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

Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2019-2020 Puget Sound Chinook Harvest Plan, Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service, and Fisheries Authorized by the U.S. Fraser Panel in 2019

NMFS Consultation Number: WCR-2019-00381

Action Agency: Bureau of Indian Affairs (BIA)
United States Fish and Wildlife Service (USFWS)
National Marine Fisheries Service (NMFS)

Affected Species and NMFS' Determinations:

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

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

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

Issued by: ______________________________

Ryan Wulff
Acting Assistant Regional Administrator
Sustainable Fisheries Division

Date: **May 3, 2019** (***Date expires: April 30, 2020***)

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ACOE	ARMY CORPS OF ENGINEERS
B.C.	BRITISH COLUMBIA
BIA	BUREAU OF INDIAN AFFAIRS
BO	BIOLOGICAL OPINION
BRT	BIOLOGICAL REVIEW TEAM
C&S	CEREMONIAL AND SUBSISTENCE
CA	CALIFORNIA
CHART	CRITICAL HABITAT ANALYTICAL REVIEW TEAM
CM	CENTIMETERS
CNP	CENTRAL NORTH PACIFIC
CO2	CARBON DIOXIDE
CPUE	CATCH PER UNIT EFFORT
CWT	CODED WIRE TAG
DB	DECIBELS
DDT	DICHLORODIPHENYLTRICHLOROETHANE
DFO	DEPARTMENT OF FISHERIES AND OCEANS
DIP	DEMOGRAPHICALLY INDEPENDENT POPULATION
DNA	DEOXYRIBONUCLEIC ACID
DPER	DAILY ENERGY PREY REQUIREMENT
DPS	DISTINCT POPULATION SEGMENT
DTAGS	DIGITAL ACOUSTIC RECORDING TAGS
E	ENDANGERED
EFH	ESSENTIAL FISH HABITAT
ER	EXPLOITATION RATES
ESA	ENDANGERED SPECIES ACT
ESCA	ENDANGERED SPECIES CONSERVATION ACT
ESS	EARLY SUMMER-RUN STEELHEAD

ESU	Evolutionarily Significant Unit
EWS	Early Winter Steelhead
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
FR	Federal Regulation
FRAM	Fishery Regulation Assessment Model
GB	Georgia Basin
GSI	Genetic Stock Identification
HCSMP	Hood Canal Salmon Management Plan
HGMP	Hatchery and Genetic Management Plan
HOR	Hatchery-Origin
HPA	Hydraulic Project Approval
HR	Harvest Rate
HUC5	Fifth-Field Hydrologic Unit Code
ITP	Incidental Take Permit
ITS	Incidental Take Statement
kcal	kilocalorie
kg	kilogram
kHz	kiloHertz
LOAF	List of Agreed Fisheries
LOF	List of Fisheries
LWSC	Lake Washington Ship Canal
m	Meters
M/SI	Mortality and Serious Injury
MA	Marine Area
MIT	Muckleshoot Indian Tribe
MMAP	Marine Mammal Authorization Program
MMPA	Marine Mammal Protection Act
MPG	Major Population Group
MSA	Magnuson-Stevens Fishery Conservation and Management Act

MSY	Maximum Sustainable Yield
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOR	Natural-Origin
NPFMC	North Pacific Fisheries Management Council
NRC	Natural Resource Consultants
NRCS	Natural Resources Conservation Service
NWFSC	Northwest Fishery Science Center
OA	Ocean Acidification
OR	Oregon
PAH	Polycyclic Aromatic Hydrocarbon
PBDEs	polybrominated diphenyl ethers
PBFs	Physical or Biological Features
PBR	Potential Biological Removal
PCBs	polychlorinated biphenyls
PCE	Primary Constituent Element
PDO	Pacific Decadal Oscillation
PFMC	Pacific Fishery Management Council
Plan	2019-2020 Puget Sound Chinook Harvest Plan
POP	Persistent Organic Pollutant
ppb	Parts per Billion
PRA	Population Recovery Approach
PS	Puget Sound
PSIT	Puget Sound Treaty Indian Tribes
PSSMP	Puget Sound Salmon and Steelhead Management Plan
PSSTRT	Puget Sound Steelhead Technical Recovery Team
PST	Pacific Salmon Treaty
PSTRT	Puget Sound Technical Recovery Team
PVA	Population Viability Analysis
QET	Quasi-extinction Threshold
RAAMF	Risk Assessment and Adaptive Management Framework

RCA	Rockfish Conservation Area
RCW	Revised Code of Washington
RERs	Rebuilding Exploitation Rates
RMP	Resource Management Plan
ROV	Remotely Operated Vehicle
RPA	Reasonable and Prudent Alternative
SAR	Stock Assessment Report
SBC	Southern British Columbia
SEAK	Southeast Alaska
SJF	Strait of Juan de Fuca
SRKW	Southern Resident Killer Whale
SSPS	Shared Strategy for Puget Sound
SUS	Southern United States
SWFSC	Southwest Fishery Science Center
T	Threatened
TRT	Technical Recovery Team
TTS	Temporary Threshold Shifts
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VRAP	Viable Risk Assessment Procedure
VSP	Viable Salmonid Populations
WA	Washington
WCVI	West Coast Vancouver Island
WDFW	Washington Department of Fish and Wildlife
WNP	Western North Pacific
mPa	Micropascal

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

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available through the NOAA Institutional Repository (https://repository.library.noaa.gov/), after approximately two weeks. A complete record of this consultation is on file at the Seattle NMFS West Coast Regional office.

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

(1) The BIA's authority to assist with the development and implementation of the co-managers 2019-2020 Plan as reflected in BIA's April 24, 2019 request for consultation to NMFS and BIA's Environmental Assessment.

(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, 2019-April 30, 2020.

(3) Two actions associated with the management of the 2019 U. S. Fraser Panel sockeye and pink fisheries under the Pacific Salmon Treaty (PST):
    (a) the U.S. government's relinquishment of regulatory control to the bilateral Fraser Panel within specified time periods and,
    (b) the issuance of orders by the Secretary of Commerce that establish fishing times and areas consistent with the in-season implementing regulations of the U.S. Fraser River Panel. This regulatory authority has been delegated to the Regional Administrator of NMFS' West Coast Region.

NMFS is grouping these proposed Federal actions in this consultation pursuant to 50 Code of Federal Regulations (CFR) 402.14(c) because they are similar actions occurring within the same geographical area. Puget Sound non-treaty salmon fisheries and related enforcement, research, and monitoring projects associated with fisheries other than those governed by the U.S. Fraser Panel, are included as interrelated and interdependent actions, because the state of Washington and the Puget Sound treaty tribes have submitted a joint proposal for management of the 2019-2020 Puget Sound salmon fisheries, as provided under the Puget Sound Salmon Management Plan, implementation plan for *U.S. v Washington* (see 384 F. Supp. 312 (W.D. Wash. 1974)).

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

1.2 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, commercial, ceremonial, subsistence and take-home 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 2011a). NMFS consulted under ESA section 7 and issued biological opinions on its 4(d) determinations on each of these RMPs, BIA program oversight and USFWS Hood Canal Salmon Plan-related actions. Since the most recent RMP expired in 2014, NMFS has consulted under section 7 of the ESA on single year actions by the BIA, USFWS and NMFS similar to those described above. The consultations considered the effects of Puget Sound salmon fisheries on listed species based on the general management framework described in the 2010-2014 RMP as amended to address year-specific stock management issues. NMFS issued one-year biological opinions for the 2014, 2015, 2016, 2017 and 2018 fishery cycles (May 1, 2014 through April 30, 2019) that considered BIA's, USFWS', and NMFS' actions related to the planning and authorization of the Puget Sound fisheries based on the 2010-2014 RMP framework (NMFS 2014b; 2015c; 2016c; 2017b; 2018b). In each of these biological opinions NMFS concluded that the proposed fisheries were not likely to jeopardize the continued existence of listed Puget Sound Chinook salmon, Southern Resident killer whales, Puget Sound steelhead, Puget Sound/Georgia Basin Boccaccio and Puget Sound/Georgia Basin yelloweye rockfish. NMFS is currently reviewing a new RMP submitted in December 2017 for consideration under Limit 6 of the ESA 4(d) Rule and the National Environmental Policy Act but that review is not yet complete. For 2019, NMFS will complete a one-year consultation under section 7 of the ESA on the effects of Puget Sound salmon fisheries on ESA listed species.

On April 24, 2019, the BIA formally requested consultation, regarding its role in providing assistance to the Treaty Tribes and pursuant to obligations in *United States v. Washington*, on the co-manager jointly-submitted 2019-2020 Puget Sound Chinook Harvest Plan, as described in (Norton 2019). The request included a plan produced by the state of Washington and the Puget Sound Treaty Tribes, as an amendment to the 2010 Puget Sound RMP, for the proposed 2019-2020 Puget Sound salmon and steelhead fisheries, along with several additional management and technical documents supporting the plan (See section 1.3). This plan describes the framework within which the tribal and state jurisdictions jointly manage all recreational, commercial, ceremonial, subsistence and take-home salmon fisheries, and considers the total fishery-related impacts on Puget Sound Chinook Salmon from trout/char-, spiny-ray, and hatchery steelhead-directed fisheries within the greater Puget Sound area.

This opinion is based on information provided in the letter from the BIA requesting consultation to NMFS and associated documents provided with the consultation request (Norton 2019), the Environmental Assessment on the 2019 Puget Sound Chinook Harvest Plan (Norton 2019), 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.

As noted above, for a number of species affected by the Puget Sound salmon fisheries we have completed long-term biological opinions or 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, effects of the fisheries on those species are not analyzed in this opinion.

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

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

* Focus is fisheries under Pacific Fishery Management Council (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 Federal Action

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.2). Under the MSA Essential Fish Habitat consultation, Federal Action means any action authorized funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910). The actions that are subject of this opinion require consultation with NMFS because Federal agencies (BIA, USFWS, NMFS) are authorizing, funding, or carrying out actions that may adversely affect listed species (section 7(a)(2) of the ESA). NMFS is grouping these three proposed Federal actions in this consultation pursuant to 50 CFR 402.14 (c) because they are similar actions occurring within the same geographical area.

***BIA**:* The BIA has requested consultation on its authority to assist with the development and implementation of the co-managers 2019-2020 Puget Sound Chinook Harvest Plan (Plan) occurring from May 1, 2019 through April 30, 2020 as reflected in BIA's April 24, 2019request for consultation to NMFS and BIA's Environmental Assessment (Norton 2019). The Plan encompasses:

- the information and commitments of the 2010-2014 Puget Sound Salmon RMP as amended by the Summary of Modifications to Management Objectives of the 2010 Puget Sound Chinook Harvest Management Plan for the 2019-2020 Season;
- the 2019-2020 LOAF, which provides specific details about individual anticipated fisheries by location, gear, time and management entity;
- an addendum related to on-going management of the late-timed fall Chinook hatchery program in the Skokomish River; Stock Management Plan for the Nisqually Fall Chinook Recovery
- Stock Management Plan for the Nisqually Fall Chinook Recovery
- 2019 Green River Management actions,
- 2019 Puyallup River Management actions;
- a description of actions to be taken in the WDFW managed fishery season for 2019-2020 beneficial for Southern Resident Killer Whales;
- a summary assessment of the tribal salmon fishing impacts associated with the proposed 2019-20 Puget Sound Chinook Harvest Plan on Southern Resident killer whales
- the co-managers' anticipated steelhead impacts,
- Pacific Salmon Commission, Chum Technical Committee genetic stock composition research study;
- Piscivorous predator removal fishery and research study (Muckleshoot Tribe), and;
- Piscivorous predator assessment research study (WDFW).
- Nooksack early Chinook telemetry research study (Lummi Tribe)

The BIA is the lead federal action agency on this consultation.

USFWS:
The USFWS proposes to authorize fisheries that are consistent with the implementation of the Hood Canal Salmon Management Plan (Hood Canal Salmon Management Plan 1986) from May 1, 2019 through April 30, 2020. 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, 2019 through April 30, 2020 (see Norton (2019) for fisheries proposed to occur during this period).

NMFS:
The Fraser Panel controls sockeye and pink fisheries conducted in the Strait of Juan de Fuca and San Juan Island regions in the U.S., the southern Georgia Strait in the U.S. and Canada, and the Fraser River in Canada, and certain high seas and territorial waters westward from the western

coasts of Canada and the U.S. between 48 and 49 degrees N. latitude. The Fraser Panel assumes control of fisheries in these waters 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 late 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 target Fraser River-origin sockeye and, in odd-numbered years (e.g., 2013, 2015, 2017, 2019), Fraser River pink salmon. Other salmon species are caught incidentally in these fisheries. The U.S. Fraser Panel fisheries are managed in-season to meet the objectives described in Chapter 4 of the PST (the Fraser Annex). The season structure and catches are modified in-season in response to changes in projected salmon abundance, fishing effort or environmental conditions in order to assure achievement of the management objectives, and in consideration of safety concerns. U.S. Fraser Panel fisheries are also managed together with the suite of other Puget Sound and Pacific Fisheries Management Council (PFMC) fisheries to meet conservation and harvest management objectives for Chinook, coho, and chum salmon.

Two Federal actions will be taken during the 2019 fishing season (May 1, 2019 – April 30, 2020) to allow the Fraser Panel to manage Fraser River sockeye and pink fisheries in Fraser Panel Waters. One action grants regulatory control of the Fraser Panel Area Waters by the U.S. and Canadian governments to the Panel for in-season management. The other action is the issuance of in-season orders by NMFS that give effect to Fraser Panel actions in the U.S. portion of the Fraser Panel Area. The Pacific Salmon Treaty Act of 1985 (16 U.S.C. 3631 et seq.) grants to the Secretary of Commerce authority to issue regulations implementing the Pacific Salmon Treaty. Implementing regulations at 50 CFR 300.97 authorize the Secretary to issue orders that establish fishing times and areas consistent with the annual Pacific Salmon Commission regime and in-season orders of the Fraser River Panel. This authority has been delegated to the Regional Administrator of NMFS' West Coast Region.

Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration (50 CFR 402.02). Puget Sound non-treaty salmon fisheries and related enforcement, research and monitoring projects associated with fisheries other than those governed by the U.S. Fraser Panel, are included as interrelated and interdependent actions, because the state of Washington and the Puget Sound treaty tribes have submitted a joint proposal for management of the 2019-2020 Puget Sound salmon fisheries, as provided under the Puget Sound Salmon Management Plan, implementation plan for *U.S. v Washington* (see 384 F. Supp. 312 (W.D. Wash. 1974)). (50 CFR 402.02).

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

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

This opinion considers impacts of the proposed actions under the ESA on the Puget Sound Chinook salmon ESU, the Puget Sound Steelhead DPS, the Southern Resident killer whale DPS, the Mexico DPS of humpback whales, the Central America DPS of humpback whales, and the Puget Sound/Georgia Basin bocaccio and yelloweye rockfish DPSs. The NMFS concluded that the proposed actions are not likely to adversely affect southern green sturgeon, southern eulachon, or their critical habitat. Those findings are documented in the "Not Likely to Adversely Affect" Determinations section (2.12).

2.1 Analytical Approach

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

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

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

In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

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

- *Identify the rangewide status of the species and critical habitat likely to be adversely affected by the proposed action.* Section 2.2 describes the current status of each listed species and its critical habitat relative to the conditions needed for recovery. For listed salmon and steelhead, NMFS has developed specific guidance for analyzing the status of the listed species' component populations in a "viable salmonid populations" paper (VSP; McElhany et al. 2000). Similar criteria are used to analyze the status of ESA-listed rockfish because these parameters are applicable for a wide variety of species. The VSP approach considers the abundance, productivity, spatial structure, and diversity of each population as part of the overall review of a species' status. For listed salmon and steelhead, the VSP criteria therefore encompass the species' "reproduction, numbers, or distribution" (50 CFR 402.02). In describing the rangewide status of listed species, we rely on viability assessments and criteria in technical recovery team documents and recovery plans, and other information where available, that describe how VSP criteria are applied to specific populations, major population groups, and species. We determine the rangewide status of critical habitat by examining the condition of its physical or biological features (also called "primary constituent elements" or PBFs in some designations) which were identified when the critical habitat was designated.
- *Describe the environmental baseline in the action area.* The environmental baseline (Section 2.3 and 2.4) includes the past and present impacts of Federal, state, or private actions and other human activities <u>in the action area</u>. 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 2.5), 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 2.6), as defined in our implementing regulations (50 CFR 402.02), are the effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area. Future Federal actions that are unrelated to the proposed action are not considered because they require separate section 7 consultation.
- *Integrate and synthesize the above factors* by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat. (Section 2.7).

- *Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.* These conclusions (Section 2.8) flow from the logic and rationale presented in the Integration and Synthesis section (2.7).
- *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 2.9. The RPA must not be likely to jeopardize the continued existence of listed species nor adversely modify their designated critical habitat and it must meet other regulatory requirements.

2.2 Range-wide Status of the Species and Critical Habitat

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

2.2.1 Status of Listed Species

Climate change and other ecosystem effects

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

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 likely affected by climate change, both in their freshwater and marine habitat. 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 0.1-0.6ºC 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 salmon and 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[1]. 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

[1] Long Live the Kings 2015: http://marinesurvivalproject.com/the-project/why/

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.

The Northwest Fishery Science Center (NWFSC 2015) 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 Oscillation[2] is anticipated to continue. This and other similar environmental indicators suggest the continuation of warming ocean temperatures; fragmented or degraded freshwater spawning and rearing habitat; reduced snowpack; altered hydrographs producing reduced summer river flows and warmer water; and low marine survival for salmonids in the Salish Sea (NWFSC 2015). Specifically, the exceptionally warm marine water conditions in 2014 and 2015 combined with warm freshwater stream temperatures lowered steelhead marine and freshwater survival (NWFSC 2015) in the most recent years. Any rebound in VSP parameters for Puget Sound steelhead are likely to be constrained under these conditions (NWFSC 2015).

The potential impacts of climate and oceanographic change on Southern Resident killer whales and humpback whales will likely affect habitat availability and food availability. Site selection for migration, feeding, and breeding may be influenced by factors such as ocean currents and water temperature. Any changes in these factors could render currently used habitat areas unsuitable. Changes to climate and oceanographic processes may also lead to decreased prey productivity and different patterns of prey distribution and availability. Different species of marine mammals will likely react to these changes differently. For example, range size, location, and whether or not specific range areas are used for different life history activities (e.g. feeding, breeding) are likely to affect how each species responds to climate change (Learmonth et al. 2006). 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; Department of Fish and Oceans 2010; Jeffries 2011; Chasco et al. 2017a). In addition to predation by marine mammals, Fresh (1997) reported that 33 fish species and 13 bird species are predators of juvenile and adult salmon, particularly during freshwater rearing and migration stages.

2.2.1.1 Status of Puget Sound Chinook

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability

[2] A positive pattern in the Pacific Decadal Oscillation (PDO) has been in place since 2014.

of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (McElhany et al. 2000). These 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 deoxyribonucleic acid (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).

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 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 status review of all ESA-listed salmon and steelhead species on the West Coast, on May 26, 2016 (81 FR 33469), and concluded that this species (the Puget Sound Chinook ESU) should remain listed as threatened. As part of the review, NOAA's Northwest Fisheries Science Center evaluated the viability of the listed species undergoing 5-year reviews and issued a review providing updated information and analysis of the biological status of the listed species (NWFSC 2015). The NMFS' status review incorporated the findings of the Science Center's report, summarized new information concerning the delineation of the ESU and inclusion of closely related salmonid hatchery programs, and included an evaluation of the listing factors(NMFS 2017a). Where possible, particularly as new material becomes available, the status review information is supplemented with more recent information and other population specific data that may not have been considered during the status review so that NMFS is assured of using the best available information within its biological opinions.

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 (Puget Sound Salmon Recovery Plan (SSPS 2005) and Final Supplement to the Shared Strategy's Puget Sound Salmon Recovery Plan (NMFS 2006b)). The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Ruckelshaus et al. 2002; Ruckelshaus et al. 2006). 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-term[3];

3. At least one or more populations from major diversity groups historically present in each of the five Puget Sound regions attain a low risk status;

4. Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario;

5. Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery.

Spatial Structure and Diversity

The PSTRT determined that 22 historical populations currently contain Chinook salmon and grouped them into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information,

[3] 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.

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 extinct[4] (Ruckelshaus 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, the ESU includes 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).

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

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

[4] 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.

Geographic Region	Population (Watershed)
	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 2006b).

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 2006b). 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 2006b).

The Technical Recovery Team (TRT) did not define the relative roles of the remaining populations in the Whidbey and Central/South Sound Basins for 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, and adaption 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 (NMFS 2010b) (Figure 1). This framework, termed the *Population Recovery Approach*, carries forward the biological viability and delisting criteria described in the Supplement to the Puget Sound Salmon Recovery Plan (Ruckelshaus et al. 2002; NMFS 2006b). 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; 2005d; 2008e; 2008d; 2010a; 2011b; 2013b; 2014b; 2015c; 2016c; 2017b; 2018b).

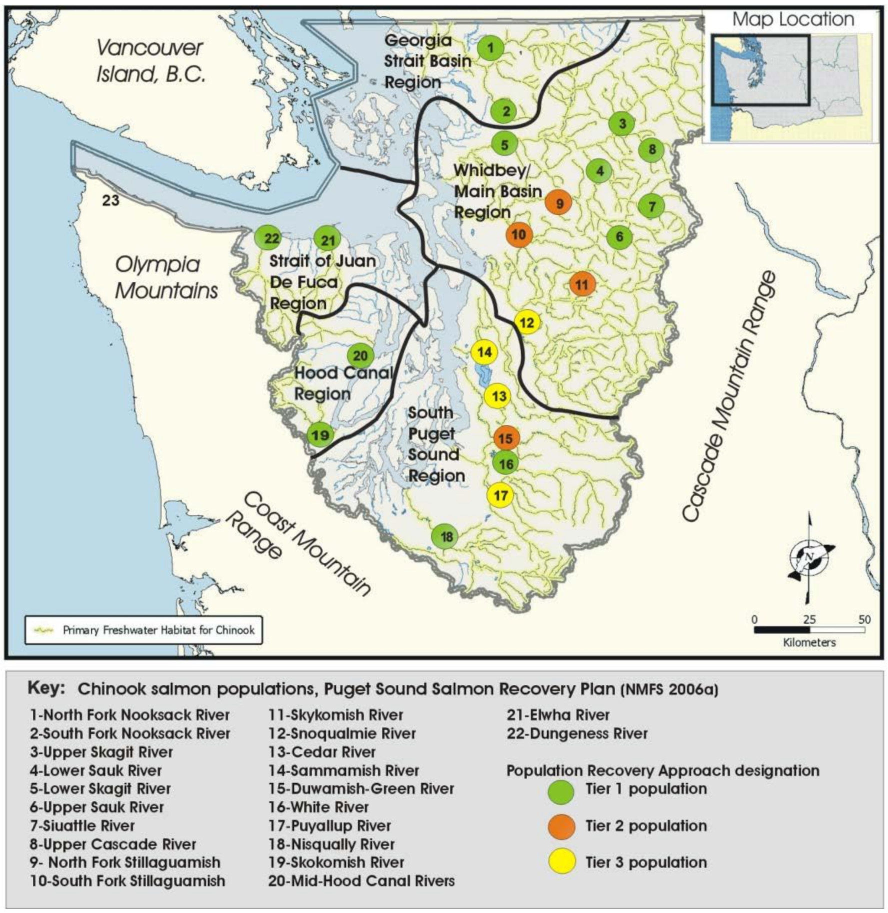

Figure 1. Puget Sound Chinook populations.

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 fractions of natural-origin spawner abundance, in six of the 10 populations within the Region. All other regions have moderate to high proportions of hatchery-origin spawners (Table 3).

In general, the Strait of Juan de Fuca, Georgia Basin, and Hood Canal regions are at greater risk than the other regions due to critically low natural abundance and/or declining growth rates of the populations in these regions. In addition, spatial structure, or geographic distribution, of the White, Skagit, Elwha and Skokomish populations has been substantially reduced or impeded by the loss of access to the upper portions of those tributary basins due to flood control activities and hydropower development. Habitat conditions conducive to salmon survival in most other watersheds have been reduced significantly by the effects of land use, including urbanization, forestry, agriculture, and development (NMFS 2005a; SSPS 2005; NMFS 2008b; 2008c; 2008a). It is likely that genetic and life history diversity has been significantly adversely affected 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, currently 20 populations exhibit a stable or increasing trend in natural escapement (Table 4). 14 of 22 populations show a growth rate in the 18-year geometric mean natural-origin spawner escapement that is greater or equal to 1.00. Both the previous status review in 2015 (NWFSC 2015), and the 2016 Pacific Salmon Commission Chinook Technical Committee's Evaluation Report (CTC 2018) had similarly concluded there was a widespread negative trend for the total ESU. Both reports were based on data through 2013 or 2014 and was the best available information at the time of the completion of previous opinions (NMFS 2016c; 2017b; CTC 2018). For this review, the results incorporate an updated long-term data series, and three additional years of escapement data (2015-2017) (Table 4). Incorporation of this information indicates more positive f trend in natural-origin Chinook salmon spawner population across the ESU).[5] For populations which did experience increased escapements over the updated long term data series, when the average natural-origin escapements for 2010-2014 are compared to the average natural-origin escapements reported in 2015-2017, these recent average escapements represent an 8-53% increase in natural-origin escapement (for the Lower and Upper Sauk, Upper Skagit, North Fork and South Fork Stillaguamish, Skykomish, Snoqualmie, Cedar, Green, Puyallup, Nisqually and Dungeness populations). The population represent three of the five recovery regions in Puget Sound.

Natural-origin escapements for six populations are at or below their critical thresholds[6]. Both populations in three of the five biogeographical regions are below or near their critical threshold: Georgia Strait, Hood Canal and Strait of Juan de Fuca (Table 3). However, the NF Stillaguamish population geomean is just above the critical threshold. When hatchery spawners are included,

[5] This is a synopsis of information provided in the recent five-year status review and supplemental data and complementary analysis from other sources, including the NWFCS Abundance and Productivity Tables. 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).

[6] 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 2000).

aggregate average escapement is over 1,000 for one of the two populations in each of these three regions; reducing the demographic risk to the populations in these regions. Ten populations are above their rebuilding thresholds[7]; eight of them in the Whidbey/Main Basin Region. This appears to reflect modest improvements in population status since these previous opinions (NMFS 2016c; 2017b; 2018b) for the Puget Sound salmon fisheries were completed. However, in 2018 NMFS and the NWFSC updated the rebuilding thresholds for several key Puget Sound populations. These thresholds represent the Maximum Sustained Yield estimate of spawners based on available habitat. The new spawner-recruit analyses for several populations indicated a significant reduction in the number of spawners that can be supported by the available habitat when compared to analyses conducted 10-15 years ago. This may be due to further habitat degradation or improved productivity assessment or, more likely, a combination of the two. For example, the updated rebuilding escapement threshold for the Green River is 1,700 spawners compared to the previous rebuilding escapement threshold of 5,523 spawners. So although several populations are above the updated rebuilding thresholds, indicating that escapement is sufficient for the available habitat in many cases, the overall abundance has declined.

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, 14 populations show productivity that is at or above replacement for natural-origin escapement including populations in all regions. Ten populations in four 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).

Life history traits such as size at age can also affect growth rate of recruitment. Studies examining those variables responsible for influencing the fecundity of female salmonids indicate that as the average body size at maturation is reduced, the productivity of the population also exhibits a reduction. This reduction is related to the production of fewer and smaller eggs, and the reduced ability to dig redds deep enough to withstand scouring (Healey and Heard 1984; Healey 1991; Hixon et al. 2014). Because Puget Sound Chinook salmon populations are not exhibiting a reduction in body size at age of maturation (Ohlberger et al. 2018), the productivity estimates reported (Table 4) for many of the populations continue to demonstrate stable levels of recruitment.

[7] The rebuilding threshold is defined as the escapement that will achieve Maximum Sustainable Yield (MSY) under current environmental and habitat conditions (NMFS 2000), and is based on an updated spawner-recruit assessment in the Puget Sound Chinook Harvest Management Plan, December 1, 2018. 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 at or below their critical escapement threshold are **bolded**. For several populations, hatchery contribution to natural spawning data are limited or unavailable.

