action is 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.

2.7.3 Puget Sound/Georgia Basin Rockfish

After reviewing the current status of yelloweye rockfish, canary rockfish and bocaccio within the Puget Sound/Georgia Basin DPSs, the environmental baseline for the action area, the effects of the proposed fisheries, 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.

2.7.4 Southern Resident Killer Whales

After reviewing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of Southern Resident killer whales or adversely modify its designated critical habitat

2.8 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 takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

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.

2.8.1 Amount or Extent of Take

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

2.8.1.1 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, 2016 through April 30, 2017 through contact with fishing gear. NMFS anticipates Puget Sound salmon fisheries occurring in 2016 together with ocean and Puget Sound fisheries approved under existing consultations will not exceed the exploitation rates summarized in Table 13 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 13. 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 action; (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.

2.8.1.2 Puget Sound Steelhead

NMFS anticipates incidental take to occur in Puget Sound tribal marine and freshwater commercial, and ceremonial and subsistence, and U.S. Fraser Panel non-tribal fisheries from May 1, 2016 through April 30, 2017 through contact with fishing gear.

NMFS anticipates that 129 steelhead will be killed in marine area fisheries as a result of the proposed (Section 2.4.2.2). Since not all catch is sampled for marks, this estimate includes an unknown proportion of listed natural-origin, and listed and unlisted natural and hatchery fish as well as both encounters and incidental mortality.

NMFS also anticipates that the average harvest rate on natural-origin steelhead in freshwater tribal fisheries targeting salmon and unlisted hatchery steelhead will be no more than 1.1%. 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). The 1.1% harvest rate is represents an average across the five winter steelhead populations; it is not an anticipated population specific freshwater harvest rate.

NMFS anticipates that no more than 13 steelhead incidental mortalities will occur in tribal research test fisheries May 1, 2016 through April 30, 2017.

2.8.1.3 Puget Sound/Georgia Basin Rockfish

NMFS anticipates that incidental take of ESA listed rockfish will 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 6 yelloweye rockfish, 17 canary rockfish and 7 bocaccio will be killed as bycatch in commercial anglers during the 2016/2017 Puget Sound salmon fishing season that is the subject of this opinion. NMFS anticipates that some minimal

take of listed-rockfish will 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 listed-rockfish. Estimating the specific number of 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 the tribal and U.S. Fraser Panel fisheries that are subject of this opinion also track derelict nets through their reporting system and partnership with the Northwest Straits Initiative.

2.8.1.4 Southern Resident Killer Whales

The harvest of Chinook salmon that would occur under the proposed action 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 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 (Table 1 in Appendix A of NMFS 2011a; No Action FRAM abundance w/ 6.6% reduction in abundance from proposed fisheries: 873,766 – 1,747,166 Chinook).

2.8.2 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 action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.8.3 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).

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 2.4.1.2 and 2.4.2.2) and defined in Section 2.9.1.
- (2) Catch and other management measures used to control fisheries shall be monitored using best available measures.
- (3) The fisheries shall be sampled for stock composition and other biological information.
- (4) Post season reports shall be provided of take on listed salmon and steelhead in the proposed fisheries.
- (5) Escapement monitoring for the salmon and steelhead population that are affected by the proposed action shall be improved using available resources.
- (6) A revised long-term strategy and adaptive management plan shall be developed for Nisqually Chinook by the end of September 2016.

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 action 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 measure is 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.

2.8.4 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 this incidental take statement (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 action would likely lapse.

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

- 1a. Work with the Puget Sound treaty tribes and U.S. Fraser Panel to ensure that preseason, and 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 to complete preseason annual steelhead fishing plans for all populations (where data are available) as described in Section 2.4.2.2 prior to implementation of the following steelhead fishing season no later than December 15, 2016. 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 2.8.1.2.