Region	Population	1999 to 2017 Geometric mean Escapement (Spawners)		NMFS Escapement Thresholds		Recovery Planning Abundance Target in Spawners (productivity)[2]	Average % hatchery fish in escapement 1999-2017 (min-max)[5]
		Natural [1] 1999-2018	Natural-Origin (Productivity[2])	Critical[3]	Rebuilding[4]		
Georgia Basin	Nooksack MU	2,233	262	400	500		
	NF Nooksack	1,537	203[9] (0.3)	*200*[6]	-	3,800 (3.4)	85 (63-94)
	SF Nooksack	43	**24**[9] (1.0)	*200*[6]	-	2,000 (3.6)	85 (62-96)
Whidbey/Main Basin	Skagit Summer/Fall MU						
	Upper Skagit River	9,390	8,188[9] (1.7)	738	5,836	5,380 (3.8)	3 (1-8)
	Lower Sauk River	572	504[9] (1.5)	*200*[6]	371	1,400 (3.0)	1 (0-10)
	Lower Skagit River	2,098	1,800[9] (1.6)	281	2,475	3,900 (3.0)	4 (2-8)
	Skagit Spring MU						
	Upper Sauk River	603	530[9] (2.4)	170	484	750 (3.0)	2 (0-5)
	Suiattle River	368	332[9] (2.1)	170	250	160 (2.8)	2 (0-7)
	Upper Cascade River	301	266[9] (1.5)	130	196	290 (3.0)	9 (0-50)
	Stillaguamish MU						
	NF Stillaguamish R.	1,147	565 (0.8)	300	550	4,000 (3.4)	48 (28-71)
	SF Stillaguamish R.	111	**98** (1.1)	*200*[6]	300	3,600 (3.3)	10 (0-49)
	Snohomish MU						
	Skykomish River	3,409	2,040[9] (1.3)	400	1,500	8,700 (3.4)	34 (17-62)
	Snoqualmie River	1,526	1,110[9] (1.1)	400	900	5,500 (3.6)	19 (8-35)
Central/South Sound	Cedar River	931	837[9] (1.8)	*200*[6]	*282*[7]	2,000 (3.1)	25 (10-46)
	Sammamish River	1,164	**183**[9] (0.6)	*200*[6]	*1,250*[6]	1,000 (3.0)	84 (66-95)
	Duwamish-Green R.	3,964	1,175[9] (1.2)	400	2,200	-	64 (36-79)
	White River[10]	1,778	720[9] (0.7)	*200*[6]	488[7]	-	53 (27-87)
	Puyallup River[11]	1,655	695[9] (1.1)	*200*[6]	797[7]	5,300 (2.3)	48 (18-76)
	Nisqually River	1,658	533[9] (1.3)	*200*[6]	1,200[8]	3,400 (3.0)	67 (43-87)
Hood Canal	Skokomish River	1,357	**312** (0.9)	452	1,160	-	68 (7-95)
	Mid-Hood Canal Rivers[12]	**179**		*200*[6]	*1,250*[6]	1,300 (3.0)	53 (5-90)
Strait of Juan de Fuca	Dungeness River	356	**99**[9] (0.6)	*200*[6]	925[8]	1,200 (3.0)	71 (39-96)
	Elwha River[13]	1,388	**101**[9]	*200*[6]	*1,250*[6]	6,900 (4.6)	92 (82-98)

[1] Includes naturally spawning hatchery fish (Nooksack MU and NF and SF populations=1999-2016 geomean) .
[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 (McElhany et al. 2000; NMFS 2000; NMFS and NWFSC 2018).
[4] Rebuilding natural-origin escapement thresholds under current habitat and environmental conditions (McElhany et al. 2000; NMFS 2000; NMFS and NWFSC 2018).
[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 (WDFW and PSTIT 2005; 2006; 2007; 2008; 2009; 2010; 2011; 2012; PSIT and WDFW 2013; WDFW and PSTIT 2013; 2014; 2015a; 2016b), James and Dufault (2018) (preliminary data), and the 2010-2014 Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2010a).
[6] Based on generic VSP guidance (McElhany et al. 2000; NMFS 2000).
[7]Based on spawner-recruit assessment (Puget Sound Chinook Harvest Management Plan, December 1, 2018).
[8] Based on alternative habitat assessment.
[9] Estimates of natural-origin escapement for Nooksack available only for 1999-2015; Skagit springs, Skagit falls available only for 1999-2015; Snohomish for 1999-2001 and 2005-2017; Both Lake Washington populations (Cedar & Sammamish) for 2003-2016; White River 2005-2017; Puyallup for 2002-2017; Nisqually for 2005-2017; Dungeness for 2001-2017; Elwha for 2010-2017.
[10] 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.
[11] 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).
[12] The PSTRT 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.
[13] 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] (1990-2017)		Natural Origin Growth Rate[2] (1990-2015)	
		NMFS		Recruitment (Recruits)	Escapement (Spawners)
Georgia Basin	NF Nooksack (early)	1.12	increasing	1.04	1.02
	SF Nooksack (early)	0.99	stable	1.00	0.98
Whidbey/Main Basin	Upper Skagit River (moderately early)	1.02	stable	0.99	1.02
	Lower Sauk River (moderately early)	1.00	stable	0.96	0.99
	Lower Skagit River (late)	1.02	stable	0.98	1.01
	Upper Sauk River (early)	1.05	increasing	1.03	1.03
	Suiattle River (very early)	1.01	stable	1.02	1.01
	Upper Cascade River (moderately early)	1.02	stable	1.01	1.02
	NF Stillaguamish R. (early)	0.99	stable	0.97	1.00
	SF Stillaguamish R[3] (moderately early)	0.96	**declining**	0.94	0.97
	Skykomish River (late)	1.00	stable	1.00	1.00
	Snoqualmie River (late)	1.01	stable	0.98	0.98
Central/South Sound	Cedar River (late)	1.05	increasing	1.01	1.04
	Sammamish River[4] (late)	1.01	stable	1.02	1.04
	Duwamish-Green R. (late)	0.97	stable	0.94	0.97
	White River[5] (early)	1.10	increasing	1.02	1.05
	Puyallup River (late)	0.98	**declining**	0.92	0.94
	Nisqually River (late)	1.05	increasing	0.93	1.00
Hood Canal	Skokomish River (late)	1.02	stable	0.90	0.99
	Mid-Hood Canal Rivers[3] (late)	1.04	stable	0.97	1.04
Strait of Juan de Fuca	Dungeness River (early)	1.05	increasing	1.03	1.06
	Elwha River[3] (late)	1.04	increasing	0.91	0.93

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

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

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

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

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

Limiting factors

Limiting factors described in SSPS (2005) and reiterated in NMFS (2017a) include:

- Degraded nearshore and estuarine habitat: Residential and commercial development has reduced the amount of functioning nearshore and estuarine habitat available for salmon rearing and migration. The loss of mudflats, eelgrass meadows, and macroalgae further limits salmon foraging and rearing opportunities in nearshore and estuarine areas.
- Degraded freshwater habitat: Floodplain connectivity and function, channel structure and complexity, riparian areas and large wood supply, stream substrate, impaired passage conditions and water quality have been degraded for adult spawning, embryo incubation, and rearing as a result of cumulative impacts of agriculture, forestry, and development. Some improvements have occurred over the last decade for water quality and removal of forest road barriers.
- Anadromous salmonid hatchery programs: Salmon and steelhead released from Puget Sound hatcheries operated for harvest augmentation purposes pose ecological, genetic, and demographic risks to natural-origin Chinook salmon populations. The risk to the species' persistence that may be attributable to hatchery-related effects has decreased since the last Status Review, based on hatchery risk reduction measures that have been implemented, and new scientific information regarding genetic effects noted above (NWFSC 2015). Improvements in hatchery operations associated with on-going ESA review and determination processes are expected to further reduce hatchery-related risks.
- Salmon harvest management: Total fishery exploitation rates on most Puget Sound Chinook populations have decreased substantially since the late 1990s when compared to years prior to listing (average reduction = -22%, range = -23 to +17%), (New Fishery Regulation Assessment Model (FRAM) base period validation results, version 6.2) but weak natural-origin Chinook salmon populations in Puget Sound still require enhanced protective measures to reduce the risk of overharvest. The risk to the species' persistence because of harvest remains the same since the last status review. Further, there is greater uncertainty associated with this threat due to shorter term harvest plans and exceedance of management objectives for some Chinook salmon populations essential to recovery.
- Concerns regarding existing regulatory mechanisms, including: lack of documentation or analysis of the effectiveness of land-use regulatory mechanisms and land-use management plans, lack of reporting and enforcement for some regulatory programs, certain Federal, state, and local land and water use decisions continue to occur without the benefit of ESA review. State and local decisions have no Federal nexus to trigger the ESA Section 7 consultation requirement, and thus certain permitting actions allow direct and indirect species take and/or adverse habitat effects.

2.2.1.2 Status of Puget Sound Steelhead

The Puget Sound steelhead DPS was listed as threatened on May 11, 2007 (72 FR 26722). NOAA's Northwest Fisheries Science Center evaluated the viability of steelhead within the Puget Sound DPS (Hard et al. 2015), and issued a status review update providing new information and analysis on the biological status of the listed species (NWFSC 2015). In 2016 NMFS completed a 5-year status review of the Puget Sound Steelhead DPS (NMFS 2017a). Using key findings in NWFSC (2015), the status review concluded there were no major changes in the status or composition of the Puget Sound Steelhead DPS. The status review incorporated the findings of the Science Center's report, summarized new information concerning the delineation of the DPS and inclusion of closely related salmonid hatchery programs, and included an evaluation of the listing factors (NMFS 2017a). Based on this review, NMFS concluded that the species should remain listed as threatened. In this opinion, where possible, 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 populations within the Puget Sound steelhead DPS 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 (Puget Sound Steelhead Technical Recovery Team 2011). Populations can include summer steelhead only, winter steelhead only, or a combination of summer and winter run timing (e.g., winter run, summer run or summer/winter run). Figure 2 illustrates the DPS, MPGs, and DIPs for Puget Sound steelhead.

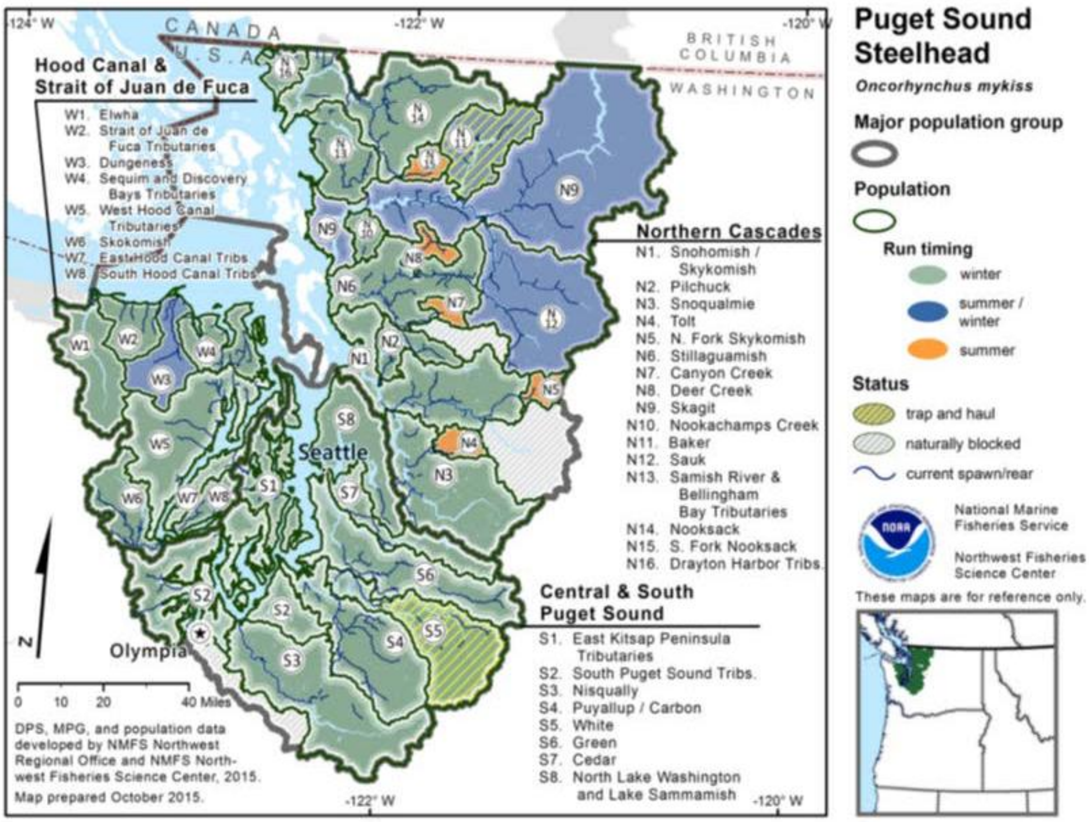

Figure 2. The Puget Sound Steelhead DPS showing MPGs and DIPs. The steelhead MPGs include the Northern Cascades, Central & Sound Puget Sound, and the Hood Canal & Strait of Juan de Fuca.

NMFS has convened recovery planning efforts across the Pacific Northwest to identify what actions are needed to recover listed salmon and steelhead. In 2014, a Puget Sound Steelhead Technical Recovery Team (PSSTRT) was established and recovery planning for Puget Sound steelhead is underway. On December 13, 2018 NMFS released the draft Puget Sound steelhead recovery plan for public review. Comments received will be considered for inclusion in the final plan, which NMFS anticipates will be completed in 2019. More information on the recovery planning process and draft documents for public comment are available at: *http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/puget_sound/overview_puget_sound_steelhead_recovery_2.html*. NMFS expects that both Federal and State steelhead recovery and management efforts will provide new tools and data and technical analyses to further refine Puget Sound steelhead population structure and viability, if needed, and better define the role of individual populations at the watershed level and in the DPS. Future consultations will incorporate information from the recovery planning process as it becomes available.

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 PSSTRT delineated populations 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 (Puget Sound Steelhead Technical Recovery Team 2011; PSSTRT 2013; NWFSC 2015). 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 (Puget Sound Steelhead Technical Recovery Team 2011). For example, the PSSTRT developed MPG and DPS viability criteria for Puget Sound steelhead. For MPGs, the viability criteria includes how many steelhead 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 (Puget Sound Steelhead Technical Recovery Team 2011).

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

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 FR 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 (Discussed further in section 2.4.1; Hard et al. 2007; Hard et al. 2015). Loss of diversity and spatial structure were judged to be "moderate" risk factors (Hard et al. 2007).

In 2013, the PSSTRT completed its evaluation of factors that influence the diversity and spatial structure VSP criteria for steelhead in the DPS. For spatial structure, this included the fraction of available intrinsic potential rearing and spawning habitat that is occupied compared to what is needed for viability.[8] 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. The PSSTRT concluded that low population viability was widespread throughout the DPS and populations showed evidence of diminished spatial structure and diversity. Specifically, population viability associated with spatial structure and diversity was highest in the Northern Cascades MPG and lowest in the Central and South Puget Sound MPG (Figure 3). Diversity was generally higher for populations within the Northern Cascades MPG, where more variability in viability was expressed and diversity generally higher, compared to populations in both the Central and South Puget Sound and Hood Canal and Strait of Juan de Fuca MPG, where diversity was depressed and viabilities were generally lower (NWFSC 2015). Most Puget Sound steelhead populations were given intermediate scores for spatial structure and low scores for diversity because of extensive hatchery influence, low breeding population sizes, and freshwater habitat fragmentation or loss (NWFSC 2015).

[8] Where intrinsic potential is the area of habitat suitable for steelhead rearing and spawning, at least under historical conditions (Puget Sound Steelhead Technical Recovery Team 2011; PSSTRT 2013).

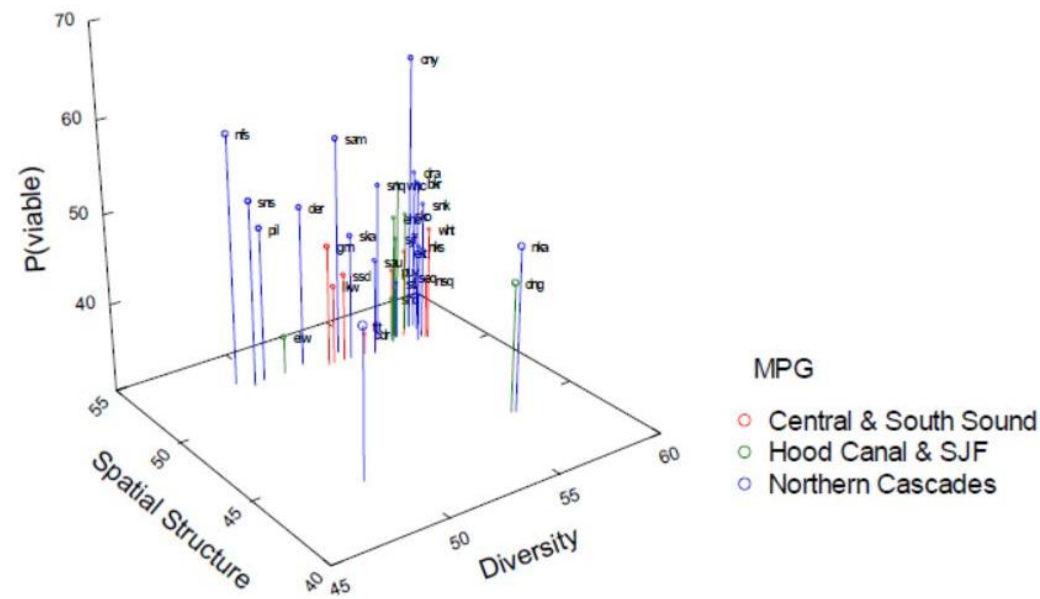

Figure 3. Scatter plot of the probabilities of viability for each of the 32 steelhead populations in the Puget Sound DPS as a function of VSP parameter estimates of influence of diversity and spatial structure on viability (Puget Sound Steelhead Technical Recovery Team 2011).

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). Since publication of the NWFSC report in 2015 even further reductions in hatchery production have occurred and will be discussed in detail in section 2.4.1. In addition, the fraction of hatchery steelhead spawning naturally are low for many rivers (NWFSC 2015). Steelhead hatchery programs are discussed in further detail in the Environmental Baseline section (2.4.1). 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 spawners[1] for 22 of the 32 DIPs in the DPS for which data are available (NWFSC 2015).

Run Type	DIP	Year				
		1990-1994	1995-1999	2000-2004	2005-2009	2010-2014
Winter	Cedar River					
	Green River	0.91	0.95	0.96		
	Nisqually River	0.99	1.00	1.00	1.00	1.00
	N. Lake WA/Lake Sammamish	1.00	1.00	1.00	1.00	
	Puyallup River/Carbon River	0.95	0.92	0.91	0.91	
	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
	West Hood Canal Tributaries		1.00	1.00	1.00	
	Nooksack River			0.96	0.97	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	0.94	0.95	0.94	0.96	
	Snoqualmie River	0.79	0.76	0.58	0.66	
	Stillaguamish River	1.00	0.88	0.75	0.81	
Summer	Tolt River	1.00	1.00	1.00	1.00	1.00

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

Early winter-run fish produced in isolated hatchery programs are derived from Chambers Creek stock in southern Puget Sound, which has been selected for early spawn timing, a trait known to be inheritable in salmonids.[9] 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). The production and release of hatchery fish of both run types (winter and summer) may continue to pose risk to diversity in natural-origin steelhead in the DPS, as described in Hard et al. (2007) and Hard et al. (2015).

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

[9] The natural Chambers Creek steelhead stock is now extinct.

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 diminishing abundance of some steelhead populations, especially in south Puget Sound, Hood Canal, and the Strait of Juan de Fuca (Hard et al. 2007).

Abundance and productivity estimates have been made available in the NWFSC status review update (NWFSC 2015). Steelhead abundance estimates are available for 7 of the 11 winter-run DIPs and 1 of the 5 summer-run DIPs in the Northern Cascades MPG,[10] 6 of the 8 winter-run DIPs in the Central and South Puget Sound MPG,[11] and 8 of the 8 winter-run DIPs in the Hood Canal and Strait of Juan de Fuca MPG.[12] Little or no data is available on summer run populations to evaluate extinction risk or abundance trends. Because of their small population size and the complexity of monitoring fish in headwater holding areas, summer steelhead have not been broadly monitored. Data were available for only one summer-run DIP, the Tolt River steelhead population in the Northern Cascades MPG. Total abundance of steelhead in these populations (Figure 4) has shown a generally declining trend over much of the DPS.

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

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

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

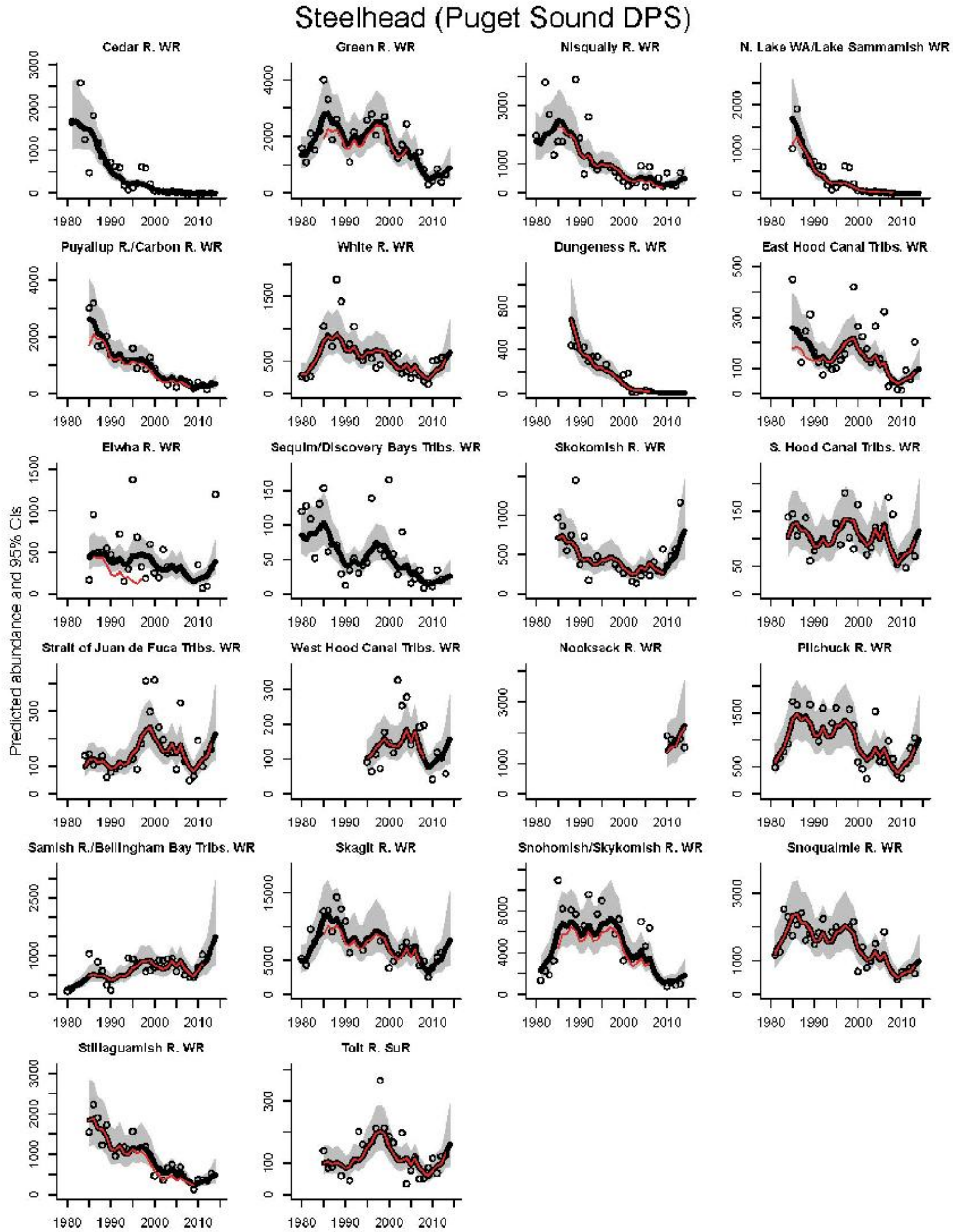

Figure 4. Trends in estimated total (black line) and natural (red line) population spawning abundance of Puget Sound steelhead. The circles represent annual raw spawning abundance data and the gray bands represent the 95% confidence intervals around the estimates (NWFSC 2015).

Since 2009, nine of the 22 populations indicate small to modest increases in abundance.[13] Most steelhead populations remain small. From 2010 to 2014, 8 of the 22 steelhead populations had fewer than 250 natural spawners annually, and 11 of the 22 steelhead populations had fewer than 500 natural spawners (Table 7).

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

MPG	Run	Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
Northern Cascades	Winter	Nooksack River	--	--	(80)	--	1779 (1834)	--
		Pilchuck River	1300 (1300)	1465 (1465)	604 (604)	597 (597)	614 (614)	3 (3)
		Samish River/Bellingham Bay	316 (316)	717 (717)	852 (852)	534 (534)	846 (846)	58 (58)
		Skagit River	7189 (7650)	7656 (8059)	5424 (5675)	5547 (4767)	(5123)	(7)
		Snohomish/Skykomish River	3634 (3877)	4141 (4382)	2562 (2711)	2945 (3084)	(930)	(-70)
		Snoqualmie River	1832 (2328)	2060 (2739)	856 (1544)	1396 (1249)	(680)	(-46)
		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 (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)	413 (413)	375 (375)	442 (442)	18 (18)
		N. Lk WA/Lk Sammamish	321 (321)	298 (298)	37 (37)	12 (12)	--	--
		Puyallup River/Carbon River	1860 (1954)	1523 (1660)	907 (1000)	641 (476)	(277)	(-42)
		White River	696 (696)	519 (519)	466 (466)	225 (225)	531 (531)	136 (136)
Hood Canal/ SJF	Winter	Dungeness River	356 (356)	--	182 (186)	--	(141)	--
		East Hood Canal	110	176	202	62	60	-3

[13] Pilchuck River, Samish River/Bellingham Bays Tributaries, Nisqually River, White River, Sequim/Discovery Bay Tributaries, Skokomish River winter-run populations. The Tolt River, Skagit River and Stillaguamish River summer-run steelhead populations are also showing early signs of upward trends.

MPG	Run	Population	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	% Change
		Tribs.	(110)	(176)	(202)	(62)	(60)	(-3)
		Elwha River	206 (358)	127 (508)	(303)	--	--	--
		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 (-43)
		Strait of Juan de Fuca Tribs.	--	275 (275)	212 (212)	244 (244)	147 (147)	-40 (-40)
		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 seven steelhead populations include, the Stillaguamish River and Snohomish/Skykomish River winter-run populations 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 predominantly 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 5). 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 and South Hood Canal Tributaries and Strait of Juan de Fuca Tributaries winter-run steelhead populations in the Hood Canal and Strait of Juan de Fuca MPG.

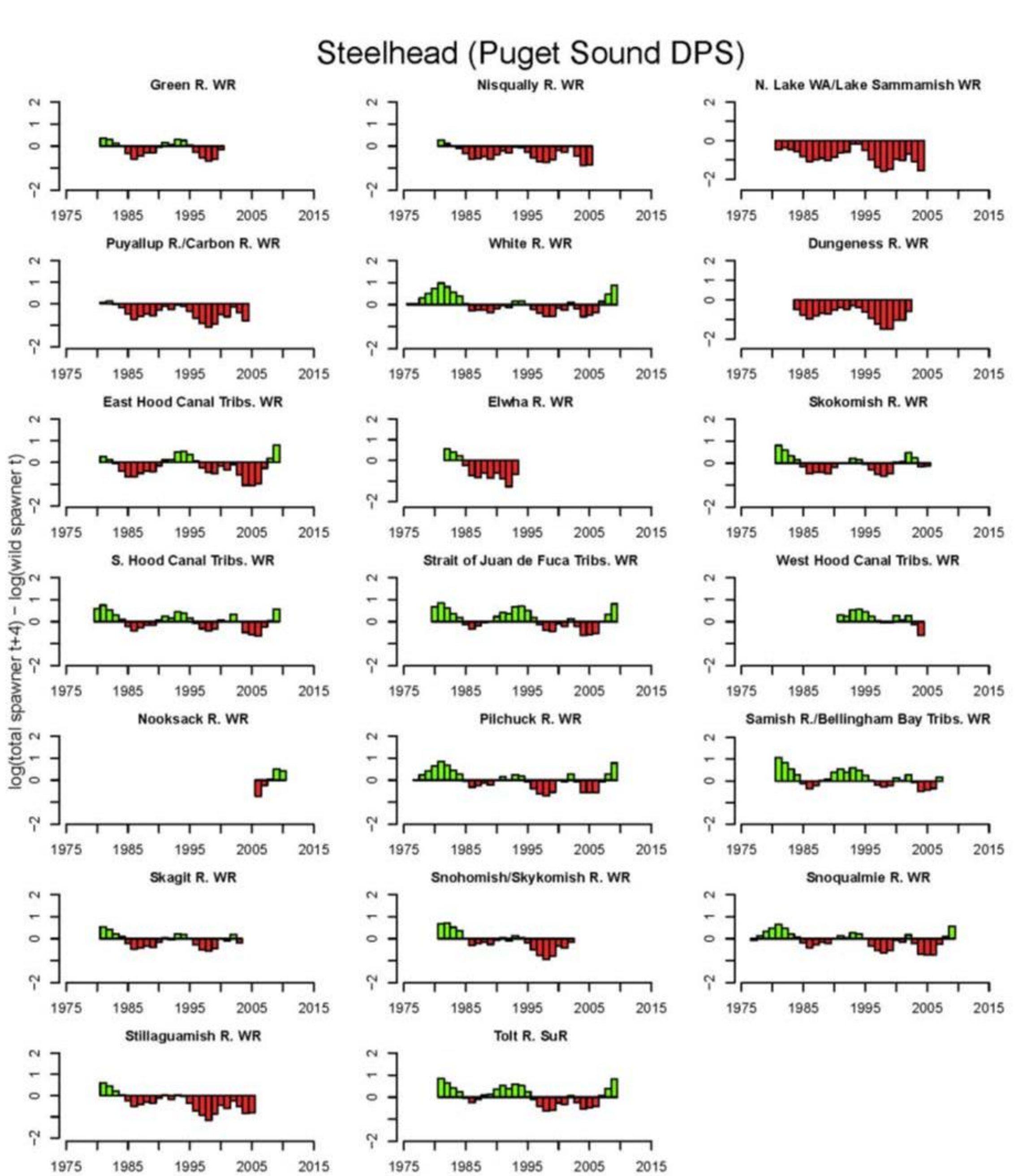

Figure 5. Trends in population productivity of Puget Sound steelhead (NWFSC 2015).

Harvest can affect the abundance and overall productivity of Puget Sound steelhead. Since the 1970s and 1980s, harvest rates have differed greatly among various watersheds, but all harvest rates on Puget Sound steelhead in the DPS have declined (NWFSC 2015). From the late 1970s to early 1990s, harvest rates on natural-origin steelhead averaged between 10% and 40%, with some populations in central and south Puget Sound[14] at over 60% (Figure 6). Harvest rates on natural-origin steelhead vary widely among watersheds, but have declined since the 1970s and 1980s and are now stable and generally less than 5% (NWFSC 2015; discussed further in Environmental Baseline section 2.4.1). Current harvest rates are low enough that they are unlikely to substantially reduce spawner abundance for most steelhead populations in Puget Sound (NWFSC 2015).

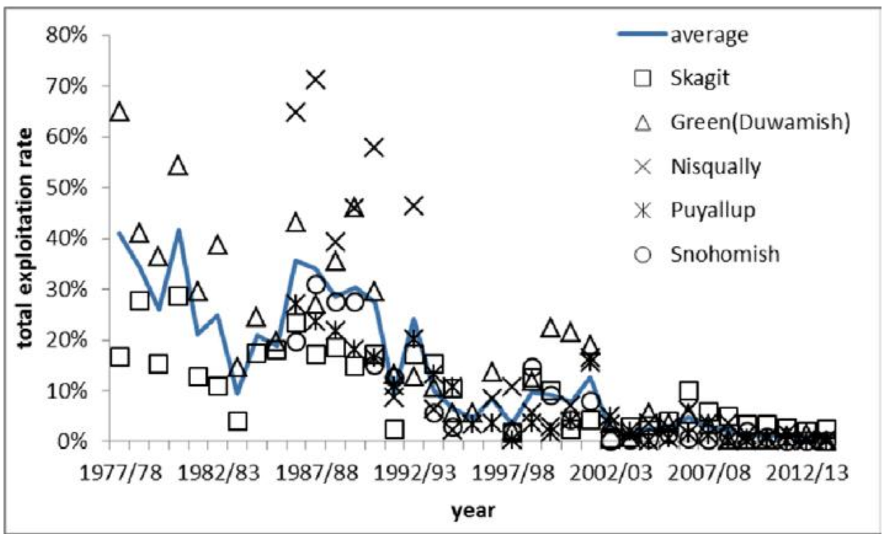

Figure 6. Total harvest rates on natural steelhead in Puget Sound Rivers (WDFW (2010) in NWFSC (2015)).

Overall, the status of steelhead based on the best available data on spatial structure, diversity, abundance, and productivity has not changed since the last status review (NWFSC 2015). Recent increases in abundance observed for a few steelhead DIPs have been modest and within the range of variability observed in the past several years and trends in abundance remain negative or flat for just over one half of the DIPs in the DPS 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 (Hard et al. 2007; Hard et al. 2015) although hatchery production has declined in recent years across the DPS and the fraction of hatchery spawners are low for many rivers. Recent increasing estimates of productivity for a few steelhead populations are encouraging but include only one to a few years, thus, the patterns of improvement in productivity are not widespread or considered certain to continue at this time. Total harvest rates are low and are unlikely to increase substantially in the foreseeable future and are low enough that they are unlikely to substantially reduce spawner abundance for most Puget Sound steelhead populations (NWFSC 2015).

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[14] 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. Information reviewed by NWFSC (2015) did not identify any new key emergent habitat concerns for the Puget Sound steelhead DPS since the 2011 status review.

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

2.2.1.3 Status of Puget Sound/Georgia Basin Rockfish

Detailed assessments of yelloweye rockfish and bocaccio can be found in the recovery plan (NMFS 2017e) and the 5-year status review (NMFS 2016a), and are summarized here. We describe the status of yelloweye rockfish and bocaccio with nomenclature referring to specific areas of Puget Sound. 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 areas called 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 DPS of yelloweye rockfish is listed under the ESA as threatened, and bocaccio are listed as endangered (75 FR 22276, April 28, 2010). On January 23, 2017, we issued a final rule to remove the Puget Sound/Georgia Basin canary rockfish (*Sebastes pinniger*) DPS from the Federal List of Threatened and Endangered Species and remove its critical habitat designation. We proposed these actions based on newly obtained samples and genetic analysis that demonstrates that the Puget Sound/Georgia Basin canary rockfish population does not meet the DPS criteria and therefore does not qualify for listing under the Endangered Species Act. Within the same rule, we extended the yelloweye rockfish DPS area further north in the Johnstone Strait area of Canada, as reflected in Figure 7. This extension was also the result of new genetic analysis of yelloweye rockfish. The final rule was effective March 24, 2017.

The DPSs include all yelloweye rockfish and bocaccio found in waters of Puget Sound, the Strait of Georgia, and the Strait of Juan de Fuca east of Victoria Sill (Figure 7 and Figure 8). Yelloweye rockfish and bocaccio are 2 of 28 species of rockfish in Puget Sound (Palsson et al. 2009).

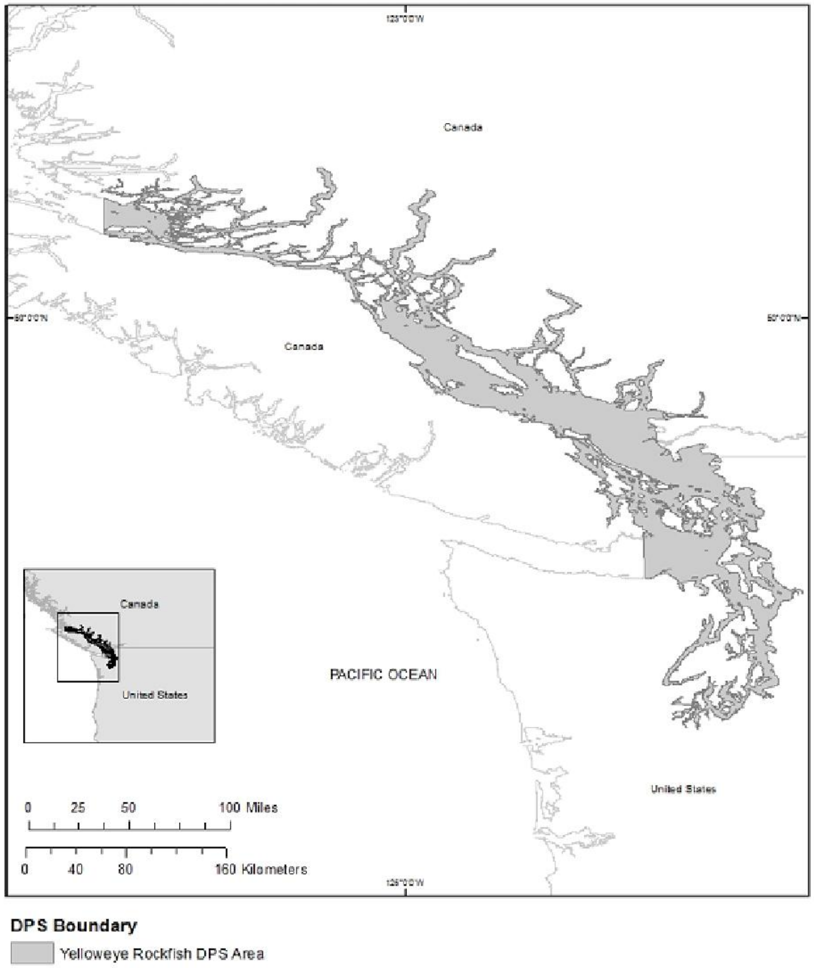


Figure 7. Yelloweye rockfish DPS area.

Figure 8. Bocaccio DPS area.

The life histories of yelloweye rockfish and bocaccio include a larval/pelagic juvenile stage followed by a juvenile stage, and subadult and adult stages. Much of the life history and habitat use for these two species is similar, with important differences noted below. Rockfish fertilize their eggs internally and the young are extruded as larvae. Individual mature female yelloweye rockfish and bocaccio produce from several thousand to over a million eggs each breeding cycle (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 (Shaffer et al. 1995; Love et al. 2002), but are also distributed throughout the water column (Weis 2004). Unique oceanographic conditions within Puget Sound proper likely result in most larvae staying within the basin where they are released (e.g., the South Sound) rather than being broadly dispersed (Drake et al. 2010).

When bocaccio reach sizes of 1 to 3.5 inches (3 to 9 centimeters (cm)) (approximately 3 to 6 months old), they settle onto shallow nearshore waters in rocky or cobble substrates with or without kelp (Love et al. 1991; Love et al. 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; Matthews 1989; Hayden-Spear 2006). Unlike bocaccio, juvenile yelloweye rockfish do not typically occupy intertidal waters (Love et al. 1991; Studebaker et al. 2009), but settle in 98 to 131 feet (30 to 40 m) of water near the upper depth range of adults (Yamanaka and Lacko 2001).

Subadult and adult yelloweye rockfish and bocaccio typically utilize habitats with moderate to extreme steepness, complex bathymetry, and rock and boulder-cobble complexes (Love et al. 2002). Within Puget Sound proper, each species has been documented in areas of high relief rocky and non-rocky substrates such as sand, mud, and other unconsolidated sediments (Washington 1977; Miller and Borton 1980). Yelloweye rockfish remain near the bottom and have small home ranges, while 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) (Orr et al. 2000; Love et al. 2002).

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

In the following section, we summarize the condition of yelloweye rockfish and bocaccio at the DPS level according to the following demographic viability criteria: abundance and productivity, spatial structure/connectivity, and diversity. These viability criteria are outlined in McElhany 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. 2010). There are several common risk factors detailed below at the introduction of each of the viability criteria for each listed rockfish species. Habitat and species limiting factors can affect abundance, spatial structure and diversity parameters, and are described.

Abundance and Productivity

There is no single reliable historical or contemporary population estimate for the yelloweye rockfish or bocaccio within the full range of the Puget Sound/Georgia Basin DPSs (Drake et al. 2010). Despite this limitation, there is clear evidence each species' abundance has declined dramatically, largely due to recreational and commercial fisheries that peaked in the early 1980's (Drake et al. 2010; Williams et al. 2010a). Analysis of SCUBA surveys, recreational catch, and WDFW trawl surveys indicated total rockfish populations in the Puget Sound region are estimated to have declined between 3.1 and 3.8 percent per year for the past several decades, which corresponds to a 69 to 76 percent decline from 1977 to 2014 (NMFS 2016a).

Catches of yelloweye rockfish and bocaccio have declined as a proportion of the overall rockfish

[15] Life History of Bocaccio: www.fishbase.org

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

Bocaccio consisted of 8 to 9 percent 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. 2010). From 1975 to 1979, bocaccio averaged 4.6 percent of the catch. From 1980 to 1989, they were 0.2 percent 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), but a few have been observed in recent remotely operated vehicle (ROV) surveys and other research activities.

Productivity is the measurement of a population's growth rate through all or a portion of its life cycle. Life history traits of yelloweye rockfish and bocaccio suggest generally low levels of inherent productivity because they are long-lived, mature slowly, and have sporadic episodes of successful reproduction (Tolimieri and Levin 2005; Drake et al. 2010). 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 on 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) (Boehlert et al. 1982; Bobko and Berkeley 2004; 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 typically once annually, 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. 2010).

Future climate-induced changes to rockfish habitat could alter their productivity (Drake et al. 2010). Harvey (2005) created a generic bioenergetic model for rockfish, showing that 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 listed rockfish population viability (Drake et al. 2010), 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. The San Juan Basin has the most suitable rocky benthic habitat (Palsson et al. 2009) and historically was the area of greatest numbers of angler catches (Moulton and Miller 1987; Olander 1991).

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

In Canada, yelloweye rockfish biomass is estimated to be 12 percent of the unfished stock size on the inside waters of Vancouver Island (DFO 2011). There are no analogous biomass estimates in the U.S. portion of the yelloweye rockfish DPS. However, WDFW has generated several population estimates of yelloweye rockfish in recent years. ROV surveys in the San Juan Island region in 2008 (focused on rocky substrate) and 2010 (across all habitat types) estimated a population of 47,407±11,761 and 114,494±31,036 individuals, respectively. A 2015 ROV survey of that portion of the DPSs south of the entrance to Admiralty Inlet encountered 35 yelloweye rockfish, producing a preliminary population estimate of 66,998±7,370 individuals (video review is still under way) (WDFW 2017a). For the purposes of this analysis we use the an abundance scenario derived from the combined WDFW ROV survey in the San Juan Islands in 2010, and the 2015 ROV survey in Puget Sound proper. We chose the 2010 survey in the San Juan Islands because it occurred over a wider range of habitat-types than the 2008 survey. We use the lower confidence intervals for each survey to form a precautionary analysis and total yelloweye population estimate of 143,086 fish within the U.S. portion of the DPS.

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

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

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

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

Spatial Structure and Connectivity

Spatial structure consists of a population's geographical distribution and the processes that generate that distribution (McElhany 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 (McElhany et al. 2000). Prior to contemporary fishery removals, each of the major basins in the range of the DPSs likely hosted relatively large populations of yelloweye rockfish and bocaccio (Washington 1977; Washington et al. 1978; Moulton and Miller 1987). 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 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. 2010). These sills regulate water exchange from one basin to the next, and thus likely moderate the movement of rockfish larvae (Drake et al. 2010). When localized depletion of rockfish occurs, it can reduce stock resiliency (Hilborn et al. 2003; Hamilton 2008). 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 likely most acute within the basins of Puget Sound proper. Yelloweye rockfish are probably most abundant within the San Juan Basin, but the likelihood of juvenile recruitment from this basin to the adjacent basins of Puget Sound proper is naturally low because of the generally retentive circulation patterns that occur within each of the major basins of Puget Sound proper.

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. 2010) with no documented occurrences in the San Juan Basin until 2008[16]. 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. 2010). The apparent reduction of populations of bocaccio in the Main Basin and South Sound represents a further impairment in the historically spatially limited distribution of bocaccio, and adds 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 on species viability are likely most acute for yelloweye rockfish because of their sedentary nature as adults.

Diversity

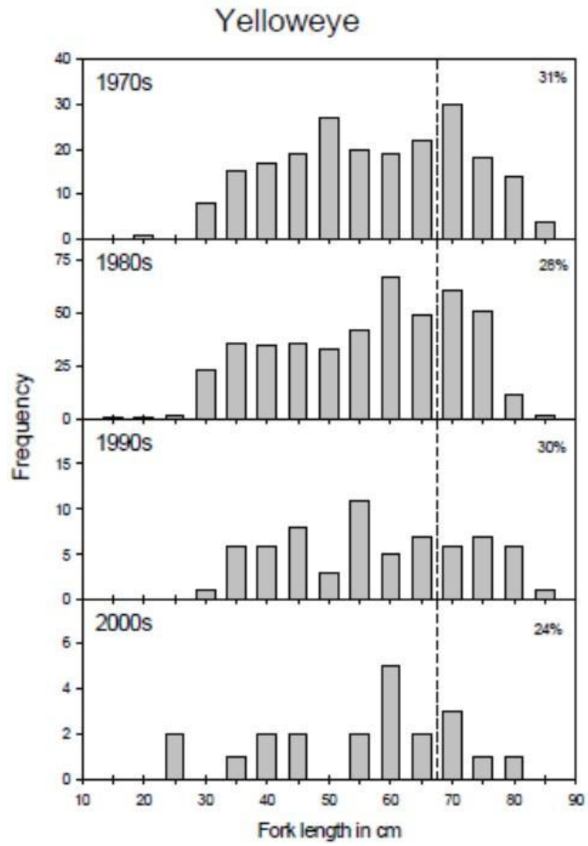
Characteristics of diversity for rockfish include fecundity, timing of the release of larvae and their condition, morphology, age at reproductive maturity, physiology, and molecular genetic characteristics. In spatially and temporally varying environments, there are three general reasons why diversity is important for species and population viability: (1) diversity allows a species to

[16] WDFW 2011: Unpublished catch data 3003-2009

use a wider array of environments, (2) diversity protects a species against short-term spatial and temporal changes in the environment, and (3) genetic diversity provides the raw material for surviving long-term environmental changes.

Yelloweye Rockfish Diversity

Yelloweye rockfish size and age distributions have been truncated (Figure 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. 2010). 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 centimeters(cm)) (Pacunski et al 2013). Since these fish were observed several years ago, they are likely bigger. However, 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. 2010). Recent genetic information for yelloweye rockfish further confirmed the existence of fish genetically differentiated within the Puget Sound/Georgia Basin compared to the outer coast (NMFS 2016b) and that yelloweye rockfish in Hood Canal are genetically divergent from the rest of the DPS. Yelloweye rockfish in Hood Canal are addressed as a separate population in the recovery plan (NMFS 2017e).



3.2.1.3

Figure 9. Yelloweye rockfish length frequency distributions (cm) binned within four decades.

Bocaccio Diversity

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

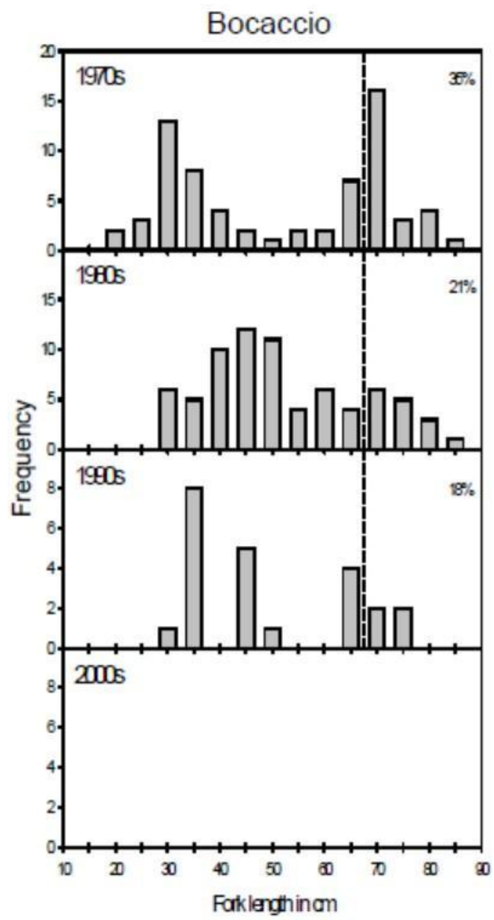


Figure 10. Bocaccio length frequency distributions (cm) within four decades. The vertical line depicts the size at which about 30 percent of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for a later decade.

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

Limiting Factors

Climate Change and Other Ecosystem Effects

As reviewed in ISAB (2007), average annual Northwest air temperatures have increased by approximately 1.8°F (1°C) since 1900, which is nearly twice that for the previous 100 years, indicating an increasing rate of change. Summer temperatures, under the A1B emissions scenario (a "medium" warming scenario), are expected to increase 3°F (1.7°C) by the 2020s and 8.5°F (4.7°C) by 2080 relative to the 1980s in the Pacific Northwest (Mantua et al. 2010). This change in surface temperature has already modified, and is likely to continue to modify, marine habitats of listed rockfish. There is still a great deal of uncertainty associated with predicting specific changes in timing, location, and magnitude of future climate change.

As described in ISAB (2007), climate change effects that have, and will continue to, influence the habitat, include increased ocean temperature, increased stratification of the water column, and intensity and timing changes of coastal upwelling. These continuing changes will alter primary and secondary productivity, marine community structures, and in turn may alter listed rockfish growth, productivity, survival, and habitat usage. Increased concentration of carbon dioxide (CO_2) (termed Ocean Acidification, or OA) reduces carbonate availability for shell-forming invertebrates. Ocean acidification will adversely affect calcification, or the precipitation of dissolved ions into solid calcium carbonate structures, for a number or marine organisms, which could alter trophic functions and the availability of prey (Feely et al. 2010). Further research is needed to understand the possible implications of OA 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 markedly 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 and Voorhis 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).

<u>Commercial and Recreational Bycatch</u>

Listed rockfish are caught in some recreational and commercial fisheries in Puget Sound. Recreational fishermen targeting bottom fish the shrimp trawl fishery in Puget Sound can incidentally catch listed rockfish. In 2012, we issued an incidental take permit (ITP) to the WDFW for listed rockfish in these fisheries (Table 8) and the WDFW is working on a new ITP application (WDFW 2017a). If issued, the new permit would be in effect for up to 15 years.

Table 8. Anticipated Maximum Annual Takes for Bocaccio, Yelloweye Rockfish by the fisheries within the WDFW ITP (2012 – 2017) (WDFW 2012).

	Recreational bottom fish		**Shrimp trawl**		**Total Annual Takes**	
	Lethal	**Non-lethal**	**Lethal**	**Non-lethal**	**Lethal**	**Non-lethal**
Bocaccio	12	26	5	0	17	26
Yelloweye Rockfish	55	87	10	0	65	87

In addition, NMFS permits limited take of listed rockfish for scientific research purposes (section 2.4.5). Listed rockfish can be caught in the recreational and commercial halibut fishery. In 2018 we estimated that these halibut fisheries would result in up to 270 lethal takes in addition, NMFS permits limited take of listed rockfish for scientific research purposes (section 2.4.4). Listed rockfish can be caught in the recreational and commercial halibut fishery. In 2017 we estimated that these halibut fisheries would result in up to 270 lethal takes of yelloweye rockfish, and 40 bocaccio (all lethal) (NMFS 2018d).

Other Limiting Factors

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

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

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

2.2.1.4 Status of Southern Resident Killer Whales

The Southern Resident killer whale DPS, composed of J, K and L pods, was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). A 5-year review under the ESA completed in 2016 concluded that Southern Residents should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016g).

The limiting factors described in the final recovery plan included reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008f). This section summarizes the status of Southern Resident killer whales throughout their range. This section summarizes information taken largely from the recovery plan (NMFS 2008f), recent 5-year review (NMFS 2016g), as well as new data that became available more recently.

Abundance, Productivity, and Trends

Southern Resident killer whales are a long-lived species, with late onset of sexual maturity (review in NMFS (2008f)). Females produce a low number of surviving calves over the course of their reproductive life span (Bain 1990; Olesiuk et al. 1990). Compared to Northern Resident killer whales (a resident killer whale population with a sympatric geographic distribution ranging from coastal waters of Washington State and British Columbia north to Southeast Alaska) Southern Resident females appear to have reduced fecundity (Ward et al. 2013; Velez-Espino et al. 2014); the average inter-birth interval for reproductive Southern Resident females is 6.1 years, which is longer than the 4.88 years estimated for Northern Resident killer whales (Olesiuk et al. 2005). Recent evidence has indicated pregnancy hormones (progesterone and testosterone) can be detected in Southern Resident killer whale feces and have indicated several miscarriages, particularly in late pregnancy (Wasser et al. 2017). The authors suggest this reduced fecundity is largely due to nutritional limitation. Mothers and offspring maintain highly stable social bonds throughout their lives, which is the basis for the matrilineal social structure in the Southern Resident population (Bigg et al. 1990; Baird 2000; Ford et al. 2000). Groups of related matrilines form pods. Three pods – J, K, and L – make up the Southern Resident community. Clans are composed of pods with similar vocal dialects and all three pods of the Southern Residents are part of J clan.

At present, the Southern Resident population has declined to historically low levels (Figure 11). Since censuses began in 1974, J and K pods have steadily increased their sizes. However, the population suffered an almost 20 percent decline from 1996-2001 (from 97 whales in 1996 to 81 whales in 2001), largely driven by lower survival rates in L pod. The overall population had increased slightly from 2002 to 2010 (from 83 whales to 86 whales). During the international science panel review of the effects of salmon fisheries (Hilborn et al. 2012), the Panel stated that during 1974 to 2011, the population experienced a realized growth rate of 0.71 percent, from 67 individuals to 87 individuals. In 2014 and 2015, there was a “baby boom” in the Southern Resident Killer Whale (SRKW) population that was the result of multiple successful pregnancies that occurred in 2013 and 2014. However, as of April 2019, the population has decreased to only 75 whales, a historical low in the last 30 years with a current realized growth rate (from 1974 to 2018) at less than half of the previous estimate described in the Panel report, 0.16 percent.

Figure 11. Population size and trend of Southern Resident killer whales, 1960-2018. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk et al. (1990). Data from 1974-2018 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) in this community and were provided by the Center for Whale Research (unpublished data) and NMFS (2008f). Data for these years represent the number of whales present at the end of each calendar year.

There is representation in all three pods, with 22 whales in J pod, 18 whales in K pod and 35 whales in L pod. Although the age and sex distribution is generally similar to that of Northern Residents that are a stable and increasing population (Olesiuk et al. 2005), there are several demographic factors of the Southern Resident population that are cause for concern, namely reduced fecundity, sub-adult survivorship in L pod, and the total number of individuals in the population (review in NMFS 2008f). Based on an updated pedigree from new genetic data, many of the offspring in recent years were sired by two fathers, meaning that less than 30 individuals make up the effective reproducing portion of the population. Because a small number of males were identified as the fathers of many offspring, a smaller number may be sufficient to support population growth than was previously thought (Ford et al. 2011b; Ford et al. 2018). Inbreeding may be common amongst this small population, with a recent study by Ford et al. (2018) finding that four sampled offspring were the result of inbreeding. However, the fitness effects of this inbreeding remain largely unknown (Ford et al. 2018).

The historical abundance of Southern Resident killer whales is estimated from 140 to an unknown upper bound. The minimum estimate (~140) is the number of whales killed or removed for public display in the 1960s and 1970s added to the remaining population at the time the captures ended. Several lines of evidence (i.e., known kills and removals (Olesiuk et al. 1990), salmon declines (Krahn et al. 2002) and genetics (Krahn et al. 2002; Ford et al. 2011b)) all indicate that the population used to be larger than it is now and likely experienced a recent reduction in size, but there is currently no reliable estimate of the upper bound of the historical population size.

Seasonal mortality rates among Southern and Northern Resident whales may be highest during the winter and early spring, based on the numbers of animals missing from pods returning to inland waters each spring. Olesiuk et al. (2005) identified high neonate mortality that occurred outside of the summer season. At least 12 newborn calves (9 in the southern community and 3 in the northern community) were seen outside the summer field season and disappeared by the next field season. Additionally, stranding rates are higher in winter and spring for all killer whale forms in Washington and Oregon (Norman et al. 2004). Data collected from three Southern Resident killer whale strandings in recent years have contributed to our knowledge of the health of the population and the impact of the threats to which they are exposed. Transboundary partnerships have supported thorough necropsies of L112 in 2012, J32 in 2014, and L95 in 2016, which included testing for contaminant load, disease and pathogens, organ condition, and diet composition[17]. A final necropsy report for J34, who was found dead near Sechelt, British Columbia on December 20, 2016 is still pending[18].

The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the work on population viability analyses conducted for the 2004 Status Review for Southern Resident Killer Whales and the science panel review of the effects of salmon fisheries (Krahn et al. 2004a; Hilborn et al. 2012; Ward et al. 2013). Following from that work, the data now suggests a downward trend in population growth projected over the next 50 years. As the model projects out over a longer time frame (50 years) there is increased uncertainty around the estimates, however, if all of the parameters in the model remain the same the overall trend shows a decline in later years. This downward trend is in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (Figure 12, NMFS (2016g)). To explore potential demographic projections, Lacy et al. (2017) constructed a population viability assessment that considered sub-lethal effects and the cumulative impacts of threats (contaminants, acoustic disturbance, and prey abundance). They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate. Furthermore, they suggested in order for the population to reach the recovery target of 2.3 percent growth rate, the acoustic disturbance would need to be reduced in half and the Chinook abundance would need to be increased by 15 percent (Lacy et al. 2017).

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[17] Reports for those necropsies are available at: http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/rpi_strandings.html

[18] The initial findings can be found at: http://www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/mammalsmammiferes/srkw-eprs-j34-eng.html

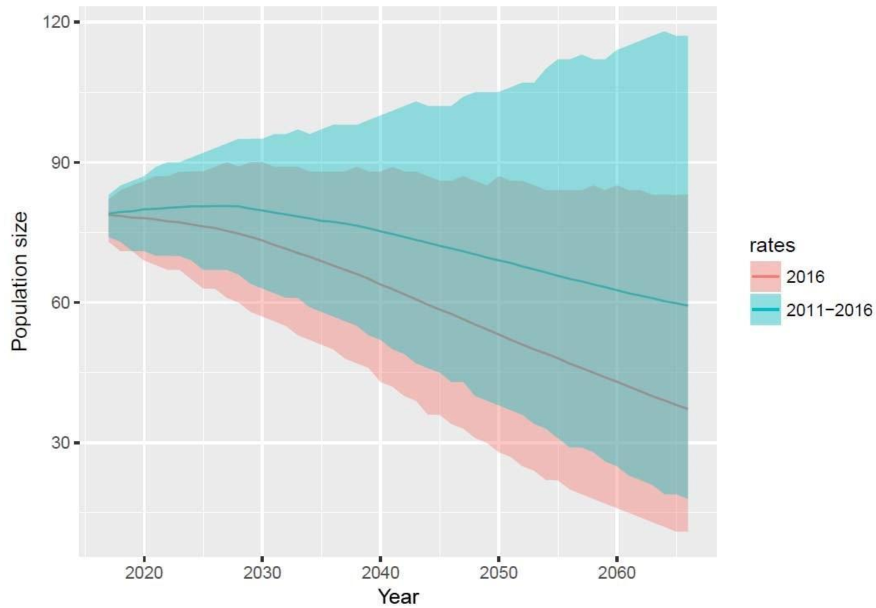

Figure 12. Southern Resident killer whale population size projections from 2016 to 2066 using 2 scenarios: (1) projections using demographic rates held at 2016 levels, and (2) projections using demographic rates from 2011 to 2016. The pink line represents the projection assuming future rates are similar to those in 2016, whereas the blue represents the scenario with future rates being similar to 2011 to 2016 (NMFS 2016g).