- 1c. In cooperation with the Puget Sound treaty tribes and WDFW as appropriate, ensure that commercial fishers report the loss of any fishing gear within 24 hours of its loss to appropriate authorities.³⁰
2. 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.
3. Work with the Puget Sound treaty tribes 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 2016 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.
- 4a. Work with the affected tribes to provide post season reports that include estimates of catch and encounters of listed Chinook in the fisheries that are the subject of this opinion and other relevant information described in Section 7.5 in the 2010 Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2010a). The reports will also include escapement estimates for the populations affected by this proposed action and the results of the work described in reasonable and prudent alternative 3.
- 4b. Work with the affected treaty tribes, in cooperation with WDFW, to provide postseason annual reports for the 2016-17 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, 2016 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;

30 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.

- 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.
- 5a. 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 action to improve escapement estimation and to determine and/or augment harvest rate estimates on natural-origin stocks.
- 5b. 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.
- 6. The Nisqually Tribe committed as part of the proposed action 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 the end of September 2016 (Grayum 2016). In doing so, managers propose using the HSRG's recovery framework (HSRG 2015) as the template for revising the strategy (Troutt 2016a, Troutt 2016b). 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 2.4.1.2:
 - (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.
 - (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) For the stepping stone/integrated hatchery programs:
 - a. In the context of the HSRG framework, define the role and benchmarks for the programs for each phase of recovery.
 - b. 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
 - c. 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.
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 implement all conservation measures that are part of the proposed action in a timely manner, as specified by the time line for completion in the conservation measures.
 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.

2.9 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02). 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) In 2015 the co-managers provided a Management Performance Assessment for four of the 22 Puget Sound Chinook populations that had an apparent pattern of exceeding their exploitation rate ceilings (Skagit summer/fall, Puyallup, Nisqually, and Skokomish Chinook). The report reviewed past performance and identified factors that contributed to the observed overages and remedial actions to address them (Graham and Unsworth 2015). In 2016, the tribes in collaboration with WDFW provided a draft report that assessed the efficacy of these actions in terms of 2015 postseason performance for these four populations (James 2016). The results of both reports were considered in the above opinion. Performance improved in several areas although deviations from preseason abundance expectations still present challenges for terminal area management 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, 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.

2.10 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.

2.11 “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. 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 primary constituent elements (PCEs) 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) 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).

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 action 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 action.

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 2015b) it is likely that fewer nets will become derelict in the upcoming 2016/17 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 2015b), 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 six to 20 gill nets may be lost in the 2016/2017 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 action 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 action 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 maximum sustained yield (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 action 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 one acre 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 EFH

The proposed action 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 measures for salmon EFH because the proposed action 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 action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH conservation recommendations (50 CFR 600.920(l)).

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the biological opinion addresses these DQA components, documents compliance with the DQA, and certifies that this biological 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. The agencies, applicants, and the American public will benefit from the consultation. Individual copies of this opinion were provided to the BIA 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 contain more background on information sources and quality.

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

Review Process: This consultation was drafted by NMFS staff with training in ESA and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5. REFERENCES

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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 tle 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 RET⁴)), 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

⁴ Also referred to in previous opinions as the Upper Escapement Threshold.

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 levels⁵ and a moderate to high likelihood that a majority of populations would achieve their 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 action against the baseline condition, and require that the proposed action 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.

⁵ The Biological Requirements Work Group defined these as levels below which uncertainties about processes or 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.

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* (McElhany et al. 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,⁶ and \mathbf{e} is a vector of environmental, density-independent indicators of annual survival.

⁶ Equivalently, this could be termed "potential spawners" because it represents the number of fish that would return to spawn absent harvest-related mortality.

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). 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-variates. Equations for the three models are as follows:

$$R = (aSe^{-bS})(M^c e^{dF}) \quad \text{[Ricker]}$$

$$R = (S/[bS + a])(M^c e^{dF}) \quad \text{[Beverton-Holt]}$$

$$R = (\min[aS, b])(M^c e^{dF}) \quad \text{[hockey stick]}$$

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.⁷ 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%

⁷ 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.

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 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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