Because of this population's small abundance, it is also susceptible to demographic stochasticity – randomness in the pattern of births and deaths among individuals in a population. Several other sources of stochasticity can affect small populations and contribute to variance in a population's growth and extinction risk. Other sources include environmental stochasticity, or fluctuations in the environment that drive fluctuations in birth and death rates, and demographic heterogeneity, or variation in birth or death rates of individuals because of differences in their individual fitness (including sexual determinations). In combination, these and other sources of random variation combine to amplify the probability of extinction, known as the extinction vortex (Gilpin and Michael 1986; Fagan and Holmes 2006; Melbourne and Hastings 2008). The larger the population size, the greater the buffer against stochastic events and genetic risks. A delisting criterion for the Southern Resident killer whale DPS is an average growth rate of 2.3 percent for 28 years (NMFS 2008f). In light of the current average growth rate of 0.16 percent (from 1974 to 2018), this recovery criterion reinforces the need to allow the population to grow quickly.

Population growth is also important because of the influence of demographic and individual heterogeneity on a population's long-term viability. Population-wide distribution of lifetime reproductive success can be highly variable, such that some individuals produce more offspring than others to subsequent generations, and male variance in reproductive success can be greater than that of females (i.e., Clutton-Brock 1988; Hochachka 2006). For long-lived vertebrates such as killer whales, some females in the population might contribute less than the number of offspring required to maintain a constant population size (n = 2), while others might produce more offspring. The smaller the population, the more weight an individual's reproductive success has on the population's growth or decline (i.e., Coulson et al. 2006). For example, although there are currently 29 reproductive aged females (ages 10-42) in the Southern Resident killer whale population, only half have successfully reproduced in the last 10 years (CWR unpubl. data). This further illustrates the risk of demographic stochasticity for a small population like Southern Resident killer whales – the smaller a population, the greater the chance that random variation will result in too few successful individuals to maintain the population.

Geographic Range and Distribution

Southern Residents occur throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008f; Hanson et al. 2013; Carretta et al. 2017b) (Figure 13). Southern Residents are highly mobile and can travel up to 86 miles (160 km) in a single day (Erickson 1978; Baird 2000), with seasonal movements likely tied to the migration of their primary prey, salmon. During the spring, summer, and fall months, the whales have spent a substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford et al. 2000; Krahn et al. 2002; Hauser et al. 2007). In general, the three pods are increasingly more present in May and June and have spent a considerable amount of time in inland waters through September (Table 9). Late summer and early fall movements of Southern Residents in the Georgia Basin are consistent, with strong site fidelity shown to the region as a whole and high occurrence in the San Juan Island area (Hauser et al. 2007; Hanson and Emmons 2010). All three pods generally remain in the Georgia Basin through October and make frequent trips to the outer coasts of Washington and southern Vancouver Island and are occasionally sighted as far west as Tofino and Barkley Sound (Ford et al. 2000; Hanson and Emmons 2010; Whale Museum unpublished data). Sightings in late fall decline as the whales shift to the outer coasts of Vancouver Island and Washington.

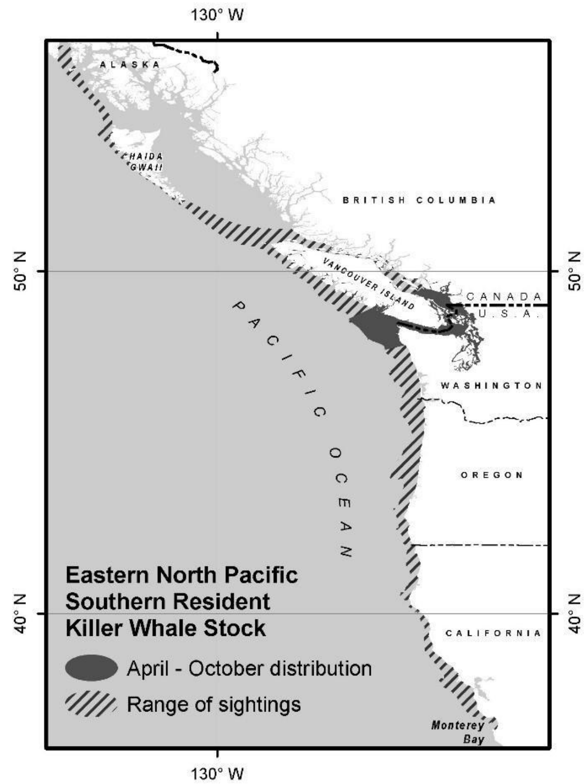

Figure 13. Geographic range of Southern Resident killer whales (reprinted from Carretta et al. (2017a)).

Table 9. Average and maximum number of observed days spent by Southern Residents (per pod) in inland waters per month (raw data from The Whale Museum, from 2003-2017).

MONTH	AVERAGE OBSERVED DAYS			MAXIMUM OBSERVED DAYS		
	J	K	L	J	K	L
JAN	7	5	3	16	13	10
FEB	6	3	2	15	10	11
MARCH	7	2	2	18	14	6
APRIL	9	2	2	24	9	14
MAY	20	4	5	30	20	11
JUNE	23	13	19	30	27	26
JULY	26	20	23	31	31	31
AUG	22	21	22	30	31	30
SEPT	23	20	22	27	27	28
OCT	16	14	13	22	21	22
NOV	12	9	6	16	16	12
DEC	10	10	5	18	18	10

Although seasonal movements are generally predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present in recent years (Hanson and Emmons 2010; Whale Museum unpublished data). For example, K pod has had variable occurrence in June ranging from 0 days of occurrence in inland waters to over 25 days (Figure 14). Fewer observed days in inland waters likely indicates changes in their prey availability (i.e., abundance, distribution and accessibility). During fall and early winter, Southern Resident pods, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum, coho, and Chinook salmon runs (Osborne 1999; Hanson et al. 2010) (Ford et al. 2016).

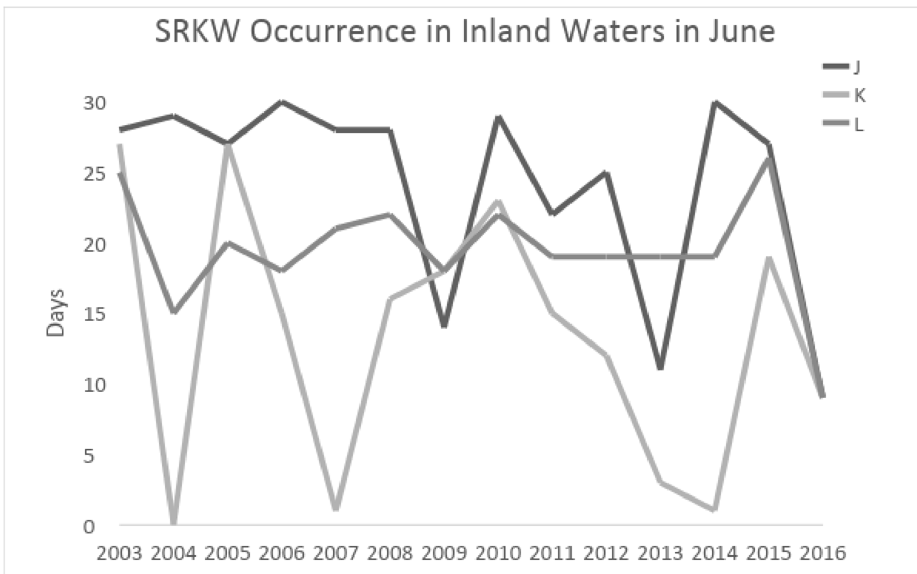

Figure 14. Number of days of SRKW occurrence in inland waters number in June for each year from 2003 to 2016 (data from The Whale Museum).

In recent years, several sightings and acoustic detections of Southern Residents have been obtained off the Washington and Oregon coasts in the winter and spring (Hanson et al. 2010; Hanson et al. 2013; NWFSC unpublished data). Satellite-linked tag deployments have also provided more data on the Southern Resident killer whale movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months. Detection rates of K and L pods on the passive acoustic recorders indicate Southern Residents occur with greater frequency off the Columbia River and Westport and are most common in March (Hanson et al. 2013). J pod has also only been detected on one of seven passive acoustic recorders positioned along the outer coast (Hanson et al. 2013). The limited range of the sightings/ acoustic detections of J pod in coastal waters, the lack of coincident occurrence during the K and L pod sightings, and the results from satellite tagging in 2012–2016 (NWFSC unpublished data) indicate J pod's limited occurrence along the outer coast and extensive occurrence in inland waters, particularly in the northern Georgia Strait.

Limiting Factors and Threats

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 to impact the whales. Modeling exercises have attempted to identify which threats are most significant to survival and recovery (Lacy et al. 2017) and available data suggests that all of the threats are potential limiting factors (NMFS 2008f).

Quantity and Quality of Prey

Southern Resident killer whales consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford et al. 2000; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016), but salmon are identified as their primary prey. Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. The diet data indicate that the whales are consuming mostly larger (i.e., older) Chinook salmon. Chinook salmon is their primary prey despite the much lower abundance in some areas and during certain time periods in comparison to other salmonids, for mechanisms that remain unknown but factors of potential importance include the species' large size, high fat and energy content, and year-round occurrence in the whales' geographic range. Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (kilocalorie/kilogram (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). Recent research suggests that killer whales are capable of detecting, localizing and recognizing Chinook salmon through their ability to distinguish Chinook echo structure as different from other salmon (Au et al. 2010).

Scale and tissue sampling from May to September in inland waters of WA and B.C. indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90%) (Hanson et al. 2010; Ford et al. 2016). Genetic analysis of the Hanson et al. (2010) samples indicate that when Southern Residents are in inland waters from May to September, they consume Chinook stocks that originate from regions including the Fraser River (including Upper Fraser, Mid Fraser, Lower Fraser, North Thompson, South Thompson and Lower Thompson), Puget Sound (North and South Puget Sound), the Central British Columbia Coast and West and East Vancouver Island.

DNA quantification methods are used to estimate the proportion of different prey species in the diet from fecal samples (Deagle et al. 2005). Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to the Southern Residents in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98% of the inferred diet, of which almost 80% were Chinook salmon. Coho salmon and steelhead are also found in the diet in spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40% of the diet in late summer, which is evidence of prey shifting at the end of summer towards coho salmon (Ford et al. 1998; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016). Less than 3% each of chum salmon, sockeye salmon, and steelhead were observed in fecal DNA samples collected in the summer months (May through September). Prey remains and fecal samples collected in inland waters during October through December indicate Chinook and chum salmon are primary contributors of the whale's diet (NWFSC unpublished data).

Observations of whales overlapping with salmon runs (Wiles 2004; Zamon et al. 2007; Krahn et al. 2009) and collection of prey and fecal samples have also occurred in coastal waters in the winter months. Preliminary analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated the majority of prey samples were Chinook salmon, with a smaller number of steelhead, chum salmon, and halibut (NWFSC unpublished data). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook genetic stock identification from samples collected in winter and spring in coastal waters included 12 U.S. west coast stocks, and over half the Chinook salmon consumed originated in the Columbia River (NWFSC unpublished data). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon comprise over 90% of the whales' coastal Chinook salmon diet (NWFSC unpublished data).

In general, over the past decade, some Chinook salmon stocks within the range of the whales have had relatively high abundance (e.g. Washington (WA)/Oregon (OR) coastal stocks, some Columbia River stocks) compared to previous decade, whereas other stocks originating in the more northern and southern ends of the whales' range (e.g. most Fraser stocks, Northern and Central British Columbia (B.C.) stocks, Georgia Strait, Puget Sound, and Central Valley) have declined. Changing ocean conditions driven by climate change may influence ocean survival of Chinook and other Pacific salmon, further affecting the prey available to Southern Residents.

In an effort to identify Chinook salmon stocks that are important to SRKW and prioritize recovery efforts to increase the whales' prey base, NMFS and WDFW released a priority stock report identifying the Chinook salmon stocks of most importance to the health of the Southern Resident populations along the West Coast (NOAA and WDFW 2018)[19]. The priority stock report was created by analyzing scat and prey scale/tissue samples to identify Chinook salmon stocks in the whales' diet, observing the killer whale body condition through aerial photographs, and estimating the spatial and temporal overlap with Chinook salmon stocks ranging from Southeast Alaska (SEAK) to California (CA). Extra weight was given to the salmon runs that support the Southern Residents during times of the year when the whales' body condition is more likely reduced and when Chinook salmon may be less available, such as in winter months. Table 10 is a summary of those stock descriptions.

[19]https://www.westcoast.fisheries.noaa.gov/publications/protected_species/marine_mammals/killer_whales/recovery/srkw_priority_chinook_stocks_conceptual_model_report___list_22june2018.pdf

Table 10. Summary of the priority Chinook salmon stocks (adapted from NOAA and WDFW (2018)).

Priority	ESU/Stock Group	Run Type	Rivers or Stocks in Group
1	North Puget Sound	Fall	Nooksack, Elwha, Dungeness, Skagit, Stillaguamish, Snohomish, Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal Systems
	South Puget Sound		
2	Lower Columbia Strait of Georgia	Fall	Fall Tules and Fall Brights (Cowlitz, Kalama, Clackamas, Lewis, others), Lower Strait (Cowichan, Nanaimo), Upper Strait (Klinaklini, Wakeman, others), Fraser (Harrison)
3	Upper Columbia & Snake	Fall	Upriver Brights, Spring 1.3 (Upper Pitt, Birkenhead; Mid & Upper Fraser; North and South Thompson) and Spring 1.2 (Thompson, Louis Creek, Bessette Creak); Lewis, Cowlitz, Kalama, Big White Salmon
	Fraser	Spring	
	Lower Columbia	Spring	
4	Middle Columbia	Fall	Fall Brights
5	Snake River	Spring/summer	Snake, Salmon, Clearwater, Nooksack, Elwha, Dungeness, Skagit (Stillaguamish, Snohomish)
	Northern Puget Sound	Spring	
6	Washington Coast	Spring and Fall	Hoh, Queets, Quillayute, Grays Harbor
7	Central Valley	Spring	Sacramento and tributaries
8	Middle/Upper Columbia	Spring/Summer	Columbia, Yakima, Wenatchee, Methow, Okanagan
9	Fraser	Summer	Summer 0.3 (South Thompson, Lower Fraser, Shuswap, Adams, Little River, Maria Slough) and Summer 1.3 (Nechako, Chilko, Quesnel, Clearwater River)
10	Central Valley Klamath River	Fall and late Fall	Sacramento, San Joaquin, Upper Klamath, and Trinity
		Fall and Spring	
11	Upper Willamette	Spring	Willamette
12	South Puget Sound	Spring	Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal systems
13	Central Valley	Winter	Sacramento and tributaries
14	North/Central Oregon Coast	Fall	Northern (Siuslaw, Nehalem, Siletz) and Central (Coos, Elk, Coquille, Umpqua)
15	West Vancouver Island	Fall	Robertson Creek, WCVI Wild
16	Southern OR & Northern CA Coastal	Fall and Spring	Rogue, Chetco, Smith, Lower Klamath, Mad, Eel, Russian

There are many factors that affect the abundance, productivity, spatial structure, and diversity, of Chinook salmon (as described above) and thus affect prey availability for the whales. For example, LCR Chinook salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable, particularly given these changing habitat conditions. Human impacts and limiting factors come from multiple sources, including hydropower development, habitat degradation, hatchery effects, fishery management and harvest decisions, and ecological factors, including predation and environmental variability.

The effects of fisheries on prey availability has been described in multiple biological opinions (e.g. NMFS 2008d; 2011a; 2018b). Following issuance of the 2011 biological opinion on the management plan for Puget Sound fisheries (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 at a broad scale, salmon abundance will likely influence the recovery of the whales, but 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). Following the independent science panel approach on the effects of salmon fisheries on SRKW (Hilborn et al. 2012), NMFS and partners have actively engaged in research and analyses to fill gaps and reduce uncertainties raised by the panel in their report.

Currently, hatchery production is a significant component of the salmon prey base returning to watersheds within the range of Southern Resident killer whales (Barnett-Johnson et al. 2007; NMFS 2008f). Although hatchery production has contributed some offset of the historical declines in the abundance of natural-origin salmon within the range of the whales, hatcheries also pose risks to natural-origin salmon populations (Nickelson et al. 1986; Ford 2002; Levin and Williams 2002; Naish et al. 2007). Healthy natural-origin salmon populations are important to the long-term maintenance of prey populations available to Southern Residents because it is uncertain whether a hatchery dominated mix of stocks is sustainable indefinitely and because hatchery fish can differ, relative to natural-origin Chinook salmon, for example, in size and hence caloric value and in availability/migration location and timing. However, the release of hatchery fish has not been identified as a threat to the survival or persistence of Southern Residents. It is possible that hatchery produced fish may benefit this endangered population of whales by enhancing prey availability as scarcity of prey is a primary threat to Southern Resident killer whale survival and hatchery fish often contribute to the salmon stocks consumed (Hanson et al. 2010).

Nutritional Limitation and Body Condition

When prey is scarce, Southern Residents likely spend more time foraging than when prey is plentiful. Increased energy expenditure and prey limitation can cause poor body condition and nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources and as a chronic condition, can lead to reduced body size of individuals and to lower reproductive and survival rates of a population (Trites and Donnelly

2003). During periods of nutritional stress and poor body condition, cetaceans lose adipose tissue behind the cranium, displaying a condition known as "peanut-head" in extreme cases (Pettis et al. 2004; Bradford et al. 2012; Joblon et al. 2014). Between 1994 and 2008, 13 Southern Resident killer whales were observed from boats to have a pronounced "peanut-head"; and all but two subsequently died (Durban et al. 2009; Center for Whale Research unpublished data). None of the whales that died were subsequently recovered, and therefore definitive cause of death could not be identified. Both females and males across a range of ages were found in poor body condition.

Since 2008, NOAA's (National Oceanic and Atmospheric Administration's) SWFSC (Southwest Fishery Science Center) has used aerial photogrammetry to assess the body condition and health of Southern Resident killer whales, initially in collaboration with the Center for Whale Research and, more recently, with the Vancouver Aquarium and SR[3]. Aerial photogrammetry studies have provided finer resolution for detecting poor condition, even before it manifests in "peanut heads" that are observable from boats. Annual aerial surveys of the population from 2013-2017 (with exception of 2014) have detected declines in condition before the death of seven Southern Residents (L52 and J8 as reported in Fearnbach et al. (2018); J14, J2, J28, J54, and J52 as reported in Durban et al. (2017)), including five of the six most recent mortalities (Trites and Rosen 2018). These data have provided evidence of a general decline in Southern Resident killer whale body condition since 2008, and documented members of J pod being in poorer body condition in May compared to September (at least in 2016 and 2017) (Trites and Rosen 2018).

Although body condition in whales can be influenced by a number of factors, including prey availability, disease, physiological or life history status, and may vary by season and across years, prey limitation is the most likely cause of observed changes in body condition in wild mammalian populations (Matkin et al. 2017). It is possible that poor nutrition could contribute to mortality through a variety of mechanisms. To demonstrate how this is possible, we reference studies that have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) on adult females and juveniles, which have been studied extensively (e.g., adult females: Gamel et al. (2005), Schaefer (1996), Daan et al. (1996), juveniles: Noren et al. (2009), Trites and Donnelly (2003)). Small, incremental increases in energy demands should have the same effect on an animal's energy budget as small, incremental reductions in available energy, such as one would expect from reductions in prey. Ford and Ellis (2006) report that resident killer whales engage in prey sharing about 76% of the time. Prey sharing presumably would distribute more evenly the effects of prey limitation across individuals of the population than would otherwise be the case (i.e., if the most successful foragers did not share with other individuals). Therefore, although cause of death for most individuals that disappear from the population is unknown, poor nutrition could occur in multiple individuals as opposed to only unsuccessful foragers, contributing to additional mortality in this population.

Toxic Chemicals

Various adverse health effects in humans, laboratory animals, and wildlife have been associated with exposures to persistent pollutants. These pollutants have the ability to cause endocrine disruption, reproductive disruption or failure, immunotoxicity, neurotoxicity, neurobehavioral disruption, and cancer (Reijnders 1986; Subramanian et al. 1987; de Swart et al. 1996; Bonefeld-Jørgensen et al. 2001; Reddy et al. 2001; Schwacke et al. 2002; Darnerud 2003; Legler and Brouwer 2003; Viberg et al. 2003; Ylitalo et al. 2005; Fonnum et al. 2006; Viberg et al. 2006; Darnerud 2008; Legler 2008). Southern Residents are exposed to a mixture of pollutants, some of which may interact synergistically and enhance toxicity, influencing their health. High levels of these pollutants have been measured in blubber biopsy samples from Southern Residents (Ross et al. 2000; Krahn et al. 2007; Krahn et al. 2009), and more recently, these pollutants were measured in fecal samples collected from Southern Residents providing another potential opportunity to evaluate exposure to these pollutants (Lundin et al. 2016a; Lundin et al. 2016b).

Killer whales are exposed to persistent pollutants primarily through their diet. For example, Chinook salmon contain higher levels of some persistent pollutants than other salmon species, but only limited information is available for pollutant levels in Chinook salmon (Krahn et al. 2007; O'Neill and West 2009; Veldhoen et al. 2010; Mongillo et al. 2016). These harmful pollutants, through consumption of prey species that contain these pollutants, are stored in the killer whale's blubber and can later be released; when the pollutants are released, they are 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. The release of pollutants can also occur during gestation or lactation. Once the pollutants mobilize in to circulation, they have the potential to cause a toxic response. Therefore, nutritional stress from reduced Chinook salmon populations may act synergistically with high pollutant levels in Southern Residents and result in adverse health effects.

In April 2015, NMFS hosted a 2-day Southern Resident killer whale health workshop to assess the causes of decreased survival and reproduction in the killer whales. Following the workshop, a list of potential action items to better understand what is causing decreased reproduction and increased mortality in this population was generated and then reviewed and prioritized to produce the Priorities Report (NMFS 2015d). The report also provides prioritized opportunities to establish important baseline information on Southern Resident and reference populations to better assess negative impacts of future health risks, as well as positive impacts of mitigation strategies on Southern Resident killer whale health.

Disturbance from Vessels and Sound

Vessels have the potential to affect killer whales through the physical presence and activity of the vessel, increased underwater sound levels generated by boat engines, or a combination of these factors. Vessel strikes are rare, but do occur and can result in injury or mortality (Gaydos and Raverty 2007). In addition to vessels, underwater sound can be generated by a variety of other human activities, such as dredging, drilling, construction, seismic testing, and sonar (Richardson et al. 1995; Gordon and Moscrop. 1996; National Research Council 2003). Impacts from these sources can range from serious injury and mortality to changes in behavior. In other cetaceans, hormonal changes indicative of stress have been recorded in response to intense sound exposure (Romano et al. 2003). Chronic stress is known to induce harmful physiological conditions including lowered immune function, in terrestrial mammals and likely does so in cetaceans (Gordon and Moscrop. 1996).

Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. While in inland waters of Washington and British Columbia, Southern Resident killer whales are the principal target species for the commercial whale watch industry (Hoyt 2001; O'Connor et al. 2009) and encounter a variety of other vessels in their urban environment (e.g., recreational, fishing, ferries, military, shipping). Several main threats from vessels include direct vessel strikes, the masking of echolocation and communication signals by anthropogenic sound, and behavioral changes (NMFS 2008f). There is a growing body of evidence documenting effects from vessels on small cetaceans and other marine mammals (NMFS 2010c; 2016g; 2018e). Research has shown that the whales spend more time traveling and performing surface active behaviors and less time foraging in the presence of all vessel types, including kayaks, and that noise from motoring vessels up to 400 meters away has the potential to affect the echolocation abilities of foraging whales (Holt 2008; Lusseau et al. 2009; Noren et al. 2009; Williams et al. 2010b). Individual energy balance may be impacted when vessels are present because of the combined increase in energetic costs resulting from changes in whale activity with the decrease in prey consumption resulting from reduced foraging opportunities (Williams et al. 2006; Lusseau et al. 2009; Noren et al. 2009; Noren et al. 2012).

At the time of the whales' listing under the ESA, NMFS reviewed existing protections for the whales and developed recovery actions, including vessel regulations, to address the threat of vessels to killer whales. NMFS concluded it was necessary and advisable to adopt regulations to protect killer whales from disturbance and sound associated with vessels, to support recovery of Southern Resident killer whales. Federal vessel regulations were established in 2011 to prohibit vessels from approaching killer whales within 200 yards (182.9 m) and from parking in the path of the whales within 400 yards (365.8 m). These regulations apply to all vessels in inland waters of Washington State with exemptions to maintain safe navigation and for government vessels in the course of official duties, ships in the shipping lanes, research vessels under permit, and vessels lawfully engaged in commercial or treaty Indian fishing that are actively setting, retrieving, or closely tending fishing gear (76 FR 20870, April, 14, 2011).

In the final rule, NMFS committed to reviewing the vessel regulations to evaluate effectiveness, and also to study the impact of the regulations on the viability of the local whale watch industry. In March 2013, NMFS held a killer whale protection workshop[20] to review the current vessel regulations, guidelines, and associated analyses; review monitoring, boater education, and enforcement efforts; review available industry and economic information and identify data gaps; and provide a forum for stakeholder input to explore next steps for addressing vessel effects on killer whales.

In December 2017, NOAA Fisheries completed a technical memorandum evaluating the

[20] The presentations and supporting documents (including workshop notes) can be found at http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/vessel_regulations.html.

effectiveness of regulations adopted in 2011 to help protect endangered Southern Resident killer whales from the impacts of vessel traffic and noise (Ferrara et al. 2017). In the assessment, Ferrara et al. (2017) used five measures: education and outreach efforts, enforcement, vessel compliance, biological effectiveness, and economic impacts. For each measure, the trends and observations in the 5 years leading up to the regulations (2006-2010) were compared to the trends and observations in the 5 years following the regulations (2011-2015). The memo finds that the regulations have benefited the whales by reducing impacts without causing economic harm to the commercial whale-watching industry or local communities. The authors also find room for improvement in terms of increasing awareness and enforcement of the regulations, which would help improve compliance and further reduce biological impacts to the whales.

Oil Spills

In the Northwest, Southern Resident killer whales are the most vulnerable marine mammal population to the risks imposed by an oil spill due to their small population size, strong site fidelity to areas with high oil spill risk, large group size, late reproductive maturity, low reproductive rate, and specialized diet, among other attributes (Jarvela Rosenberger et al. 2017). Oil spills have occurred in the range of Southern Residents in the past, and there is potential for spills in the future. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines. Despite many improvements in spill prevention since the late 1980s, much of the region inhabited by Southern Residents remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers in inland waters. Numerous oil tankers transit through the inland waters range of Southern Residents throughout the year. The magnitude of risk posed by oil discharges in the action area is difficult to precisely quantify. The total volume of oil spills declined from 2007 to 2013, but then increased from 2013 to 2017 (WDOE 2017). The percent of potential high-risk vessels that were boarded and inspected between 2009 to 2017 also declined (from 26% inspected in 2009 to 12.2% by 2017) (WDOE 2017).

Repeated ingestion of petroleum hydrocarbons by killer whales likely causes adverse effects; however, long-term consequences are poorly understood. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion and disease, pneumonia, liver disorders, neurological damage, adrenal toxicity, reduced reproductive rates, and changes in immune function (Geraci and Aubin 1990; Schwacke et al. 2013; Venn-Watson et al. 2015; de Guise et al. 2017; Kellar et al. 2017), potentially death and long-term effects on population viability (Matkin et al. 2008; Ziccardi et al. 2015). For example, 122 cetaceans stranded or were reported dead within 5 months following the Deepwater Horizon spill in the Gulf of Mexico (Ziccardi et al. 2015). An additional 785 cetaceans were found stranded from November 2010 to June 2013, which was declared an Unusual Mortality Event (Ziccardi et al. 2015). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect Southern Residents by reducing food availability.

2.2.1.5 Status of the Mexico and Central America DPSs of Humpback Whales

The humpback whale was listed as endangered under the Endangered Species Conservation Act (ESCA) on December 2, 1970 (35 FR 18319). Congress replaced the ESCA with the ESA in 1973, and humpback whales continued to be listed as endangered. NMFS recently conducted a global status review and changed the status of humpback whales under the ESA (81 FR 62260; September 8, 2016). Under the final rule, 14 DPSs of humpback whales are recognized worldwide:

- North Atlantic
  - West Indies
  - Cape Verde Islands/Northwest Africa
- North Pacific
  - Western North Pacific (WNP)
  - Hawaii
  - Mexico
  - Central America
- Northern Indian Ocean
  - Arabian Sea
- Southern Hemisphere
  - Brazil
  - Gabon/Southwest Africa
  - Southeast Africa/Madagascar
  - West Australia
  - East Australia
  - Oceania
  - Southeastern Pacific

We used information available in the recovery plan (NMFS 1991), status review (Bettridge et al. 2015), most recent stock assessments (Muto et al. 2017; Muto et al. 2018a; Muto et al. 2018b), report on estimated abundance and migratory destinations for North Pacific humpback whales (Wade et al. 2016a), and recent biological opinions to summarize the status of the species, as follows.

NMFS has identified three DPSs of humpback whales that may be found off the coasts of Washington, Oregon and California. These are the Hawaiian DPS (found predominately off Washington and southern British Columbia [SBC]) which is not listed under the ESA; the Mexico DPS (found all along the U.S. west coast) which is listed as threatened under the ESA; and the Central America DPS (found predominately off the coasts of Oregon and California) which is listed as endangered under the ESA. Humpback whales in the Puget Sound action area may belong to the Mexico, Hawaii, or Central America DPSs and photo-identification matching is ongoing to assess which DPSs are present in inland waters. The majority of humpback whales observed in coastal waters of Washington and British Columbia are from the Hawaiian breeding population (approximately 53%), or Mexico (42% with a 95% confidence interval of 30% - 54%), and a few from Central American (5% with a 95% confidence interval of 0% - 15%) (Wade et al. 2016a).

In December, 2016, NMFS WCR released a memo outlining evaluation of the distribution and relative abundance of ESA-listed DPSs that occur in the waters off the United States West Coast (NMFS 2016f) and until additional information is available for Puget Sound, will use the same proportions for coastal and inland waters of Washington. In summary, the proportional approach breaks down as follows:

Table 11. Proportional estimates of each DPS that will be applied in waters off of Washington/South British Columbia. E=Endangered, T=Threatened.

Feeding Areas	Central America DPS (E)	Mexico DPS (T)
Washington/SBC	15%[21]	42%

Based on the December 2016 memo, this biological opinion evaluates impacts on both the Central American and Mexico DPSs of humpback whales as both are expected to occur in the action area in the relative proportions described above. To the extent that impacts are evaluated at an individual animal level, these proportions would be used as the likelihood that the affected animal is from either DPS.

The most current stock assessment report (SAR) for humpback whales on the west coast of the United States (Carretta et al. 2018b) has not modified the Marine Mammal Protection Act (MMPA) definition of humpback whale stocks in response to the new ESA listings; thus we use the existing SARs and sometimes refer to the Mexico DPS and the Central America DPS in the entire action area as a part of the Central North Pacific (CNP) and CA/OR/WA stocks. These MMPA stocks include whales from multiple DPSs. The CA/OR/WA stock spends the winter primarily in coastal waters of Mexico and Central America, and the summer along the West Coast from California to British Columbia. The CNP stock primarily spends winters in Hawaii and summers in Alaska, and its distribution may partially overlap with that of the CA/OR/WA stock off the coast of Washington and British Columbia (Clapham 2009). There is some mixing between these populations, though they are still considered distinct stocks.

Abundance, Productivity and Trends

Wade et al. (2016a) estimated the abundance of the Mexico DPS to be 3,264 based on revised analysis of the available data. Although no specific estimate of the current growth rate of this

[21] We use the upper bound of the 95% confidence interval to estimate the proportion of humpback whales found foraging in the inland waters of Washington State in order to ensure we do not underestimate impacts on animals from the endangered Central America DPS due to its low abundance and the persistence of threats to these animals. We do not apply the upper 95% confidence interval estimate to the Mexico DPS as the underlying information supporting those estimates yielded a significantly lower coefficient of variation and the more robust population status of this DPS obviates the need for the conservative approach we are taking to estimate impacts on the endangered Central America DPS.

DPS is available, it is likely that the positive growth rates of humpback whales along the U.S. west coast and in the North Pacific at large that have been documented are at least somewhat reflecting positive growth of this DPS, given its relative population size. Current estimates of abundance for the Central America DPS range from approximately 400 to 600 individuals (Bettridge et al. 2015; Wade et al. 2016a). The size of this population is relatively low compared to most other North Pacific breeding populations. The population trend for the Central America DPS is unknown (Bettridge et al. 2015).

Geographic Range and Distribution

Humpback whales are widely distributed in the Atlantic, Indian, Pacific, and Southern Oceans. Individuals generally migrate seasonally between warmer, tropical and sub-tropical waters in winter months (where they reproduce and give birth to calves) and cooler, temperate and sub-Arctic waters in summer months (where they feed). In their summer foraging areas and winter calving areas, they tend to occupy shallower, coastal waters; though during seasonal migrations they disperse widely in deep, pelagic waters and tend to avoid shallower coastal waters (Winn and Reichley 1985).

Limiting Factors and Threats

The humpback whale species was originally listed as endangered because of past commercial whaling. Additional threats to the species include ship strikes, fisheries interactions (including entanglement), noise, loss of habitat, loss of prey (for a variety of reasons including climate variability), and pollutants. Brief descriptions of threats to humpback whales follow. More detailed information can be found in:

- The Humpback Whale Recovery Plan (NMFS 1991) (available at: http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_humpback.pdf);
- Alaska and Pacific Ocean Marine Mammal Stock Assessments, 2018 (available at: http://www.nmfs.noaa.gov/pr/sars/species.htm);
- Global Status Review (Fleming and Jackson 2011)(available at: http://www.car-spaw-rac.org/IMG/pdf/Global_review_of_humpback_whales_Megaptera_novaeangliae_.pdf); and
- Status Review of Humpback Whale (*Megaptera novaeangliae*) (Bettridge et al. 2015) (available at http://www.nmfs.noaa.gov/pr/species/Status%20Reviews/humpback_whale_sr_2015.pdf).

Natural Threats

The most common predator of humpback whales is the killer whale (*Orcinus orca*, Jefferson et al. (1991)), although predation by large sharks may also be significant (attacks are mostly undocumented). Predation by killer whales on humpback calves has been inferred by the presence of distinctive parallel 'rake' marks from killer whale teeth across the flukes (Shevchenko 1975). While killer whale attacks of humpback whales are rarely observed in the field (Ford and Reeves 2008), the proportion of photo-identified whales bearing rake scars is between zero and 40 percent, with the greater proportion of whales showing mild scarring (1-3 rake marks) (Mehta et al. 2007; Steiger et al. 2008). This suggests that attacks by killer whales on humpback whales vary in frequency across regions. It also suggests either that most killer whale attacks result in mild scarring, or that those resulting in severe scarring (4 or more rakes, parts of fluke missing) are more often fatal. Most observations of humpback whales under attack from killer whales reported vigorous defensive behavior and tight grouping where more than one humpback whale was present (Ford and Reeves 2008).

Photo-identification data indicate that rake marks are often acquired very early in life, though attacks on adults also occur (Mehta et al. 2007; Steiger et al. 2008). Killer whale predation may be a factor influencing survival during the first year of life (Mehta et al. 2007). There has been some debate as to whether killer whale predation (especially on calves) is a motivating factor for the migratory behavior of humpback whales (Corkeron and Connor 1999; Clapham 2001), however, this remains unsubstantiated.

There is also evidence of shark predation on calves and entangled whales (Mazzuca et al. 1998). Shark bite marks on stranded whales may often represent post-mortem feeding rather than predation, i.e., scavenging on carcasses (Long and Jones 1996).

Other natural threats include exposure and effects from toxins and parasites. For example, domoic acid was detected in all 13 species examined in Alaska and had 38 percent prevalence in humpback whales. Saxitoxin was detected in 10 of the 13 species, with the highest prevalence in humpback whales (50%) (Lefebvre et al. 2016). Humpback whales can also carry the giant nematode *Crassicauda boopis* (Baylis 1920), which appears to increase the potential for kidney failure in humpback whales and may be preventing some populations from recovering (Lambertsen 1992). No information specific to the various DPSs is available.

Anthropogenic Threats

Fleming and Jackson (2011), Bettridge et al. (2015), and the 1991 Humpback Whale Recovery Plan (NMFS 1991) list the following range-wide anthropogenic threats for the species including fishery interactions including entanglement in fishing gear, vessel strikes, pollution, and acoustic disturbance. Here we briefly discuss these threats.

Fishery Interactions including Entanglements

Entanglement in fishing gear is a documented source of injury and mortality to cetaceans. Entanglement may result in only minor injury or may potentially significantly affect individual health, reproduction, or survival (Fleming and Jackson 2011). Bettridge et al. (2015) report that fishing gear entanglements may moderately reduce the population size or the growth rate of the Mexico and Central America DPSs.

The estimated impact of fisheries on the CA/OR/WA humpback whale stock is likely underestimated, since the serious injury or mortality of large whales due to entanglement in gear may go unobserved because whales swim away with a portion of the net, line, buoys, or pots. Pot and trap gear are the most commonly documented source of mortality and serious injury to humpback whales off the U.S. West Coast (Carretta et al. 2017a; Carretta et al. 2018a) and entanglement reports have increased considerably since 2014. In 2018, at least 12 humpback whales were reported entangled in fishing gear in inland Washington or coastal Oregon and Washington waters (NMFS West Coast Region entanglement response database). Two of these entanglements were confirmed to be commercial Dungeness crab gear, and three were gillnets.

Humpback whales feed on euphausiids and various schooling fishes, including herring, capelin, sand lance, and mackerel (Clapham 2009). The Pacific Fishery Management Council manages fisheries that target coastal pelagic species on the U.S. West Coast such as mackerel and sardine. These fisheries could reduce some of the prey available for humpback whales.

Vessel Strikes and Disturbance

Vessel strikes often result in life-threatening trauma or death for cetaceans. Impact is often initiated by forceful contact with the bow or propeller of the vessel. Ship strikes on humpback whales are typically identified by evidence of massive blunt trauma (fractures of heavy bones and/or hemorrhaging) in stranded whales, propeller wounds (deep slashes or cuts into the blubber), and fluke/fin amputations on stranded or live whales (Fleming and Jackson 2011). Humpback whales, especially calves and juveniles, are highly vulnerable to ship strikes (Stevick 1999) and other interactions with non-fishing vessels. Off the U.S. west coast, humpback whale distribution overlaps significantly with the transit routes of large commercial vessels, including cruise ships, large tug and barge transport vessels, and oil tankers in the proposed action area. Whale watching boats and research activities directed toward whales may have direct or indirect impacts on humpback whales as harassment may occur, preferred habitats may be abandoned, and fitness and survivability may be compromised if disturbance levels are too high.

Pollution

Humpback whales can accumulate persistent organic pollutants (POPs) and pesticides (e.g. Dichlorodiphenyltrichloroethane (DDT)) in their blubber, as a result either of feeding on contaminated prey (bioaccumulation) or inhalation in areas of high contaminant concentrations (e.g. regions of atmospheric deposition) (Barrie et al. 1992; Wania and Mackay 1993). The health effects of different doses of contaminants are currently unknown for humpback whales (Krahn et al. 2004b).

Recently, Elfes et al. (2010) compared POPs, in biopsy samples collected from humpback whales from different feeding areas in the North Pacific and North Atlantic. These feeding areas included the coastal waters off California, Washington, and Alaska, and off the Gulf of Maine. In general, POP levels were higher in humpback whales from the North Atlantic than whales from the North Pacific (Elfes et al. 2010). However, DDT levels in North Atlantic humpback whales were slightly less than that measured in humpback whales feeding in southern California. DDTs in humpback whales off California were remarkably high, and when compared between the two California feeding regions, the whales feeding in the southern region had levels more than 6 times those measured in whales feeding in northern California. In fact, all POP classes were higher in the blubber of humpback whales off southern California than in other feeding regions in the North Pacific. The authors note this difference was not surprising because this area, which includes the action area, is highly urbanized and impacted by more pollutant inputs (such as wastewater and stormwater) than northern California, and humpback whales demonstrate strong site fidelity to feeding areas.

Humpback whales from Alaskan waters had the lowest concentrations of POPs compared to that found in the other feeding regions off California and Washington (Elfes et al. 2010). These relatively low levels of POPs in humpback whales are not isolated to the less urbanized waters off Alaska. Stranded juvenile humpback whales in Hawaii had levels that overlapped the lower end of that found in humpbacks from Alaska (Bachman et al. 2014). Furthermore, Dorneles et al. (2015) measured POPs in humpbacks from the southern hemisphere (Antarctic Peninsula) and found concentrations were lower than that described in humpbacks from the Northern hemisphere.

Acoustic Disturbance

Anthropogenic sound has increased in all oceans over the last 50 years and is thought to have doubled each decade in some areas of the ocean over the last 30 or so years (Croll et al. 2001; Weilgart 2007). Low-frequency sound comprises a significant portion of this and stems from a variety of sources including shipping, research, naval activities, and oil and gas exploration. Understanding the specific impacts of these sounds on baleen whales, and humpback whales specifically, is difficult. However, it is clear that the geographic scope of potential impacts is vast, as low-frequency sounds can travel great distances under water.

It does not appear that humpback whales are often involved in strandings related to noise events. There is one record of two humpback whales found dead with extensive damage to the temporal bones near the site of a 5,000-kg explosion, which likely produced shock waves that were responsible for the injuries (Weilgart 2007). Other detrimental effects of anthropogenic noise include masking and temporary threshold shifts (TTS).

Summary

Between 2012-2016, there were a total of 123 human-related interactions involving the CA/OR/WA humpback whale stock. 57 of these interactions involved pot/trap fisheries, 49 were unidentified fishery interactions, 13 were vessel strikes, 3 were gillnet fisheries, and 1 was a marine mooring (Carretta et al. 2018a). There were an additional 21 entanglements and one vessel strike during this time period attributed to "unidentified whales" (totaling 17 serious injuries and mortalities), some of which were certainly humpback whales. These interactions resulted in 14.1 annual mortality and serious injury from commercial fishery entanglements, 0.2 from non-fishery entanglements, 0.15 from recreational crab pot fisheries, 2.1 from ship strikes, and 2.2 unidentified entanglements assigned to humpback whales, totaling 18.8 animals annually.

Annual human-caused mortality and serious injury from 2012-2016 for the Central North Pacific stock totaled 26 whales. Commercial fisheries represented 9.9 of these mortalities and serious injuries, 0.4 were recreational fisheries, 0.5 were subsistence fisheries, 7.7 were unknown fisheries, 2.6 were marine debris, and 4.6 were due to other causes such as ship strikes (Muto et al. 2018b). Most fisheries interactions with this stock have been attributed to Alaska or Hawaii fisheries.

The potential biological removal (PBR), which is defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population, allocation for U.S. waters is 83 whales per year for the CNP stock (the minimum population estimate for this stock is 7,890 whales) and 16.7 for the CA/OR/WA stock (the minimum population estimate for this stock is 1,876 whales) (Carretta et al. 2018b; Muto et al. 2018b). These stocks consist of a mixture of individuals from multiple DPSs; including Mexico DPS and Central America DPS humpback whales.

2.2.2 Status of Critical Habitat

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

For salmon and steelhead, NMFS ranked watersheds within designated critical habitat at the scale of the fifth-field hydrologic unit code (HUC5) in terms of the conservation value they provide to each listed species they support[22]; 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

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[22] 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" (NMFS 2005c).

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). It does not include marine or open ocean waters. http://www.nmfs.noaa.gov/pr/pdfs/fr/fr70-52630.pdf. http://www.westcoast.fisheries.noaa.gov/publications/gis_maps/maps/salmon_steelhead/critical_habitat/chin/chinook_pug.pdf.

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

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

2.2.2.2 Puget Sound Steelhead

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

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

Puget Sound steelhead also occupy marine waters in Puget Sound and vast areas of the Pacific Ocean where they forage during their juvenile and subadult life phases before returning to spawn in their natal streams (NMFS 2015a). The NMFS (NMFS 2015a), could not identify "specific areas" within the marine and ocean range that meet the definition of critical habitat. Instead, NMFS considered the adjacent marine areas in Puget Sound when designating steelhead freshwater and estuarine critical habitat. Critical habitat information can be found online at: http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead_listings/steelhead/puget_sound/puget_sound_steelhead_proposed_critical_habitat_supporting_information.html.

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

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

2.2.2.3 Puget Sound/Georgia Basin Rockfish

Critical habitat was designated for all three species of rockfish in 2014 under section 4(a)(3)(A) of the ESA (79 FR 68041, November 13, 2014), and critical habitat for canary rockfish was removed when the species was delisted on January 23, 2017 (82 FR 7711). The specific areas designated for bocaccio include approximately 1,083.11 square miles (1,743.10 sq. km) of deep water (< 98.4 feet [30 meters(m)]) and nearshore (> 98.4 feet [30 m]) marine habitat in Puget Sound. The specific areas designated for yelloweye rockfish include 438.45 square miles (705.62 sq. km) of deepwater marine habitat in Puget Sound, all of which overlap with areas designated for bocaccio. Approximately 46 percent of designated critical habitat for adult yelloweye rockfish and bocaccio overlaps with areas where the halibut fishery in Puget Sound occurs. Section 3(5)(A) of the ESA defines critical habitat as "(i) the specific areas within the geographical area occupied by the species, at the time it is listed . . . on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed . . . upon a determination by the Secretary that such areas are essential for the conservation of the species."

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

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

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

Juvenile bocaccio only: Juvenile settlement sites located in the nearshore with substrates such as sand, rock, and/or cobble compositions that also support kelp. These features are essential for conservation because they enable forage opportunities and refuge from predators, and enable behavioral and physiological changes needed for juveniles to occupy deeper adult habitats. Several attributes of these sites affect the quality of the area and are useful in considering the conservation value of the feature in determining whether the feature may require special management considerations or protection, and in evaluating the effects of a Proposed 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 C.F.R. § 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 C.F.R. § 424.02(j) define "special management considerations or protection" to mean "any methods or procedures useful in protecting physical and biological features of the environment for the conservation of listed species." We identified a number of activities that may affect the physical and biological features essential to yelloweye rockfish and bocaccio such that special management considerations or protection may be required. Major categories of such activities include: (1) nearshore development and in-water construction (e.g., beach armoring, pier construction, jetty or harbor construction, pile driving construction, residential and commercial construction); (2) dredging and disposal of dredged material; (3) pollution and runoff; (4) underwater construction and operation of alternative energy hydrokinetic projects (tidal or wave energy projects) and cable laying; (5) kelp harvest; (6) fisheries; (7) non-indigenous species introduction and management; (8) artificial habitat creation; (9) research activities; (10) aquaculture, and (11) activities that lead to global climate change.

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

2.2.2.4 Southern Resident Killer Whale

Critical habitat for the Southern Resident killer whale DPS was designated on November 29, 2006 (71 FR 69054). Critical habitat includes approximately 2,560 square miles of inland waters of Washington in 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. On January 21, 2014, NMFS received a petition requesting that we revise critical habitat citing recent information on the whales' habitat use along the West Coast of the United States. Center for Biological Diversity proposes that the critical habitat designation be revised and expanded to include areas of the Pacific Ocean between Cape Flattery, WA, and Point Reyes, CA, extending approximately 47 miles (76 km) offshore. NMFS published a 90-day finding on April 25, 2014 (79 FR 22933) that the petition contained substantial information to support the proposed measure and that NMFS would further consider the action. We also solicited information from the public. Based upon our review of public comments and the available information, NMFS issued a 12-month finding on February 24, 2015 (80 FR 9682) describing how we intended to proceed with the requested revision, which is currently in development.

Water Quality

Water quality in Puget Sound, in general, is degraded as described in the Puget Sound Partnership 2018-2022 Action Agenda and Comprehensive (Puget Sound Partnership 2018). For example, toxicants in Puget Sound persist and build up in marine organisms including Southern Residents and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. The primary concern for direct effects on whales from water quality is oil spills, although oil spills can also have long-lasting impacts on other habitat features. The Environmental Protection Agency and U.S. Coast Guard oversee the Oil Pollution Prevention regulations promulgated under the authority of the Federal Water Pollution Control Act. There is a Northwest Area Contingency Plan, developed by the Northwest Area Committee, which serves as the primary guidance document for oil spill response in Washington and Oregon. In 2017, the Washington State Department of Ecology published a new Spill Prevention, Preparedness, and Response Program Annual Report describing the Spills Program as well as the performance measures from 2007 – 2017 (WDOE 2017).

Prey Quantity, Quality, and Availability

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

Contaminants and pollution also affect the quality of Southern Resident killer whale prey in Puget Sound. Contaminants enter marine waters and sediment from numerous sources, but are typically concentrated near areas of high human population and industrialization. Once in the environment these substances proceed up the food chain, accumulating in long-lived top predators like Southern Resident killer whales. Chemical contamination of prey is a potential threat to Southern Resident killer whale critical habitat, despite the enactment of modern pollution controls in recent decades, which were successful in reducing, but not eliminating, the presence of many contaminants in the environment. The size of Chinook salmon is also an important aspect of prey quality (i.e., Southern Residents primarily consume large Chinook, as discussed above), and any reduction in Chinook salmon size is therefore a threat to their critical habitat. In addition, vessels and sound may reduce the effective zone of echolocation and reduce availability of fish for the whales in their critical habitat (Holt 2008).

Passage

Southern Residents are highly mobile and use a variety of areas for foraging and other activities, as well as for traveling between these areas. Human activities can interfere with movements of the whales and impact their passage. In particular, vessels may present obstacles to whale passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior (review in NMFS (2010c), Ferrara et al. (2017)).

2.2.2.5 Humpback Whale DPS Critical Habitat

There is no critical habitat designated for the any of the listed humpback whale DPSs. At the time NMFS revised the listing of humpback whales under the ESA (81 FR 62260; September 8, 2016), NMFS found that critical habitat was not determinable for the three listed DPSs in U.S. waters (the endangered Western North Pacific and Central America DPSs, and the threatened Mexico DPS). If critical habitat is not determinable at the time of listing, regulations allow NMFS one additional year in which to publish a final regulation designating such habitat (50 CFR 424.17(b)).

In March 2018, the Center for Biological Diversity, Turtle Island Restoration Network, and the Wishtoyo Chumash Foundation filed a lawsuit against NMFS for failure to designate critical habitat. Per a stipulated settlement agreement and a stipulated request to extend the deadlines, NMFS plans to submit to the *Federal Register* for publication a proposed determination concerning the designation of critical habitat for the three DPSs (i.e., proposing to designate critical habitat or finding that it would not be prudent to do so) by September 26, 2019. To the extent NMFS has published a proposed rule to designate critical habitat, NMFS will submit to the *Federal Register* for publication a final determination concerning the designation of critical habitat for the DPSs by September 28, 2020.

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02). For the purposes of this opinion, the action area (Figure 15) includes all marine water fishing areas and fishing areas in rivers entering into 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 (treaty Indian drift net, set net, and purse seine fisheries) , and in the San Juan Islands region Catch Reporting Areas 6, 6A (treaty only), 7, and 7A; treaty Indian drift net, set net, and purse seine fisheries and non-treaty drift net, reef net, and purse seine fisheries.

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

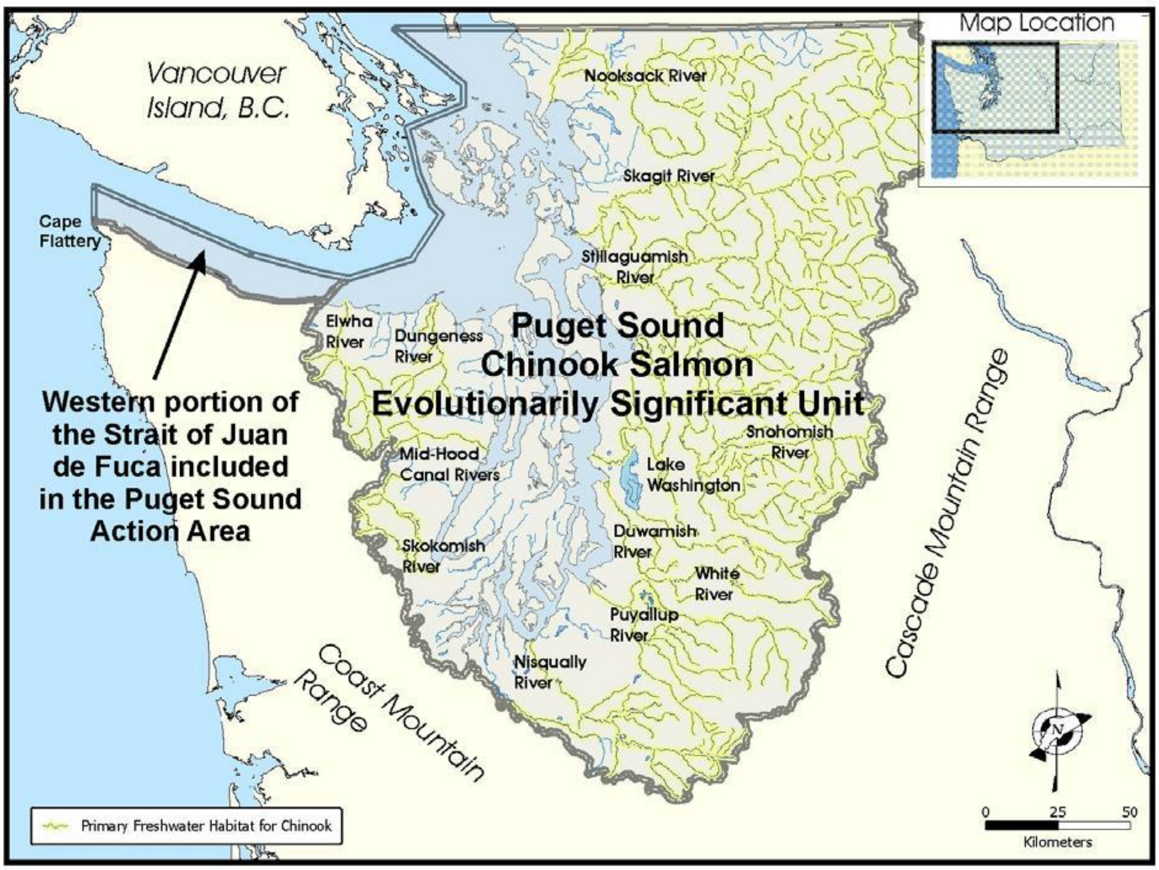

Figure 15. Puget Sound Action Area, which includes the Puget Sound Chinook ESU and the western portion of the Strait of Juan de Fuca in the United States.

2.4 Environmental Baseline

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

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

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

2.4.1 Puget Sound Chinook and Steelhead

Climate change and other ecosystem effects

Changes in climate and ocean conditions happen on several different time scales and have had a profound influence on distributions and abundances of marine and anadromous fishes. Evidence suggests that marine survival among salmonids fluctuates in response to 20 to 30-year cycles of climatic conditions and ocean productivity. The fluctuations in salmon survival that occur with these changes in climate conditions can also affect species that depend on salmon for prey such as Southern Resident killer whales. More detailed discussions about the likely effects of large-scale environmental variation on salmonids, including climate change, are found in Section 2.2.1 of this opinion, and biological opinions on the Snohomish Basin Salmonid Hatchery Operations (NMFS 2017c) and the implementation of the Mitchell Act (NMFS 2017d). The University of Washington Climate Impacts Group summarized the current state of knowledge of climate change and anticipated trends on Puget Sound and its environs including those that would affect salmon (Mauger et al. 2015). Warmer streams, ocean acidification, lower summer stream flows, and higher winter stream flows are projected to negatively affect salmon. The persistence of cold water "refugia" within rivers and the diversity among salmon populations will be critical in helping salmon populations adapt to future climate conditions. Similar types of effects on salmon may occur in the marine ecosystem including warmer water temperatures, loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (Mauger et al. 2015).

Harvest

Salmon and steelhead fisheries

In the past, fisheries in Puget Sound were generally not managed in a manner appropriate for the conservation of naturally spawning Chinook salmon populations. Fisheries exploitation rates were in most cases too high—especially 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 more 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 = -33%, range = -67 to +30%)(New FRAM base period validation results, August 2017). 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 have managed Chinook mortality in Puget Sound salmon and Tribal steelhead fisheries to meet the conservation and allocation objectives described in the jointly-developed 2010-2014 Puget Sound Chinook Harvest RMP (PSIT and WDFW 2010a), and as amended in 2014 (Grayum and Anderson 2014; Redhorse 2014), 2015, 2016, 2017, and 2018 (Grayum and Unsworth 2015; Shaw 2015; 2016; Speaks 2017). The 2010-2014 Puget Sound Chinook Harvest RMP was adopted as the harvest component of the Puget Sound Salmon Recovery Plan for the Puget Sound Chinook ESU (NMFS 2011a). Recent year exploitation rates are summarized in Table 12 **(**FRAM validation runs, August 2017**)**.

Fifty percent or more of the harvest of 8 of the 14 Puget Sound Chinook salmon management units occurs in salmon fisheries outside the Action Area, primarily in Canadian waters (Table 12). Salmon fisheries in Canadian waters are managed under the terms of the PST. Ocean salmon fisheries in contiguous U.S. federal waters are managed by NMFS and the PFMC, under the MSA. For salmon fisheries off of the Southeast coast of Alaska, in Federal waters, the North Pacific Fisheries Management Council (NPFMC) delegates its management authority to the State of Alaska. All salmon fisheries in U.S. federal waters are managed consistent with the PST. The effects of these Northern fisheries on Puget Sound Chinook were assessed in previous biological opinions (NMFS 2004a; 2008d; 2019b).

Table 12. Average 2009 to 2016 total and southern U.S. (SUS) exploitation rates (ER) for Puget Sound Chinook management units (see Table 3 for correspondence to populations). This encompasses the provisions of the most recent Pacific Salmon Treaty Chinook Annex.

Management Unit	% of total ER in AK/CAN fisheries	SUS Exploitation Rate (PFMC and PS fisheries)	Total Exploitation Rate	Total ER Pre-listing (1992-1998)
Nooksack early	78%	7%	30%	48%
Skagit spring	50%	11%	21%	23%
Skagit summer/fall	58%	26%	45%	45%
Stillaguamish	64%	8%	23%	32%
Snohomish	63%	7%	19%	40%
Lake Washington	48%	15%	28%	43%
Duwamish-Green River	42%	18%	31%	49%
White River	33%	15%	22%	28%
Puyallup River	29%	32%	45%	59%
Nisqually River	18%	43%	52%*	75%
Skokomish River	20%	46%	58%*	41%
Mid-Hood Canal rivers	52%	11%	23%	33%
Dungeness River	72%	4%	15%	12%
Elwha River	75%	4%	14%	17%

*Beginning in 2010, the Skokomish Chinook Management Unit was managed for 50% and the Nisqually Chinook Management Unit was managed for stepped harvest rates of 65% (2010-11) – 56% (2012-2013) – 52% (2014-2015), 50% (2016), 47% (2017).

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

In marine areas, the majority of fisheries target salmon species other than steelhead. However, Puget Sound treaty marine salmon fisheries encounter listed summer and winter steelhead. An annual average of 126 (hatchery and wild combined) (range 7 – 266) summer and winter steelhead were landed incidentally in treaty marine fisheries (commercial and ceremonial and subsistence) from all Puget Sound marine areas combined during the 2001/2002 to 2006/2007 time period[23]. An annual average of 59 (hatchery and wild combined) (range 2 – 128) summer and winter steelhead were landed incidentally in treaty marine fisheries from all Puget Sound marine areas combined during the 2008/2009 to 2017/2018 time period (WDFW and PSTIT 2016a; 2017a; WDFW and PSIT 2018; WDFW and PSTIT 2019). 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 (James 2018c).

In marine non-treaty salmon commercial fisheries retention of steelhead is prohibited (Revised Code of Washington (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)). From 2009 to 2018, 36 steelhead were encountered in 3,440 observed sets (Addae 2019). With retention of steelhead prohibited, WDFW Enforcement may seize any retained steelhead landed. In 2013 an additional 4 steelhead were recorded as "seized" during the MCA 7 net fisheries (Addae 2019). The catch estimates reported include listed and non-listed unmarked and marked steelhead. When steelhead are observed in the net, fishery observers attempt to record the mark status, and collect scales and a fin clip for genetic stock identification (GSI). If it is determined that the process of collecting biological information will be at the detriment of the fish, the observers only record the encounter and return the fish to the water (Addae 2019).

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 106 (range 15 – 213) hatchery summer and winter steelhead were landed incidentally in non-treaty marine recreational fisheries from all Puget Sound marine areas combined during the 2008/2009 to 2017/2018 time period (WDFW and PSTIT 2019). The catch of steelhead in recreational fisheries has therefore declined by 54% in recent years. There is some additional mortality associated with the catch-and-release of unmarked steelhead in the recreational fishery. However, the mortality rate associated with catch-and-release is 10%, so the additional mortality is assumed to be low.

In summary, at the time of listing, during the 2001/02 to 2006/07 seasons, an average of 325 steelhead were caught in marine treaty and non-treaty commercial, ceremonial and subsistence

[23] NMFS 2010: Unpublished data on Puget Sound steelhead harvest rates from 2001/2002 to 2006/2007

(C&S), and recreational fisheries (i.e., 126 treaty marine; 1 non-treaty commercial; 198 non-treaty recreational). An average of 169 steelhead were caught in marine treaty and non-treaty commercial, ceremonial and subsistence, and recreational fisheries (i.e., 59 treaty marine; 4 non-treaty commercial; 106 non-treaty recreational) for the most recent time period (2007/2008 to 2017/2018) (Table 13). The fish caught include ESA-listed steelhead, unlisted hatchery steelhead, and hatchery and natural-origin fish from Canada. Overall, the average treaty and non-treaty catch in marine area fisheries has declined by 48% compared with the earlier period.

Table 13. Average marine area catch on steelhead from 2001/02 to 2006/07 and 2007/08 to 2017/18 time periods.

	Marine Catch			
Time Period	**Treaty commercial & C&S**	**Non-Treaty Commercial**	**Non-Treaty Recreational**	**Total**
2001/02 to 2006/07	126	1	198	325
2007/08 to 2017/18	59	4	106	169

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. These fisheries also capture natural-origin summer run steelhead incidentally while targeting other salmon species. However, these impacts are likely low 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). 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.

On April 11, 2018 NMFS approved a five-year, joint tribal and state plan for a treaty harvest and recreational catch and release fishery for natural-origin steelhead in the Skagit River basin under the ESA 4(d) rule (NMFS 2018a). Fishing under this plan occurred in the Skagit River and surrounding marine areas from April 14, 2018 until April 29, 2018. In the short time the Skagit recreational catch-and-release steelhead fishery was open for 2018 an estimated total of 568 wild steelhead were caught and released (WDFW and PSTIT 2018). In addition three hatchery steelhead were caught and kept (WDFW and PSTIT 2018). The annual, allowable catch in the Skagit area fisheries covered by this plan will be determined using a tiered system based on terminal run size estimates for the Skagit River (Table 14). NMFS (2018a) concluded that the effects of the Skagit steelhead fishery to the viability and recovery of the Puget Sound steelhead DPS would be low.

Table 14. Steelhead impact levels as proposed by the Skagit River RMP. Impact levels include both treaty harvest and recreational catch and release fisheries and are tiered based on forecasted terminal run levels for natural-origin steelhead (Sauk-Suiattle Indian Tribe et al. 2016).

Preseason Forecast for Natural-Origin Skagit Steelhead	Allowable Impact Rate Terminal Run
≤ 4,000	4%
4,001 ≤ Terminal Run <6,000	10%
6,001 ≤ Terminal Run <8,000	20%
Terminal Run ≥ 8,001	25%

Available data on escapement of summer, winter, and summer/winter steelhead populations in Puget Sound are limited. For the five Puget Sound summer-run populations, no complete long-term time series of escapement and catch to perform total run reconstructions are available, however an escapement time series is available for one of these (Tolt R. summer-run) (Marshall 2018). Complete long-term time series of escapement and run reconstruction data are available for 14 of the 23 winter run populations, and for none of the four summer/winter run populations (Marshall 2018). Additionally 3 Puget Sound winter-run steelhead populations have long-term time series of escapement data but no harvest data for run reconstruction (Marshall 2018). However, a combined time series of escapement and run reconstruction data for Skagit River summer/winter and Sauk River summer/winter populations is available (Marshall 2018). Data are currently insufficient to provide a full run reconstruction of natural-origin steelhead populations needed to assess harvest rates for any of the summer-run steelhead populations and many of the summer/winter and winter run populations. Given these circumstances, NMFS used the available data for five Puget Sound winter and summer/winter steelhead populations to calculate terminal harvest rates on natural-origin steelhead. NMFS calculated that the harvest rate on a subset of watersheds for natural-origin steelhead averaged 4.2% annually in Puget Sound fisheries during the 2001/2002 to 2006/2007 time period just prior to listing (NMFS 2010b) (Table 15). Average harvest rates on the same subset of watersheds for natural-origin steelhead demonstrated a reduction to 1.43% in Puget Sound fisheries during the 2007/2008 to 2017/2018 time period (Table 15). These estimates include sources of non-landed mortality such as hooking mortality and net dropout. Overall, the average harvest rate for these five indicator populations declined from 4.2% to 1.43% (i.e., 66.0% decline) through 2018.

Table 15. 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 PSTIT 2017a; 2018; 2019).

Year	Skagit	Snohomish	Green	Puyallup	Nisqually[a]
2001-02	4.2	8.0	19.1	15.7	N/A
2002-03	0.8	0.5	3.5	5.2	N/A
2003-04	2.8	1.0	0.8	2.2	1.1
2004-05	3.8	1.0	5.8	0.2	3.5
2005-06	4.2	2.3	3.7	0.8	2.7
2006-07	10.0	N/A[b]	5.5	1.7	5.9
Avg HRs 2001-07	**4.3**	**2.6**	**6.4**	**4.3**	**3.3**
Total Avg HR	**4.2%** total average harvest rate across populations from 2001-02 to 2006-07				
2007-08	5.90	0.40	3.50	1.00	3.70
2008-09	4.90	1.10	0.30	0.00	3.70
2009-10	3.30	2.10	0.40	0.00	1.20
2010-11	3.40	1.50	1.60	0.60	1.80
2011-12	2.90	0.90	2.00	0.40	2.50
2012-13	2.30	1.10	2.38	0.70	1.10
2013-14	2.60	0.89	1.09	0.56	1.33
2014-15	1.25	1.00	1.05	0.54	0.89
2015-16	1.12	0.90	0.92	0.06	0.20
2016-17	1.70	1.00	0.90	0.10	0.00
2017-18	1.87	1.20	0.50	0.10	0.10
Avg HRs 2007-18	**2.84**	**1.10**	**1.33**	**0.37**	**1.50**
Total Avg HR	**1.43%** total average harvest rate across all populations from 2007-08 to 2017-18				
Total average HR 2001-02 to 2017-18	**2.35**				

[a] Escapement methodology for the Nisqually River was adjusted in 2004; previous estimates are not comparable.
[b] Catch estimate not available in 2006-07 for Snohomish River.

As mentioned above, NMFS concluded in the final steelhead listing determination that previous harvest management practices likely contributed to the historical decline of Puget Sound steelhead. However, 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. The NWFSC's recent status review update confirmed continued declines in natural-origin steelhead harvest rates are not likely to substantially affect steelhead spawner abundance in the DPS (NWFSC 2015). The addition of Skagit steelhead harvest in 2018 is also projected to have very low impact on these spawner abundances in the long term and the five year Skagit steelhead harvest plan would not jeopardize the DPS (NMFS 2018a).

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 2018d). The total estimated non-retention mortality of Chinook salmon in Puget Sound recreational halibut fisheries is extremely low, averaging just under two Chinook salmon per year. Of these, the estimated catch of listed fish (hatchery and wild) is between one and two Puget Sound Chinook per year. Given the very low level of impacts and the fact that the fishery occurs in mixed stock areas, different populations within the ESUs are likely affected each year. No steelhead have been observed in the fishery.

Puget Sound bottomfish and shrimp trawl fisheries

Recreational fishers targeting bottom fish and the shrimp trawl fishery in Puget Sound can incidentally catch listed Puget Sound Chinook. In 2012 NMFS issued an incidental take permit to the WDFW for listed species caught in these two fisheries, including Puget Sound Chinook salmon (NMFS 2012). The permit was in effect for 5 years and authorized the total incidental take of up to 92 Puget Sound Chinook salmon annually. Some of these fish would be released. Some released fish were expected to survive; thus, of the total takes, we authorized a subset of lethal take of up to 50 Chinook salmon annually. As of 2018 this permit has not been renewed. WDFW has applied for a permit allowing incidental take of 137 Chinook annually in the coming years.

Hatcheries

Hatcheries can provide benefits to the status of Puget Sound Chinook and steelhead by reducing demographic risks and preserving genetic traits for populations at low abundance in degraded habitats. In addition, hatcheries help to provide harvest opportunity, which is an important contributor to the meaningful exercise of treaty rights for the Northwest tribes. Hatchery-origin fish may also pose risk to listed species 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 about their effects became available (PSIT and WDFW 2004), in response to reviews of hatchery programs (e.g., Busack and Currens (1995), HSRG (2000), Hatchery Scientific Review Group (2002)), and as part of the region-wide Puget Sound salmon recovery planning effort (SSPS 2005). 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 broodstocks that differ substantially from natural populations, such as out-of-basin or out-of-ESU stocks, and 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 protocols[24] 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 Coded Wire Tags (CWTs) or with a clipped adipose fin so that they can be differentiated and accounted for separately from juvenile and returning adult natural-origin fish.

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

There are currently 13 hatchery programs in Puget Sound that propagate steelhead. Currently

[24] 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.

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, one conservation program operates to rebuild the native White River winter-run steelhead population. Upon construction of the Fish Restoration Facility in the Green River basin, two conservation programs will operate to rebuild the native Green River winter-run steelhead, in order to mitigate for lost natural-origin steelhead abundance and harvest levels associated with the placement and operation of Howard Hanson Dam (Jones 2015). 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 functioned to rebuild native stock winter-run steelhead abundances in the Dewatto, Duckabush, and South Fork Skokomish river watersheds. The original Hood Canal Steelhead Supplementation program has been terminated with the last adult fish produced returning in 2019. A newer recovery program operated out of the North Fork Skokomish Hatchery by Tacoma Power and Utilities now supports the recovery of native Skokomish River winter steelhead. The Elwha River Native Steelhead program preserves and assists in the recolonization of native Elwha River winter-run steelhead. The integrated programs listed above produce hatchery-origin steelhead 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.

On April 15, 2016, NMFS announced the release of a Final Environmental Impact Statement (FEIS; NMFS 2016e)) its decision (Turner 2016b; 2016a) regarding its approval under the salmon and steelhead 4(d) rule of early winter steelhead Hatchery and Genetic Management Programs (HGMPs) submitted by the co-managers. The HGMPs describe five early winter steelhead hatchery programs in the Dungeness, Nooksack, Stillaguamish, Skykomish, and Snoqualmie River basins. NMFS approved the programs as consistent with ESA requirements.

After a two year hiatus in response to a settlement agreement between WDFW and an environmental group, smolt releases from these programs were reinitiated in 2016 after their approval by NMFS under ESA 4(d) rule, limit 6 for effects on ESA-listed steelhead and Chinook salmon (NMFS 2016d; 2016e). In evaluating and approving the Early Winter Steelhead (EWS) programs for effects on listed fish (NMFS 2016d; 2016e), and based on analyses of genetic data provided by WDFW (Warheit 2014), NMFS determined that gene flow levels for the five EWS programs were very low and unlikely to pose substantial genetic diversity reduction risks to natural-origin winter-run steelhead populations. Of particular importance to this harvest evaluation is that EWS have been artificially selected to return and spawn in peak abundance as adults earlier in the winter than the associated natural-origin Puget Sound winter-run steelhead populations in the watersheds where the hatchery fish are released. This timing difference, in addition to other factors, including hatchery risk reduction management measures that reduce natural spawning and natural spawning success by EWS act to reduce gene flow and associated genetic risks to natural-origin steelhead. The temporal separation between EWS and natural-origin steelhead adult return and spawn timing provides protection to the later-returning natural-origin steelhead populations in harvest areas when and where fisheries directed at EWS occur (Crawford 1979).

Three other harvest augmentation programs propagate non-listed early summer-run steelhead (ESS) derived from Columbia River, Skamania stock. The EWS and ESS stocks reared and released as smolts through the eight programs are considered more than moderately diverged from any natural-origin steelhead stocks in the region and were therefore excluded from the Puget Sound Steelhead DPS. Gene flow from naturally spawning fish produced by the eight hatchery programs may pose genetic risks to natural-origin steelhead (NMFS 2016e).

As described in Section 2.2.1.2, NWFSC (2015) hatchery steelhead releases in Puget Sound have declined in most areas. Between 2007 and 2014 Puget Sound steelhead hatchery releases totaled about 2,468,000 annually (NMFS 2014a). These reductions were largely due to the need to reduce risks to natural Puget Sound steelhead after the 2007 listing and subsequent risk analyses (NMFS 2014a; Warheit 2014). Reductions were focused on unlisted steelhead programs. Currently hatchery programs propagating unlisted steelhead in Puget Sound account for approximately 57% of hatchery-origin steelhead smolt releases, which total 891,000 annually (this total includes 490,000 summer steelhead and 401,000 winter steelhead) in the Puget Sound DPS (Appendix A in NMFS (2016e)). When compared to total historic release levels analyzed for the EWS and ESS in the Puget Sound Hatcheries DEIS prepared in 2004 (Appendix A in NMFS (2004c)), which was prior to listing, this represents an overall reduction of 31%. The number of EWS releases in 2005 compared to proposed levels in 2018 alone represent a 77% reduction after listing.

The ESS as well as other on-going programs, currently operated by the State of Washington, that have not undergone ESA consultation are reviewed in The Cumulative Effects Section 2.6 of the Opinion.

Habitat

Human activities have degraded extensive areas of salmon and steelhead 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 2005).

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 2005). 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 (Elwha-Dungeness Planning Unit 2005; SSPS 2005). 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 2005). There are substantial habitat blockages by dams in the Skagit and Skokomish River basins, in the Elwha until 2013 which was prior to the implementation of the Elwha Dam Removal Plan, and minor blockages, including impassable culverts, throughout the region. Historically, low flows resulting from operation of the Cushman dams and habitat degradation of freshwater and estuarine habitat have adversely affected the Skokomish basin. 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 through on-going restoration activities, and restore an early Chinook life history in the river using supplementation. 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 Elwha[25] river basins (Appendix B in NMFS (2015a)). 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 (2015a)). 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 (2015a)). Forestry practices, urban development, and agriculture have resulted in the loss of wetland and riparian habitat, creating dramatic changes in the hydrology of many streams, 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). Additionally 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 2015a). Constriction of river flows, particularly during high flow events, increases the

[25] 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.

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 2015a). In addition to being a factor that contributed to the present decline of Puget Sound Chinook and steelhead populations, the continued destruction and modification of habitat is the principal factor limiting the viability of the Puget Sound Chinook and steelhead into the foreseeable future (72 FR 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 (2015a)).

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

2.4.2 Puget Sound/Georgia Basin Rockfish

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

Most of the benthic deepwater (e.g., deeper than 90 feet (27.4 m)) 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 (Palsson et al. 2009; Drake et al. 2010). Some benthic habitats have been impacted by derelict fishing gear that include lost fishing nets, and shrimp and crab pots (Good et al. 2010). Derelict fishing gear can continue “ghost” fishing and is known to kill rockfish, salmon, and marine mammals as well as degrade rocky habitat by altering bottom composition and killing numerous species of marine fish and invertebrates that are eaten by rockfish (Good et al. 2010). Thousands of nets have been documented within Puget Sound and most have been found in the San Juan Basin and the Main Basin. The Northwest Straits Initiative has operated a program to remove derelict gear throughout the Puget Sound region. In addition, WDFW and the Lummi, Stillaguamish, Tulalip, Nisqually, and Nooksack Tribes and others have supported or conducted derelict gear prevention and removal efforts. Net removal has mostly concentrated in waters less than 100 feet (33 m) deep where most lost nets are found (Good et al. 2010). The removal of over 4,600 nets and over 3,000 derelict pots have restored over 650 acres of benthic habitat[26], 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. Because habitats deeper than 100 feet (30.5 m) are most readily used by adult yelloweye rockfish and bocaccio, there is an unknown 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 can affect adult and juvenile rockfish habitat and/or the prey that support them. Toxic pollutants in Puget Sound include oil and grease, 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). There are no studies to date that define specific adverse health effects thresholds for specific toxicants in any rockfish species; however, it is likely that PCBs pose a risk to rockfish health and fitness (Palsson et al. 2009). About 32 percent of the sediments in the Puget Sound region are considered to be moderately or highly contaminated (PSAT 2007), though some areas are undergoing clean-up operations that have improved benthic habitats (Sanga 2015).

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

[26] Derelict fishing gear removal data in Puget Sound. Available at: http://www.derelictgear.org/.

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

We discuss fisheries management pertinent to rockfish that is part of the environmental baseline in the Puget Sound area as a context for the fisheries take authorized within previous section 7 consultations (NMFS 2016a). In addition, we briefly summarize fisheries management in Canadian waters of the DPSs, as it is relevant to listed rockfish that use waters in Canada and the San Juan area. In 2010, the Washington State Fish and Wildlife Commission formally adopted regulations that ended the retention of rockfish by recreational anglers in Puget Sound and closed fishing for bottom fish in all waters deeper than 120 feet (36.6 m). On July 28, 2010, WDFW enacted the following package of regulations by emergency rule for the following non-tribal commercial fisheries in Puget Sound in order to protect dwindling rockfish populations:

1) Closure of the set net fishery
2) Closure of the set line fishery
3) Closure of the bottom trawl fishery
4) Closure of the inactive pelagic trawl fishery
5) Closure of the inactive bottom fish pot fishery

As a precautionary measure, WDFW closed the above commercial fisheries westward of the listed rockfish DPSs' boundary to Cape Flattery. The WDFW extended the closure west of the rockfish DPSs' boundary to prevent commercial fishermen from concentrating gear in that area. The commercial fisheries closures listed above were enacted on a temporary basis and WDFW permanently closed them in February 2011. The pelagic trawl fishery was closed by permanent rule on the same date.

The DPS area for yelloweye rockfish and bocaccio includes areas of the Georgia Strait thus the status of the environmental baseline and rockfish management influences fish within Puget Sound. Fisheries management in British Columbia, Canada, 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 percent of rockfish habitat of the inside waters of Vancouver Island (Yamanaka and Logan 2010). The Department of Fisheries and Oceans (DFO) defined and mapped "rockfish habitat" from commercial fisheries log Catch Per Unit Effort (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. Because 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 contain less than optimum areas of rockfish habitat (Haggarty 2013). Systematic monitoring of the RCAs may be lacking as well (Haggarty 2013). The DFO, WDFW, and NMFS conducted fish population surveys of some of the RCAs in 2018 but the results of these surveys are still being processed. Outside the RCAs, recreational fishermen generally may keep one rockfish per day from May 1 to September 30. Commercial rockfish catches in Area 4(b) are managed by a quota system (DFO 2011).

2.4.3 Southern Resident Killer Whales

The final recovery plan for Southern Resident killer whales reviews and assesses the potential factors affecting Southern Residents, and lays out a recovery program to address each of the threats (NMFS 2008f). As described in the Status of the Species (2.2.1.4), the limiting factors identified include reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008f). This section summarizes these primary threats in the action area and focuses primarily on actions that affect prey availability.

Prey Availability

Chinook salmon are the primary prey of Southern Resident killer whales throughout their geographic range, which includes the action area (see further discussion in Section 2.2.1, Status of the Species). The availability of Chinook salmon to Southern Residents is affected by a number of natural and human actions. The most notable human activities that cause adverse effects include land use activities that result in habitat loss and degradation, hatchery practices, harvest and hydropower systems. Details regarding baseline conditions of Puget Sound Chinook salmon in inland waters that are listed under the Endangered Species Act are described in Section 2.4.1.

The baseline also includes Chinook salmon that are not ESA-listed, notably Puget Sound hatchery Chinook salmon stocks that are not part of the listed entity, as well as Fraser River and Georgia Strait stocks of Chinook salmon. In addition, climate effects from Pacific decadal oscillation and the El Nino/Southern oscillation conditions and events cause changes in ocean productivity which can affect natural mortality of salmon. Predation in the ocean also contributes to natural mortality of salmon. Salmonids are prey for pelagic fishes, birds, and marine mammals (including Southern Resident killer whales). Recent work by Chasco et al. (2017a) estimated that marine mammal predation of Chinook salmon off the West Coast of North America has more than doubled over the last 40 years. They found that resident salmon-eating killer whales consume the most Chinook salmon by biomass, but harbor seals consume the most individual Chinook salmon (typically smolts). In particular, they noted that southern Chinook salmon stocks ranging south from the Columbia River have been subject to the largest increases in predation, and that Southern Residents may be the most disadvantaged compared to other more northern resident killer whale populations given the northern migrations of Chinook salmon stocks in the ocean. Ultimately, Chasco et al. (2017a) concluded that these increases in marine mammal predation of Chinook salmon could be masking recovery efforts for salmon stocks, and that competition with other marine mammals may be limiting the growth of the Southern Resident population.

Here we provide a review of Southern Resident killer whale determinations in previous ESA Section 7(a)(2) consultations where effects occurred in the action area, and where effects resulted in a significant reduction in available prey (i.e., where prey reduction was likely to adversely affect or jeopardize the continued existence of the whales). We also consider activities that have impacts in the action area, and are out of our jurisdiction for Section 7(a)(2) consultation, but nonetheless significantly reduce available prey. We then assess the remaining prey available to Southern Resident killer whales in light of this environmental baseline.

Habitat-altering activities such as agriculture, forestry, marine construction, levy maintenance, shoreline armoring, dredging, hydropower operations and new development can reduce prey available to Southern Residents. Many of these activities have a federal nexus and have undergone section 7 consultation. Those actions have all met the standard of not jeopardizing the continued existence of the listed salmonids or adversely modifying their critical habitat, or if they did not meet that standard, NMFS identified reasonable and prudent alternatives. In addition, the environmental baseline is influenced by many actions that pre-date the salmonid listings and that have substantially degraded salmon habitat and lowered natural production of Puget Sound Chinook salmon. Since the Southern Residents were listed, federal agencies have consulted on impacts to the whales in addition to salmonids, including impacts to available prey. In 2014, NMFS finalized its biological opinion on the operation and maintenance of the Mud Mountain Dam project (NMFS 2014c). The opinion concluded that the proposed action would jeopardize the continued existence of Puget Sound Chinook salmon, Puget Sound steelhead, and Southern Resident killer whales and would adversely modify or destroy their designated critical habitats. We have also previously consulted on the effects of flood insurance on Southern Residents. NMFS' biological opinion on the National Flood Insurance Program in Washington State-Puget Sound region concluded that the action was likely to jeopardize the continued existence of the Puget Sound Chinook salmon ESU, and that the potential extinction of this ESU in the long-term jeopardized the continued existence of Southern Residents (NMFS 2008f). We recently consulted on the Howard Hanson Dam, Operations, and Maintenance (NMFS 2019a). The opinion concluded that the proposed action would jeopardize the continued existence of Puget Sound Chinook salmon, Puget Sound steelhead, and Southern Resident killer whales. For these consultations, RPAs were identified in order to avoid jeopardy and not adversely modify or destroy designated critical habitat (NMFS 2008f; 2014c).

In the past harvest opinions for salmon fisheries in Puget Sound (NMFS 2011a; 2014b; 2015c; 2016c; 2017b; 2018b; 2019b), 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 salmon abundance that occur during the specified year or years defined in the opinions, 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. 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. In the most recent harvest opinion (NMFS 2019b), we also considered an additional proposed action related to the funding of a conservation program for Puget Sound Chinook salmon and Southern Resident killer whales and included support to hatchery programs and address limiting habitat conditions to benefit the salmon and the whales. It is anticipated that the conservation hatchery and habitat programs would focus on and contribute to prey abundance for Southern Residents in times and areas considered most important to Southern Resident killer whales. The increase in prey availability is expected to offset some of the loss estimated from fisheries managed under the Pacific Salmon Treaty (NMFS 2019b).

Assessing Baseline Prey Availability

We assessed Chinook availability in the action area in 2019 before Puget Sound fisheries by using a similar retrospective FRAM based analysis to that used for the 2010 Puget Sound Chinook Harvest Resource Management Plan (NMFS 2011a) with similar updates used in the consultation on the 2018 Puget Sound fisheries (NMFS 2018b). We incorporated new FRAM base data along with new information available on the diet of Southern Resident killer whales (see Status of the Species section) and updated bioenergetics needs (based on updates to the population size and age- and sex- structure). The Chinook salmon abundances and kilocalorie values estimated using the new FRAM base period (2007-2013) yielded different estimates than for the 2010 Resource Management Plan for the same fishing years modeled and thus cannot be directly compared. Here, we briefly describe the method developed to estimate the food energy of Chinook available, and provide recent updates to this methodology.

FRAM provides year-specific ocean abundance estimates for most Chinook salmon stocks from the Sacramento River to central British Columbia including nearly all listed (with the exception of Sacramento winter Chinook and California coastal Chinook salmon) and non-listed Chinook stocks within the whales' range (with the exception of Klamath, Rogue and other central-southern Oregon Coastal Chinook salmon). All Chinook stocks in FRAM travel through the range of Southern Resident killer whales.

FRAM is a single-pool model and does not have spatial distribution of the stocks represented in it. However, the stock-specific catch by area during a period of less restricted open seasons, combined with escapement, can be used to estimate the distribution of each stock and allocate abundances into three regions: (1) waters of northern British Columbia and SEAK that are outside the range of Southern Residents, (2) coastal waters within their range from central British Columbia southward, and (3) inland waters including the Strait of Juan de Fuca, Puget Sound, Johnstone Strait and Georgia Strait. For each stock, we calculate a set of three parameters: the proportion of abundance that occurs outside the range of Southern Residents, the proportion that occurs in coastal waters, and the proportion that occurs in inland waters. To generate these parameters, we use the distribution of fishery catch and escapement for each stock. We multiply the total age 3+ abundance (cohort size) of each stock by its respective inland or coastal distribution parameter, then sum up all stocks to estimate total prey availability for inland and coastal regions.

The abundance estimates are specific to time periods in FRAM for an annual cycle: October through April, May through June, and July through September. For each FRAM time period, the model produces three sets of stock and age specific cohort abundances: one initial cohort prior to any mortality, one after natural mortality that occurs within the time period, and one after both natural and total fishery mortality that occur within the time period. For this analysis we create an alternative cohort to be used, one where fishery mortality is removed but natural mortality remains included in the abundance, i.e., before natural mortality and after total fishery mortality. These stock specific abundances are apportioned into coastal and inland waters using the distributions identified above, then summed over all stocks for fish that are age three or older to give total prey availability estimates in coastal and inland waters.

Additional updates to methods for estimating FRAM based abundance of Chinook salmon prey and energy compared to those in NMFS (2011a) include removing the size selectivity function, assigning equal probability to all 3 – 5 year old Chinook salmon as available prey, and varying the kilocalories based on the lipid content of specific stocks by size and age (data from O'Neill et al. (2014)). The selectivity function was used in the previous analysis (NMFS 2011a) to determine the proportion of Chinook salmon abundance available to Southern Residents since information at the time indicated a size selective preference for 3-5 year old Chinook salmon with selectivity based on scale data from predation events. However, during the Independent Science Panel workshops (Hilborn et al. 2012), there were concerns expressed regarding the age/size selection curves and the uncertainties with this function. Therefore, as an alternative approach, we assigned equal probability to all 3-5 year old Chinook salmon as available prey, and the kilocalories varied based on the lipid content of specific stocks by size and age (data from O'Neill et al. (2014)). We incorporated the best available science to characterize the bioenergetics needs of the whales and their diet.

Using the updated FRAM and whale information we conducted a retrospective analysis to evaluate how fisheries have affected the prey available to the whales, and how we would expect fisheries in the baseline to effect prey under the new 2019 PST Agreement. First we analyzed how fisheries affected prey availability during the retrospective time period of 1992 to 2016. For each salmon fishery (Southeast Alaska, Canada, Puget Sound, and Pacific Fishery Management Council salmon fisheries), this analysis involved comparing a series of "no fishing" scenarios to the FRAM Validation scenario (November 2018[27]). For example, to estimate the effects of the SEAK salmon fisheries on prey availability during the retrospective time period, we compared FRAM results with all fisheries occurring to the FRAM results with all fisheries occurring except SEAK fisheries. The FRAM Validation scenario approximates what actually occurred from 1992 to 2016 based on post season information. These runs are also used in other forums to evaluate the model and the management system and their relative success in meeting fishery and stock specific management objectives. This provides baseline information on what prey was available, prior to natural mortality, and how fisheries reduced prey in different seasons in inland waters during the retrospective time period (Table 16). It is important to note when interpreting percent reductions that, based on the way scenarios were modeled, the reductions are cumulative across time periods, meaning that a percent reduction reported for the May-June time period includes fishery reductions that occurred in both the October-April and May-June time periods. Based on this FRAM retrospective analysis, Canadian fisheries reduced prey availability in inland waters by up to 31.0% and U.S. fisheries reduced prey available by up to 22.6%. The SEAK salmon fisheries reduced prey by up to 2.8% in inland waters, PFMC salmon fisheries reduced prey by up to 4.3%, and Puget Sound salmon fisheries reduced prey available by up to 17.7%. However, percent reductions from fisheries since the early 1990's have substantially reduced over time. For example, the average percent reduction in inland waters from Canadian and U.S. fisheries in the last 10 years of the retrospective analysis (2007-2016) was 11.2% and 10.3% retrospectively. In general, the largest reductions in prey availability from the Canadian and U.S. fisheries in inland waters occurred from May through September; reductions were relatively smaller in October through April (Table 16).

Table 16. Range in percent reductions that occurred from Canadian and total U.S. fisheries in inland waters from 1992-2016. Note: the range for SEAK, PFMC and Puget Sound do not add up to equal the total U.S. range because the highest and lowest values do not occur in the same years.

Fisheries	Region	October-April	May-June	July-September
Canadian	Coastal	0.0%-1.7%	0.5%-4.9%	2.4%-19.0%
	Inland	0.1%-2.9%	1.3%-8.4%	7.2%-31.0%
Total U.S.[28]	Coastal	0.6%-2.7%	2.9%-13.4%	8.3%-30.2%
	Inland	0.7%-4.3%	2.5%-8.6%	7.7%-22.6%

[27] The November 2018 validation scenarios was not available for previous fisheries biological opinions (e.g. (NMFS 2018b; 2019b)) and therefore was not used. In addition, in previous fisheries biological opinions the retrospective analysis included years from 1999-2014. In this biological opinion, an expanded range of years was available and includes 2015 and 2016. Therefore the percent reductions described here will be different than those provided in the SEAK fisheries consultation (NMFS 2019b) and the previous Puget Sound fisheries consultation (NMFS 2018b).
[28] Total U.S. fisheries includes SEAK, PFMC, and Puget Sound salmon fisheries.

Fisheries	Region	October-April	May-June	July-September
SEAK	Coastal	0.1%-1.3%	0.8%-3.9%	2.5%-15.0%
	Inland	0.1%-0.5%	0.6%-1.5%	1.2%-2.8%
PFMC	Coastal	0.0%-2.2%	0.6%-11.9%	1.7%-26.2%
	Inland	0.0%-0.1%	0.1%-2.4%	0.5%-4.3%
Puget Sound	Coastal	0.0%-0.6%	0.1%-1.0%	0.3%-2.7%
	Inland	0.4%-3.8%	0.5%-5.9%	4.0%-17.7%

For 2019, the FRAM runs represented what we can reasonably expect to occur under both the 2019 PST Agreement and other likely domestic constraints to evaluate how baseline fisheries (i.e. Canadian and total U.S. fisheries except the Puget Sound fisheries) might affect prey available to the whales in 2019. Based on the FRAM analysis for 2019 in inland waters, Canadian salmon fisheries would reduce prey availability by up to 11.0% in July – September, whereas in October - April they would reduce prey availability by 0.3%. In May - June, Canadian fisheries would reduce prey availability in inland waters by up to 3.9%. PFMC fisheries would reduce the prey availability in inland waters in October – April by 0.01%, up to 1.3% in May – June, and up to 2.6% in July – September. SEAK fisheries would reduce prey availability in inland waters by up to 0.3% in October – April, 0.8% in May – June, and 1.6% in July - September.

Updates to Chinook Food Energy and Whale Needs. Noren (2011) developed estimates of the potential range of daily energy expenditure and prey energy requirements for Southern Resident killer whales for all ages and both sexes. The range in the daily prey energy requirements (DPERs) for Southern Residents took digestive efficiency into account, and was calculated from body mass according to these equations:

$$\text{Lower Bound DPER} = 413.2M_b^{0.75}$$
$$\text{Higher Bound DPER} = 495.9M_b^{0.75}$$

where DPER is in kcal per day and M_b is body mass in kg. We have updated the body mass estimates (Noren 2011) to include new unpublished photogrammetry data from our SWFSC. However, these updated body mass estimates are similar to the previous body mass estimates and there is not a measurable difference in the DPER estimates.

Using these equations with more precise body mass estimates, the maximum prey energy requirements for female killer whales range between 49,657 (age 1) and 217,775 (ages 20+) kcal per day. For male killer whales, the maximum prey energy requirements range between 49,657 (age 1) and 269,458 (ages 20+) kcal per day. Assuming Southern Residents consume large adult Chinook salmon from the Fraser River, which on average are approximately 16,386 kcal/fish (Noren 2011), adult female killer whales would consume up to approximately 13 Chinook salmon per day and adult male killer whales would consume up to approximately 16 Chinook salmon per day. The prey energy requirements for the increased cost of body growth in juvenile whales and the increased cost of lactation in females who are nursing are currently unknown. Until these increases in prey energy requirements can be quantified, Noren (2011) recommends using the maximum DPER estimates. Similar to the previous analyses described in our 2011 biological opinion, we combined the sex and age specific maximum daily prey energy requirement information with the population census data to estimate daily energetic requirements for all members of the Southern Resident population, based on the population size as of April the 2019 (75 whales).

Because we are able to estimate the prey energy requirements for all members of the population each day, we can estimate the prey energy requirements for the entire year, for specific seasons, and/or for geographic areas (inland waters and coastal waters). Noren (2011) estimated the daily consumption rate of a population with 82 individuals over the age of 1 that consumes solely Chinook salmon would consume 289,131–347,000 fish/year. Williams et al. (2011) and Chasco et al. (2017a) modeled annual SRKW prey requirements and found that the whole population requires approximately 211,000 to 364,100 and 190,000 to 260,000 Chinook salmon per year, respectively. To incorporate the geographic component and estimate prey requirements when the whales are in the action area, we updated our estimates of the time observed in inland waters. Previously, we averaged the number of Southern Resident killer whales sightings in the action area by number of days per pod per month (Table 6 in the 2011 biop, data from 2003-2009) and incorporated this seasonal occurrence into the prey energy requirements for inland waters. Because the sightings data are updated annually, we revisited the Southern Resident killer whale sightings specific to each pod in inland waters (January 2003 to December 2017; Status of Listed Species Section 2.2.1.4; Table 9). Lastly, we multiplied the daily energy requirements of each pod by the average number of days that the pod was in inland waters for each FRAM time period (Oct-April; May-June; July-Sept). This provided monthly estimates of the energy required in inland waters by pod and averaged estimates of energy required by FRAM time periods (Table 17).

Table 17. Minimum and maximum DPER for the Southern Resident killer whale population of 75 individuals using the average number of days in inland waters for the three FRAM time periods.

Time Period	Average Inland	
	Min DPER	**Max DPER**
Oct-April	575,158,241	690,273,407
May-June	345,724,726	414,919,874
July-Sept	835,673,586	1,002,929,650

The NWFSC has continued to collect prey samples from Southern Residents while they are in inland waters of Washington and British Columbia (Hanson et al. 2010; Ford et al. 2016). Based on the new data, we have updated our estimates of the average proportion of Chinook salmon in the whales' inland diet for each FRAM season: (1) 55 percent from October to April, (2) 97 percent from May to June, and (3) 71 percent from July to September. Because the whales' diet is not exclusively Chinook salmon and varies by season, we incorporate these proportions in our prey energy requirements for inland waters.

We summed the energy requirements across pods by time periods and multiplied by the percent of Chinook in the diet for each time period (55% for October – April; 97% for May – June; 71% for July to September). With this approach, we are assuming that the whales' diet and needs in the past are representative of what they need in the future (i.e., does not account for potential differences in population abundance and sex / age structure over time, potential differences in time spent in inland vs. coastal waters, changes in diet composition, etc.). The DPER values by time period in inland waters were used as inputs into the FRAM modelling to assess the energy needs of Southern Residents compared with available Chinook prey.

We compared the food energy of prey available to the whales to the estimated metabolic needs of the whales. To be conservative, we relied on the estimated maximum energy needs (based on the high-end of a typical range in daily needs, (Noren 2011)). Forage ratios indicate prey available is greater than the whales' needs by the magnitude of the value. For example, a ratio of 5.0 indicates that prey availability is 5 times the energy needs of the whales. Because there is no available information on the whales' foraging efficiency, it is difficult to evaluate the impact of prey reductions on the ratios. Although we have low confidence in the ratios, we consider them as an indicator to help focus our analysis on the time and location where prey availability may be lowest and where the action may have the most significant effect on the whales. Hilborn et al. (2012) cautioned that forage ratios provide limited insight into prey limitations without knowing the whale fitness/vital rates as a function of the supply and demand, however, they suggested ratios may be informative in an ecosystem context (by species or region). In response to the latter point, Chasco et al. (2017a) compared forage ratios across regions, from California to Southeast Alaska. They found that the forage ratios (Chinook salmon available compared to the diet needs of killer whales) were useful to estimate declines in prey over the last four decades and to compare forage ratios across geographic areas. They found forage ratios were consistently higher in coastal waters of British Columbia and southeast Alaska than estimated ratios in Washington waters.

Using the methodology briefly described above to estimate Chinook food energy available, the baseline (derived from the FRAM validation scenario that approximates what actually occurred from 1992 to 2016 and is based on post season information) food energy from Chinook available compared to the whales' Chinook needs (we assumed a population size of 75 individuals for comparison purposes) in inland waters ranged from 17.57 to 29.77 in October – April, 16.39 to 30.87 in May – June, and from 8.28 to 16.89 in July – September. In 2019, the baseline (after Canadian fisheries and U.S. ocean fisheries, but without implementation of the proposed action, and prior to Chinook salmon natural morality) food energy from Chinook available compared to the whale' needs (with a population size of 75 individuals) in inland waters is within the middle range of the past baseline and estimated to be 24.43 in October – April, 23.06 in May – June, and 12.21 in July – September.

As noted earlier, FRAM outputs do not account for natural mortality. Hilborn et al. (2012) noted that natural mortality rates of Chinook salmon are likely substantially higher than the previous stock assessments. To better understand natural mortality, Chasco et al. (2017a) estimated Chinook salmon consumption in Washington inland waters by four marine mammal predators from 1970 to 2015. They found that over this time period, consumption of Chinook salmon by pinnipeds increased substantially from 68 to 625 metric tons. By 2015, pinnipeds were estimated to have consumed approximately double that of what Southern Residents consume, and approximately six times more than commercial and recreational catches.

Prey Quality

Contaminants enter marine waters and sediments from numerous sources, but are typically concentrated near populated areas of high human activity and industrialization. Freshwater contamination is also a concern because it may contaminate salmon that are later consumed by the whales in marine habitats. Chinook salmon contain higher levels of some contaminants than other salmon species, however levels can vary considerably among populations. Mongillo et al. (2016) reported data for salmon populations along the west coast of North America, from Alaska to California and found the salmon's marine distribution was a large factor affecting persistent pollutant accumulation. They found higher concentrations of persistent pollutants in Chinook salmon populations that feed in close proximity to land-based sources of contaminants. There is some information available for contaminant levels of Chinook in inland waters (i.e., Krahn et al. 2007; O'Neill and West 2009; Veldhoen et al. 2010; Mongillo et al. 2016). Some of the highest levels of certain pollutants were observed in Chinook salmon from Puget Sound and the Harrison River (Mongillo et al. 2016).

Adult Chinook salmon (ocean ages 4 and 5) along most of the eastern North Pacific Ocean are becoming smaller, whereas the size of age 2 fish are generally increasing (Ohlberger et al. 2018). Additionally, most of the Chinook salmon populations from Oregon to Alaska have experienced lower proportions of age 4 and 5 year olds and an increase in the proportion of 2-year olds; the mean age of Chinook salmon in the majority of the populations has declined over time. For Puget Sound Chinook salmon (primarily hatchery origin), there were little or weak trends in size-at-age of 4 year olds and the declining trend in the proportion of older ages in Washington stocks was also observed but slightly weaker than that in Alaska populations (Ohlberger et al. 2018).

Vessels and Sound

Vessels used for a variety of purposes (commercial shipping, military, recreation, fishing, whale watching and public transportation) occur in inland waters of the Southern Residents' range. Several studies in inland waters of Washington State and British Columbia have linked interactions of vessels and Northern and Southern Resident killer whales with short-term behavioral changes (see review in Ferrara et al. (2017)). These 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. Collisions of killer whales with vessels are rare, but remain a potential source of serious injury and mortality.

Vessel sounds in inland waters are from large ships, ferries, tankers and tugs, as well as from whale watch vessels, and smaller recreational vessels. Commercial sonar systems designed for fish finding, depth sounding, and sub-bottom profiling are widely used on recreational and commercial vessels and are often characterized by high operating frequencies, low power, narrow beam patterns, and short pulse length (National Research Council 2003). Frequencies fall between 1 and 500 kiloHertz (kHz), which is within the hearing range of some marine mammals including killer whales and may have masking effects (i.e., sound that precludes the ability to detect and transmit biological signals used for communication and foraging).

Recently, there have been several studies that have characterized sound from ships and vessels as well as ambient noise levels in the inland waters (Bassett et al. 2012; McKenna et al. 2013; Houghton et al. 2015; Veirs et al. 2016). Bassett et al. (2012) assessed ambient noise levels in northern Admiralty Inlet (a waterway dominated by larger vessels). They found that vessel activity contributed most to the variability measured in the ambient noise and cargo ships contributed to the majority of the vessel noise budget. Veirs et al. (2016) estimated sound pressure levels for larger ships that transited through the Haro Strait, and found that the received levels were above background levels, and that underwater noise from ships extends up to high frequencies similar to noise from smaller boats. Ship noise was identified as a concern because of its potential to interfere with Southern Resident killer whale communication, foraging, and navigation (Veirs et al. 2016). Although there are several vessel characteristics that influence noise levels, vessel speed appears to be the most important predictor in source levels (McKenna et al. 2013; Houghton et al. 2015; Veirs et al. 2016; Holt et al. 2017), and reducing vessel speed would likely reduce acoustic exposure to Southern Residents.

Behavioral responses of killer whales to received levels from ships was estimated using a dose-response function (Williams et al. 2014). The authors found that the whales would have a 50% chance of responding behaviorally to ship noise when received noise levels were approximately 130 dB rms. Following this study, Holt et al. (2017) utilized Digital Acoustic Recording Tags (DTAGs) to measure received noise levels by the whales (in decibels (dB) re 1 Micropascal (µPa)). The received noise levels (in the 1 to 40 kHz band) measured were between 96 and 127 dB re 1µPa, with an average of 108 dB ± 5.5. It is currently unclear if Southern Residents experience noise loud enough to have more than a short-term behavioral response; however, new research from the NWFSC is investigating fine scale details of subsurface acoustic and movement behavior under different scenarios, especially those predictive of foraging, to then determine potential effects of vessels and noise on Southern Resident killer whale behaviors.

Recent evidence indicates there is a higher energetic cost of surface active behaviors and vocal effort resulting from vessel disturbance (Williams et al. 2006; Noren et al. 2012; Noren et al. 2013; Holt et al. 2015). However, this increased energy expenditure may be less important than the reduced time spent feeding and the resulting potential reduction in prey consumption (Ferrara et al. 2017). Although the impacts of short-term behavioral changes on population dynamics is unknown, it is likely that because Southern Residents are exposed to vessels the majority of daylight hours they are in inland waters, there may be biologically relevant effects at the population-level (Ferrara et al. 2017).

The Be Whale Wise viewing guidelines and the 2011 federal vessel regulations (www.bewhalewise.org) were designed to reduce behavioral impacts, acoustic masking, and risk of vessel strike to Southern Residents in inland waters of Washington State. Since the regulations were codified, there is some evidence that the average distance between vessels and the whales has increased (Ferrara et al. 2017) (Houghton 2014). The majority of vessels in close proximity to the whales are commercial and recreational whale watching vessels and the average number of boats accompanying whales can be high during the summer months (i.e., from 2006 to 2015 an average of 11 to 18 boats;(Seely 2016)). However, fishing vessels are also found in close proximity to the whales and were responsible for 26% of the incidents of non-compliance with the Be Whale Wise Guidelines and federal regulations in 2018 (Shedd 2019). These activities included entering a voluntary no-go zone and fishing within 200 yards of the whales. A number of recommendations to improve compliance with guidelines and regulations are being implemented by a variety of partners to further reduce vessel disturbance (Ferrara et al. 2017). Based on recommendations in the WA Governor's Southern Resident Orca Task Force (2018), additional educational, enforcement and regulatory actions are currently in development with the WA State legislature.

Anthropogenic (human-generated) sound in inland waters is generated by other sources beside vessels, including construction activities, and military operations. Natural sounds in the marine environment include wind, waves, surf noise, precipitation, thunder, and biological noise from other marine species. The intensity and persistence of certain sounds (both natural and anthropogenic) in the vicinity of marine mammals vary by time and location and have the potential to interfere with important biological functions (e.g., hearing, echolocation, communication).

In-water construction activities are permitted by the Army Corps of Engineers (ACOE) under section 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act of 1899 and by the State of Washington under its Hydraulic Project Approval (HPA) program. NMFS conducts consultations on these permits and helps project applicants incorporate conservation measures to minimize or eliminate potential effects of in-water activities, such as pile driving, to marine mammals. Sound, such as sonar generated by military vessels also has the potential to disturb killer whales and mitigation including shut down procedures are used to reduce impacts.

Entrapment and Entanglement in Fishing Gear

Drowning from accidental entanglements in nets and longlines is a minor source of fishing related mortality in killer whales. One killer whale was reported interacting with a salmon gillnet in British Columbia in 1994, but did not get entangled (Guenther et al. 1995). Along the U.S. west coast, two killer whales have been recorded entangled in Dungeness crab commercial trap fishery gear (one in 2015 and one in 2016) (NMFS 2016g). In 2013, a northern resident killer whale stranded in British Columbia and a fish hook was observed in its colon, but had no evidence of perforation or mucosal ulceration (NMFS strandings data, unpubl.). Typically, killer whales are able to avoid nets by swimming around or underneath them (Jacobsen 1986; Matkin 1994), and not all entanglements automatically result in death. For example, J39, a young male killer whale in J pod, was observed with a salmon flasher hooked in his mouth during the summer of 2015 around the San Juan Islands.

Entanglements of marine mammals in fishing gear must be reported in accordance with the MMPA. MMPA Section 118 established the Marine Mammal Authorization Program (MMAP) in 1994. Under MMAP all fishers are required to report any incidental taking (injuries or mortalities) of marine mammals during fishing operations. Any animal that ingests fishing gear or is released with fishing gear entangled, trailing, or perforating any part of the body is considered injured, and must be reported[29]. No entanglements, injuries or mortalities have been reported in recent years.

Oil Spills

As described in the Status of the Species section, the inland waters of Washington State and British Columbia remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers. The total volume of oil spills has increased since 2013 and inspections of high-risk vessels have declined since 2009 (WDOE 2017). Polycyclic aromatic hydrocarbons (PAHs), a component of oil (crude and refined) and motor exhaust, are a group of compounds known to be carcinogenic and mutagenic (Pashin and Bakhitova 1979). Exposure can occur through five known pathways: contact, adhesion, inhalation, dermal contact, direct ingestion, and ingestion through contaminated prey (Jarvela-Rosenberger et al. 2017).

Following the *Deepwater Horizon* oil spill, substantial research effort has occurred to document adverse health effects and mortality in cetaceans in the Gulf of Mexico. Common dolphins (*Tursiops truncates*) in Barataria Bay, an area that had prolonged and severe contamination from the Deepwater Horizon oil spill, were found to have health effects consistent with adrenal toxicity and increased lung disease (Schwacke et al. 2013; Venn-Watson et al. 2015), low reproductive success rates (Kellar et al. 2017), and changes in immune function (de Guise et al. 2017). Previous PAH exposure estimates suggested Southern Residents can be occasionally exposed to concerning levels (Lachmuth et al. 2011). More recently, Lundin et al. (2018) measured PAHs in whale fecal samples collected in inland waters of Washington between 2010 and 2013 and found low concentrations of the measured PAHs (<10 parts per billion (ppb), wet weight). However, PAHs were as high as 104 ppb in the first year of their study (2010) compared to the subsequent years. Although it is unclear the cause of this trend, higher levels were observed prior to the 2011 vessel regulations that increased the distance vessels could approach the whales.

2.4.4 Mexico and Central America DPSs of Humpback Whales

[29] Review of reporting requirements and procedures, 50 CFR 229.6 and http://www.nmfs.noaa.gov/pr/pdfs/interactions/mmap_reporting_form.pdf

As described in the Status of the Species Section, humpback whales face anthropogenic threats from entanglements in fishing gear, vessel interactions, pollution, and disturbance. Because these threats are similar throughout the range of the species, the following section summarizes the primary threats within the action area.

Although humpback whales were common in inland Washington waters prior to the whaling period, few sightings had been reported in this area until recently, as more humpback whales have started returning to the Salish Sea (Calambokidis et al. 2017). Since 2011, the Orca Network has compiled opportunistic whale sighting reports in inland Washington waters. From March 2018 to March 2019, the Orca Network recorded 276 opportunistic sightings of humpback whales in inland Washington waters, some of which could be the same individuals[30]. The largest number of sightings occurred in the summer and fall months and research is ongoing to use photo-identification to identify which breeding populations make up the humpback whales seen in inland waters of Washington.

Fisheries

Worldwide, fisheries interactions have an impact on many marine mammal species. More than 97 percent of whale entanglement is caused by derelict fishing gear (Baulch and Perry 2014). There is also concern that mortality from entanglement may be underreported, as many marine mammals that die from entanglement tend to sink rather than strand ashore. Entanglement may also make marine mammals more vulnerable to additional dangers, such as predation and ship strikes, by restricting agility and swimming speed. There were 152 reported humpback whale entanglements in fishing gear on the U.S. West Coast from 2007 to 2017—12 of which were reported in Washington (NMFS WCR entanglement database). These entanglements were largely from pot/trap fisheries. At least 3 of the entanglements reported in Washington were seen within the action area.

Fisheries may indirectly affect humpback whales by reducing the amount of available prey or affecting prey species composition. In Puget Sound, fisheries target multiple species including halibut and several salmon populations including Chinook, steelhead, sockeye, and pink salmon, which are not known prey species for humpback whales.

Harvest

Commercial whaling in the 19th and 20th centuries removed tens of thousands of whales from the North Pacific Ocean. As discussed in Section 2.2.1.5 of this opinion, commercial harvest was the primary factor for ESA-listing of humpback whales. This historical exploitation has impacted populations and distributions of humpback whales in the action area, however, there is currently no harvest of humpbacks in the action area and it appears humpbacks have been returning to inland waters of Washington in recent years.

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[30] http://www.orcanetwork.org/Archives/index.php?categories_file=Sightings%20Archives%20Home

Natural and Anthropogenic Noise

Humpback whales in the action area are exposed to several sources of natural and anthropogenic noise. Natural sources of underwater noise include wind, waves, precipitation, and biological noise from marine mammals, fishes, and crustaceans. Anthropogenic sources of noise in the action area include: vessels (e.g. shipping, transportation, research); construction activities (e.g. drilling, dredging, pile-driving); sonars; and aircraft. The combination of anthropogenic and natural noises contributes to the total noise at any one place and time.

Vessel sounds in inland waters are from large ships, ferries, tankers and tugs, as well as from whale watch vessels, and smaller recreational vessels. Recently, there have been several studies that have characterized sound from ships and vessels as well as ambient noise levels in the action area (Bassett et al. 2012; McKenna et al. 2013; Houghton et al. 2015; Veirs et al. 2016). Bassett et al. (2012) assessed ambient noise levels in northern Admiralty Inlet (a waterway dominated by larger vessels). They found that vessel activity contributed most to the variability measured in the ambient noise and cargo ships contributed to the majority of the vessel noise budget. Veirs et al. (2016) estimated sound pressure levels for larger ships that transited through the Haro Strait, and found that the received levels were above background levels, and that underwater noise from ships extends up to high frequencies similar to noise from smaller boats. Although there are several vessel characteristics that influence noise levels, vessel speed appears to be the most important predictor in source levels (McKenna et al. 2013; Houghton et al. 2015; Veirs et al. 2016; Holt et al. 2017).

The intensity and persistence of certain sounds (both natural and anthropogenic) in the vicinity of marine mammals vary by time and location and have the potential to interfere with important biological functions (e.g., hearing, echolocation, communication). Because responses to anthropogenic noise vary among species and individuals within species, it is difficult to determine long-term effects. Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Clark et al. (2009) identified increasing levels of anthropogenic noise as a habitat concern for whales because of its potential effect on their ability to communicate (i.e. masking). Some research (Parks 2003; McDonald et al. 2006; Parks 2009) suggests marine mammals compensate for masking by changing the frequency, source level, redundancy, and timing of their calls. However, the long-term implications of these adjustments, if any, are currently unknown.

In-water construction activities are permitted by the Army Corps of Engineers (ACOE) under section 404 of the Clean Water Act and section 10 of the Rivers and Harbors Act of 1899 and by the State of Washington under its Hydraulic Project Approval (HPA) program. NMFS has conducted numerous ESA Section 7 consultations related to construction activities and helps project applicants incorporate conservation measures to minimize or eliminate effects of in-water activities, such as pile driving, to marine mammals in Puget Sound. Although most recent actions have been found to not likely adversely affect humpback whales, some of the consultations have exempted the take (by harassment) of humpback whales from noise emitted during construction activities.

In 2018, NMFS conducted a consultation on the Bremerton and Edmonds Ferry Terminals Dolphin Replacement Project, concluding that the action could adversely affect ESA-listed humpback whales through harassment, but was not likely to jeopardize the continued existence of the species. Specifically, if exposed noise from pile driving was expected to result in behavioral modifications including avoidance and interruption of feeding and migration (NMFS 2018c). Similarly, a consultation on the Seattle Ferry Terminal Project in 2014 found a similar potential for harassment to humpback whales from pile driving, resulting in avoidance and short-term behavioral responses by the whales (NMFS 2014d).

Vessel Interactions

Vessels used for a variety of purposes (commercial shipping, military, recreation, fishing, whale watching and public transportation) occur in the action area and also contribute to anthropogenic sound as well as behavioral disturbance and risk of ship strikes. Ship strikes and other interactions with vessels occur frequently with humpback whales along the West Coast, with a small number in inland waters. Between 2007 and 2016, there were 20 reported ship strikes on humpback whales along the West Coast (NMFS stranding data). Specific to inland Washington waters, two humpback whales were struck by vessels off of Clallam County, one in 2008 and one in 2016 (NMFS stranding data).

While there are no federal regulations regarding vessel distances from humpback whales in Washington waters, there are Be Whale Wise guidelines 100-yard approach[31] distance for large whales in place for inland waters of Washington and the Pacific Whale Watch industry also has guidelines to minimize impacts from their commercial whale watching activities.

Pollutants

Persistent organic pollutants can be highly lipophilic (i.e., fat soluble) and are primarily stored in the fatty tissues in marine mammals (O'Shea 1999; Aguilar et al. 2002). Phytoplankton, zooplankton, benthic invertebrates, demersal fish, forage fish, and other fishes can be exposed to and ingest these pollutants. As these exposed organisms are consumed, the contaminants can biomagnify up the food chain and can accumulate in upper-trophic level species. When marine mammals consume contaminated prey they store the contaminants primarily in their blubber. Persistent pollutants can resist metabolic degradation and can remain stored in the blubber or fatty tissues of an individual for extended periods of time. When prey is scarce and when other stressors reduce foraging efficiency, or during times of fasting, a marine mammal metabolizes their blubber lipid stores, causing the pollutants to either become mobilized to other organs or remain in the blubber and become more concentrated (Krahn et al. 2002). Adult females can also transmit large quantities of persistent pollutants to their offspring, particularly during lactation in marine mammals. The mobilized pollutants can then become bioavailable and may cause adverse health effects.

[31] https://www.fisheries.noaa.gov/topic/marine-life-viewing-guidelines#guidelines-&-distances

2.4.5 Scientific Research

The listed salmon, steelhead, rockfish, and Southern Resident killer whales 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. In the short term, take may occur in the course of scientific research. However, these activities have a great potential to benefit ESA-listed species in the long-term. Most importantly, the information gained during research and monitoring activities will assist in planning for the recovery of listed species. Research on the listed fish species in the Action Area is currently provided coverage under Section 7 of the ESA or the 4(d) research Limit 7, or included in the estimates of fishery mortality discussed in the Effects of the Proposed Action in this opinion.

For the year 2012 and beyond, NMFS has issued several section 10(a)(1)(A) scientific research permits allowing lethal and non-lethal take of listed species (Table 18). 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 18 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 18. Average annual take allotments for research on listed species in 2014-2018 (Dennis 2019).

Species	Life Stage	Production/Origin	Total Take	Lethal Take
Puget Sound Chinook	Juvenile	Natural	504,563	10,380
		Listed hatchery intact adipose	90,532	3,015
		Listed hatchery clipped adipose	178,412	11,171
	Adult	Natural	967	41
		Listed hatchery intact adipose	930	12
		Listed hatchery clipped adipose	1,630	127
Puget Sound steelhead	Juvenile	Natural	69,647	1,278
		Listed hatchery intact adipose	1,895	32
		Listed hatchery clipped adipose	4,818	109
	Adult	Natural	1,456	33
		Listed hatchery intact adipose	22	--

Species	Life Stage	Production/Origin	Total Take	Lethal Take
		Listed hatchery clipped adipose	32	8
PS/GB Bocaccio	Adult	Natural	31	17
PS/GB Yelloweye Rockfish	Adult	Natural	81	37

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.

Most of the scientific research conducted on Southern Resident killer whales occurs in inland waters of Washington State and British Columbia. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. Research activities are typically conducted between May and October in inland waters and can include aerial surveys, vessel surveys, close approaches, and documentation, and biological sampling. Most of the authorized takes would occur in inland waters, with a small portion in the coastal range of Southern Residents. In light of the number of permits, associated takes, and research vessels and personnel present in the environment, repeated disturbance of individual killer whales is likely to occur in some instances. In recognition of the potential for disturbance and takes, NMFS took steps to limit repeated harassment and avoid unnecessary duplication of effort through conditions included in the permits requiring coordination among permit holders.

Humpback whales are exposed to research activities documenting their distribution and movements throughout their ranges. There are several active research permits that include humpback whales in Washington waters. Some activities may cause stress to individual whales and cause behavioral responses, but harassment is not expected to rise to the level where injury or mortality is expected to occur.

2.5 Effects of the Action on Species and Designated Critical Habitat

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

2.5.1 Puget Sound Chinook

2.5.1.1 Assessment Approach

In assessing the effects of the proposed harvest actions on the Puget Sound Chinook salmon ESU, NMFS first analyzes the effects on individual salmon populations within the ESU using quantitative analyses where possible (i.e., where a sufficiently reliable time series of data is available) and more qualitative considerations where necessary. Risk to the survival and recovery of the ESU is then determined by next assessing the distribution of risk across the populations within each major geographic region and then accounting 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 12 individual populations within the ESU and for the Nooksack Management Unit. The RERs are converted to FRAM-based (Fishery Regulation and Assessment Model) equivalents (NMFS and NWFSC 2018)(Table 19) for the purposes of assessing proposed harvest actions, since FRAM is the analytical tool used by NMFS and the co-managers to assess proposed fishery actions within the action area.

In 2018 NMFS WCR and the NWFSC, in consultation with the Puget Sound co-managers, updated and finalized all the RERs and their associated escapement thresholds except for the Skokomish population. This updated work (NMFS and NWFSC 2018) added RERs for the Upper Cascade and Snoqualmie populations. The direction of change was toward increased rates, with seven of the FRAM RERs increasing, one remaining the same (Nooksack) and only one decreasing from the previous values (Lower Skagit S/F) (Table 19).

NMFS has identified surrogate standards 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 for the White River Chinook population provided by the co-managers).

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 thresholds[32] 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.[33] The rates that would result from the proposed fisheries are compared to the relevant RERs. Generally speaking, where estimated impacts of the proposed fisheries are less than or equal to the RERs, NMFS considers the fisheries to present a low risk to that population (NMFS 2004b). However, the RERs for individual populations are not jeopardy standards.

Table 19. Rebuilding Exploitation Rates by Puget Sound Chinook population. Surrogate RERs are italicized. Newly revised RERs are bolded.

Region	Management Unit	Population	Rebuilding Exploitation Rate	FRAM-based Rebuilding Exploitation Rate
Strait of Georgia	Nooksack Early	N.F. Nooksack S.F. Nooksack	5%	5%
Whidbey/Main Basin	Skagit Spring	Upper Sauk River	**38%**	**24%**
		Suiattle River	**55%**	**32%**
		Upper Cascade	**53%**	**35%**
	Skagit Summer/Fall	Upper Skagit River	**50%**	**46%**
		Lower Skagit River	**35%**	**36%**
		Lower Sauk River	**52%**	**49%**
	Stillaguamish	N.F. Stillaguamish River	**38%**	**22%**
		S.F. Stillaguamish River	28%	17%
	Snohomish	Skykomish River	**37%**	**19%**
		Snoqualmie	**44%**	**20%**

32 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 2000). The rebuilding threshold is defined as the escapement that will represents MSY under current environmental and habitat conditions (NMFS 2000). Thresholds were based on population-specific data where available.

33 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.

Region	Management Unit	Population	Rebuilding Exploitation Rate	FRAM-based Rebuilding Exploitation Rate
South Sound	Lake Washington Green-Duwamish White Puyallup Nisqually	Sammamish[a] Cedar[a] Duwamish-Green White[b] Puyallup[c] Nisqually[d]	**19%**	*5%* *24%* **17%** *24%* *17-35%* *35%*
Hood Canal	Mid-Hood Canal Skokomish	Mid-Hood Canal[e] Skokomish	35%	*5%* 35%
Strait of Juan de Fuca	Dungeness Elwha	Dungeness[b] Elwha[b]		*5%* *5%*

[a] Uses Upper Sauk River RER as a surrogate for the Cedar (24%) and the Nooksack RER as a surrogate for the Sammamish (5%) given similarity of current abundance and escapement trends, and watershed size.
[b] Uses Upper Sauk River (24%) as surrogate.
[c] Uses range including Skokomish (35%) and Green Rivers fall Chinook as surrogates
[d] Uses Skokomish River (35%) as surrogate.
[e] Uses Nooksack early Chinook (5%) as surrogate.

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 NMFS' guidance on the number, distribution, and life-history representation of populations within the regions and across the ESU for recovery; the role of associated hatchery programs; observed population status, and trend; and the effect of further constraints on the proposed actions. Derivation of an RER is based on conservative assumptions regarding environmental conditions, and uncertainty in management performance and population dynamics based on observed patterns over a 25-year period (Appendix A). The objectives of the RERs 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 risk[34] when the expected escapement of that population does not meet its critical threshold or the expected exploitation rate exceeds its RER. We will then examine the effects of the proposed actions on the status of the population and the degree to which the effects contribute to that status.[35]

Individual populations are also at increased risk if actual exploitation rates exceed exploitation rate ceilings that are part of the proposed actions. In most cases for most management units actual exploitation rates are routinely at or below the specified objectives. As explained in Appendix A, incorporation of uncertainty is reflected in the variability in exploitation rates observed in the simulations. That is, the derivation of RERs assume that observed exploitation rates will vary over time (above and below the RER) as a result of these uncertainties, even if fisheries are managed as closely as possible to meet the RERs. Therefore, management error is such that it is reasonable to expect that management objectives will be exceeded on occasion. However, consistent overages may reflect bias in management procedures and assumptions that need to be corrected. Because of the significant amount of analysis and staff resources required and the lag in availability of some of the information (e.g., two years to finalize sport fishery catch), exploitation rates are assessed every three years. The most recent information is available through 2016 based on work completed in 2018 (Table 20).

The co-managers routinely assess the performance of fishery management regimes and the technical tools and information that are used (e.g., abundance forecasts, management models, input parameters). Assessments typically review past performance, by comparing preseason and post season estimates of exploitation rate, identify factors that contributed to the observed overages, and identify remedial actions designed to address any identified problems. An in depth assessment was conducted in 2015 for four populations (Skagit summer/falls, Puyallup, Nisqually and Skokomish)(Grayum and Unsworth 2015). Subsequently the comanagers assessed the efficacy of the actions taken to address problems identified through the 2015 assessments in 2016 (Adicks 2016). The update of the FRAM model base period in late 2016, and again in 2018, provided another opportunity for a high level overview of management performance. The update of the FRAM model itself was designed in part to address identified problems and improve management. The co-managers conducted another review of two populations (Skokomish, Puyallup) in 2018 (James 2018b) when those populations continued to exceed their exploitation rate ceilings.

[34] When compared to a population otherwise at or above its critical threshold.

[35] 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; 2008d; 2010a; 2014e; 2015c; 2016c; 2017b; 2018b).

Table 20. Estimated exploitation rates compared with the applicable management objective for each Puget Sound Chinook Management Unit. Rates exceeding the objective are bolded*.

Region	Management Unit	2010		2011		2012		2013		2014		2015		2016	
		Actual	Objective	Actual	Objective	Actual	Objective	Actual	Objective	Actual	Objective	Actual	Objective	Actual	Objective
Georgia Basin	Nooksack early	6%	7% SUS	8%	8% SUS	**9%**	7% SUS	**8%**	7% SUS	**9%**	7% SUS	6%	7% SUS	4%	7% SUS
Whidbey/ Main Basin	Skagit spring	15%	38%	28%	38%	20%	38%	16%	38%	23%	38%	19%	38%	20%	38%
	Skagit summer/fall	38%	50%	**61%**	50%	41%	50%	40%	50%	42%	50%	38%	50%	38%	50%
	Stillaguamish	13%	25%	**29%**	25%	22%	25%	14%	25%	**31**%	25%	14%	15% SUS	5%	15% SUS
	Snohomish	13%	21%	18%	15% SUS*	20%	21%	12%	21%	**22%**	21%	9%	15% SUS	8%	15% SUS
Central/ South Sound	Lake Washington	9%	20% SUS	16**%**	20% SUS	19%	20% SUS	13%	20% SUS	17%	20% SUS	11%	20% SUS	8%	20% SUS
	Duwamish-Green R	9%	15% PT/5800	8%	15%PT/5800	13%	15%PT/5800	11%	15%PT/5800	13%	15%PT/5800	11%	15% PTSUS	7%	12% PTSUS
	White River	**21**%	20% SUS	15%	20% SUS	15%	20% SUS	9%	20% SUS	**26%**	20% SUS	11%	20% SUS	5%	20% SUS
	Puyallup River	**51%**	50%	46**%**	50%	**55%**	50%	48%	50%	**52%**	50%	38%	50%	26%	50%
	Nisqually River	61%	65%	53%	65%	50**%**	56%	48%	56%	50%	52%	46%	52%	37%	50%
Hood Canal	Mid-Hood Canal R.	9%	12% PTSUS	8%	12% PTSUS	**14%**	12% PTSUS	12%	12% PTSUS	**14%**	12% PTSUS	13%	12% PTSUS	8%	12% PTSUS
	Skokomish River	**55%**	50%	**53%**	50%	**63%**	50%	50%	50%	50**%**	50%	**63%**	50%	**56%**	50%
Strait of Juan de Fuca	Dungeness River	4%	10% SUS	6%	10% SUS	5%	10% SUS	4%	10% SUS	5%	6% SUS	2%	10% SUS	2%	6% SUS
	Elwha River	4%	10% SUS	5%	10% SUS	5%	10% SUS	4%	10% SUS	5%	10% SUS	2%	10% SUS	1%	10% SUS

*For management units like the Nooksack 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.

* Actual rates are based on post-season validation runs utilizing the new base period for FRAM. This has resulted in revisions to some of the 2010-2014 actual rates, as compared to prior versions of this table. With the co-managers recent updated the FRAM base period, they are also reviewing some population management objectives. For example, the Nooksack objective was recently updated to 10% SUS from the previous 7% SUS seen here.

The results of the FRAM base-period update and other sources of fishery information indicated that the Skokomish population continues to exceed the exploitation rate ceiling despite meaningful actions taken by the co-managers over the last several years to bring exploitation rate under the ceiling. While the updated FRAM results indicate that the Puyallup population has exceeded the exploitation rate ceiling fewer times than the previous work had indicated, it has still exceeded this rate in three out of the last 7 years available (Table 18). Specific circumstances for these areas are discussed in more detail in the Effects on the Species section for each of the relevant regions.

The Supplement to the Puget Sound Recovery Plan provides general guidelines for assessing recovery efforts across individual populations within Puget Sound and determining whether they are sufficient for delisting and recovery of the ESU (Ruckelshaus et al. 2002; NMFS 2006b). 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 2006b). 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 with respect to the survival and recovery of the ESU which is important in assessing the distribution of risk from specific proposed actions in such a complex ESU. Therefore, NMFS developed the Population Recovery Approach (PRA; see Section 2.2.1.1) to use as further guidance in its consultations. Guidance from the PSTRT, the Supplement, and the PRA provide the framework to assess risk to the Puget Sound Chinook salmon ESU. The distribution of risk across populations based on the weight of information available in the context of this framework is then used in making the jeopardy determination for the ESU as a whole. For a more detailed explanation of the technical approach (see NMFS 2000; 2004b; 2011a).

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

2.5.1.2 Effects on Puget Sound Chinook

Effects of the Proposed Actions on Puget Sound Chinook occur through implementation of the proposed Puget Sound salmon fisheries and associated research as described earlier (see sections 1.2 and 1.3). Escapements and exploitation rates expected to result from these fisheries during May 1, 2019 through April 30, 2020 are summarized in Table 21. Exploitation rates are reported by management units and escapements by populations based on the information that the FRAM model provides. NMFS has previously consulted on the impacts of PFMC, PST, and SEAK fisheries (NMFS 2004a; 2008d; 2019b). Thus, the effects of these fisheries are part of the Environmental Baseline (see Section 2.3.1). However, the harvest objectives proposed by the co-managers to manage their fisheries on Puget Sound Chinook take into account impacts in these other fisheries (Norton 2019). Thus, Table 21 represents the sum of fishing-related mortality anticipated under the proposed actions together with that expected from the PFMC, Canadian, and SEAK fisheries.

Also included in Table 21 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 populations within the ESU. For management units comprised of multiple populations, Table 21 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 Upper Sauk (24%) and the Upper Cascade (35%) populations. All of the population-specific RERs are shown in Table 19.

NMFS' critical and rebuilding escapement thresholds represent natural-origin spawners (Table 21). 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.

Table 21. FRAM adult equivalent exploitation rates in 2019 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 at least one RER in a management unit (top half of table) or fall below critical escapement thresholds (bottom half of table) are bolded.

Region	Management Unit	Ocean (AK, CAN, PFMC)	Puget Sound	Ocean + Puget Sound	RER or RER surrogate
Georgia Basin	Nooksack early	25.4%	7.8%	**33.2%**	5%
Whidbey/ Main Basin	Skagit spring	11.9%	20.2%	**32.1%**	24-35%
	Skagit summer/fall	21.4%	15.3%	**36.7%**	36-49%
	Stillaguamish	10.8%	7.2%	18.0%	22%
	Snohomish	10.8%	5.0%	15.8%	19-20%
Central/South Sound	Lake Washington	16.7%	16.5%	**33.2%**	*5-24%*
	Duwamish-Green R	16.7%	37.1%	**53.8%**	17%
	White River	9.3%	15.0%	**24.3%**	*24%*
	Puyallup River	16.7%	34.4%	**51.1%**	*17-35%*
	Nisqually River	13.1%	35.7%	**48.7%**	*35%*
Hood Canal	Mid-Hood Canal R.	16.0%	5.8%	**21.8%**	*5%*
	Skokomish River	15.9%	32.3%	**48.2%**	35%
Strait of Juan de Fuca	Dungeness River	4.5%	0.9%	**5.5%**	*5%*
	Elwha River	4.7%	1.1%	**5.8%**	*5%*

Region	Escapement	Natural (HOR+NOR)	NOR	Critical	Rebuilding
Georgia Basin	Nooksack Management Unit		242	400	500
	NF Nooksack (early)		**167**	*200*	-
	SF Nooksack (early)		**75**	*200*	-
Whidbey/ Main Basin	Upper Skagit River (moderately early)	9,554	9,274	738	5,740
	Lower Sauk River (moderately early)	587	587	*200*	371
	Lower Skagit River (late)	2,363	2,363	281	2,131
	Upper Sauk River (early)	957	957	130	470
	Suiattle River (very early)	478	478	170	223
	Upper Cascade River (moderately early)	182	182	130	148
	Stillaguamish R MU (NF + SF)[1]	872	347	400	502
	NF Stillaguamish R. (early)	802	**295**	300	550
	SF Stillaguamish R. (moderately early)	70	**52**	*200*	300
	Skykomish River (late)		2,414	400	1,491
	Snoqualmie River (late)		794	400	816
Central/South Sound	Cedar River (late)	1,217	844	*200*	282
	Sammamish River (late)	1,020	**95**	*200*	*1,250*
	Duwamish-Green R. (late)	5,842	2,161	400	1,700
	White River (early)	1,834	434	*200*	488
	Puyallup River (late)	2,695	1,115	*200*	797
	Nisqually River (late)	1,096	550	*200*	1,200
Hood Canal	Mid-Hood Canal Rivers (late)	286	**69**[2]	*200*	*1,250*
	Skokomish River (late)	2,667	**347**	452	1,160
Strait of Juan de Fuca	Dungeness River	908	**102**	*200*	925
	Elwha River	6,662	306	*200*	*1,250*

Source: Chin2719_ Final_BiOpTab.xlsm (J. Carey, pers. comm., April, 2019). Model output escapements adjusted to reflect natural-origin (NOR) or natural (hatchery-origin (HOR)+NOR) escapement as closely as possible using FRAM 2018 inputs, preseason forecasts or postseason data from previous years.

[1] Co-managers consider the Stillaguamish River to be a single population based on their consideration of genetic information collected after the completion of the Puget Sound Technical Recovery Team assessment. NMFS continues to estimate escapements for the North and South Fork Stillaguamish Rivers separately, consistent with the Puget Sound Recovery Plan and Puget Sound Technical Recovery Team assessment.

[2] Information not available to directly assess 2018 natural origin escapement. Previous postseason reports indicate NOR Chinook contributed on average approximately 24% (Mid-Hood Canal) to natural escapement since 2010.

Consequently, the preseason expectations of natural-origin escapements compared to the escapement thresholds in Table 21 were derived from several sources and represent a variety of assumptions regarding levels of hatchery contribution depending on the available information. NMFS expects the treatment of escapements to become more refined over time as information improves, as decisions are made regarding the treatment of hatchery- and natural-origin fish in an individual watershed, and as the role of individual populations in ESU recovery becomes better defined.

Test, research, update, and evaluation fisheries that inform fishery management decisions are included as part of the fishery-related mortality reflected in Table 21 and included in the estimates of exploitation rates discussed in the following paragraphs. Mortality associated with other research and monitoring, which have broader applicability to stock assessment, are not included in Table 19. Mortality from research projects in this latter category will not exceed a level equivalent to one percent of the estimated annual abundance (i.e. 1% ER), for any management unit (See Section 2.5.6). Several other related research studies are included as part of the proposed actions evaluated in the subsequent discussion. These activities are therefore part of the actions addressed in this opinion. Other research activities informing Puget Sound salmon fishery management are permitted under section 7 of the ESA or Limit 7 of the 4(d) Rule and are part of the Environmental Baseline.

Georgia Basin: There are two populations within the Strait of Georgia Basin: the North Fork Nooksack River and the South Fork Nooksack River early Chinook salmon populations (Figure 1). Both are classified as PRA Tier 1 populations and both are essential to recovery of the Puget Sound Chinook ESU (NMFS 2006b). The two populations form the Nooksack Early Management Unit. Both populations are expected to be affected by the proposed actions in the action area described in Section 2.3.

Natural-origin average escapement for the North Fork Nooksack is very near its critical escapement threshold and the South Fork Nooksack population is well below its critical escapement threshold (Table 3), indicating additional risk to both populations in this Region. Natural-origin spawners average only 203 for the North Fork Nooksack and 24 for the South Fork Nooksack since the ESU was listed in 1999. When hatchery-origin spawners are included, average spawning escapement for the North Fork Nooksack population is significantly higher. Hatchery contribution to natural escapement from the conservation program at the Kendall Creek Hatchery on the North Fork Nooksack is significant (North Fork average NOR=203, North Fork average NOR+HOR=1,494; Table 3) and the hatchery fish retain the native profile of North Fork Nooksack early Chinook.

Managers have implemented two conservation hatchery programs in the Region. Both programs are essential to recovery of each of the populations in this Region and thus to the ESU. Each program has met its hatchery's egg-take objectives in recent years with few exceptions, and is expected to do so for the foreseeable future (WDFW 2014a; LN 2015; Apgar-Kurtz 2018), 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 early Chinook population by contributing to spawning escapement, thus increasing escapements and potentially productivity in order to buffer risks while improvements in habitat, to address low productivity, occur. An aggressive captive brood stock program to enhance returns of native South Fork Nooksack Chinook began in 2007[36]. The first substantial number of adults to contribute to escapement began returning in 2015 (Chapman 2013; 2016). The 2017 returns from the program were greater than 2015 and 2016 with greater potential contribution to spawning (Apgar-Kurtz 2018). A record number of redds were observed in the South Fork sub-basin in 2018 compared with previous years. An estimated 65 percent of the carcasses were from the South Fork captive-brood program. Unlike previous years (2017) when the majority of spawners from the program were young males, 44 percent of the spawners contributing to escapement from the program in 2018 were female and 97 percent of the spawners were age 3 and older (Apgar-Kurtz 2018). These results indicate the program is achieving its goal of supplementing the critical South Fork populations and reducing demographic risk. They also are consistent with the expectation of a greater number of returning adults contributing to escapement and more diverse age structure as more brood years return and the supporting hatchery program becomes established.

Productivity (recruits/parent spawners) is 0.3 for the North Fork and 1.0 for the South Fork (Table 3). These results indicate a relative lack of response in terms of natural-origin production given the much higher total natural escapements described in the above paragraph. Trends in total escapement (hatchery + natural spawners) are increasing or stable for the North Fork and South Fork Nooksack populations, respectively (Table 4). The growth rates for natural-origin escapement and natural-origin recruitment are both positive but low for the North Fork (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. Growth rates are stable and negative, respectively, for natural-origin escapement and natural-origin recruitment for the South Fork population (Table 4) indicating the population is not maintaining itself relative to the parent generation, although the productivity is 1.0. 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 2005d; 2008b; PSIT and WDFW 2010a). Exploitation rates during 2009-2016 averaged 30 percent (total) and seven percent (SUS) (Table 12), higher than the RER but below the exploitation rate management objective for southern U.S. fisheries (SUS) in place during that time as defined by the applicable Puget Sound harvest plan[37] (Table 20). Seventy-eight percent

[36] The captive broodstock program was discontinued in 2018, having achieved its initial design objectives and will transition to program based on adult returns to the Skookum hatchery.

[37] The Nooksack management unit was managed for an objective of 7% exploitation rate in southern U.S. fisheries until 2017 when the new FRAM was implemented. A comparison of exploitation rate estimates under the old and new FRAM indicated the previous objective of 7% was equivalent to a rate of 11% under the new base period. In

of the harvest occurred in Alaska and Canadian fisheries (Table 12).

The anticipated total exploitation rate resulting from the PFMC, PSC fisheries and proposed actions is 33.2 percent, well above the RER for the management unit of five percent, although the exploitation rate in the proposed action area alone (Puget Sound) is expected to be very low, i.e., 8 percent (Table 21). Under the proposed actions, both populations are anticipated to be below their critical thresholds (Table 21), which is cause for concern, although total natural escapement for the North Fork population is anticipated to remain higher than its critical threshold in 2019 given recent year hatchery-origin contribution rates (see Table 3 for comparison of natural spawning escapement and natural-origin spawning escapement). Exploitation rates on the Nooksack population have been reduced 11 percent overall since the ESU was listed with much greater reductions in southern U.S. fisheries. Reductions in northern fisheries were negotiated and realized as part of the current Pacific Salmon Treaty annex specifically to provide greater protections to Puget Sound Chinook.

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 natural-origin 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 and mid-August for non-treaty fishermen. Since 1997, there have been limited ceremonial and subsistence fisheries in the lower river in May and early July. Beginning in 2008, the July fishery was discontinued entirely, and a portion of the ceremonial and subsistence fishery was shifted to the lower North Fork as additional conservation measures to further limit the potential harvest of the South Fork early Chinook population (PSIT and WDFW 2010a). For the last several years, selective gear and natural-origin Chinook non-retention were implemented in the largest component of the fishery. These protective measures are proposed to continue in 2019 as part of the proposed actions (Norton 2019). Any proposed extension of the in-river C&S fishery in 2019 beyond June 15 would rely on in-season monitoring and an assessment of impacts to the populations and would need NMFS concurrence (Norton 2019). In 2019, 77 percent of the harvest of Nooksack early Chinook in Puget Sound fisheries is expected to occur in tribal fisheries; primarily in C&S fisheries (FRAM Chin2719). If the proposed actions were not to occur in 2019, we estimate that at most an additional 14 and 6 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 2019 anticipated exploitation rates are substantially higher than the RERs. However, the vast majority of harvest occurs in fisheries north of the southern U.S. border, including Canadian fisheries which are outside U.S. jurisdiction. Under the proposed actions, the exploitation rate on Nooksack early Chinook within

light of the new information, co-managers revised their objective to 10.5%.

the action area is expected to be low (<8%). The managers propose actions to continue minimizing impacts to Nooksack early Chinook, particularly South Fork Nooksack Chinook which are in the most critical state. Most of the harvest of Nooksack early Chinook in SUS fisheries is expected to occur in tribal fisheries; primarily in C&S fisheries. Information suggests that past harvest constraints have had limited effect on increasing escapement of returning natural-origin fish, when compared with the return of hatchery-origin fish, and further harvest reductions in 2019 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 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 new and relatively untested, results from initial returns are promising. Therefore, any substantive constraints to fisheries occurring in 2019 would likely come at the expense of tribal fisheries and would not provide substantive benefits to either population by providing sufficient additional natural-origin 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 (Table 3). 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 2006b). The ten populations comprise four management units: Skagit Spring (Suiattle, Upper Cascade and Upper Sauk), Skagit Summer/Fall (Upper Skagit, Lower Skagit and Lower Sauk), Snohomish (Skykomish and Snoqualmie) and Stillaguamish (North Fork Stillaguamish and South Fork Stillaguamish). Hatchery contribution to natural escapement is extremely low in the Skagit system and moderate in the Snohomish and Stillaguamish systems (Table 3). All populations in the region are expected to be affected by the proposed actions.

Natural-origin average escapement from 1999-2017 is above the rebuilding thresholds for eight populations (Upper Skagit moderately-early, Lower Sauk moderately-early, Upper Sauk early, Suiattle very early, Upper Cascade moderately-early, North Fork Stillaguamish early, Skykomish late, and Snoqualmie late), below the critical threshold for the South Fork Stillaguamish moderately-early, and in between for the Lower Skagit population (Table 3). Observed productivity from 1999-2017 is 1.1 or more for all but the North Fork Stillaguamish population (Table 3) while longer term trends (1990-2015) indicate declining trends in recruitment for the six of the 10 populations (Upper Skagit, Lower Sauk, Lower Skagit, Stillaguamish and Snoqualmie) (Table 4). With the exception of the South Fork Stillaguamish, long term trends in total natural escapement are stable or increasing. Growth rates for natural-origin escapements are increasing for five of the 10 populations and all but the Suiattle are equal-to or 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 and declining escapement and growth trends for the South Fork Stillaguamish population indicate additional concern for this population.

Average observed exploitation rates for the populations in the Whidbey/Main Basin region, during 2009-2016, ranged between 19 and 45 percent (total) and 7 to 26 percent (SUS)(Table 12). Between 50 and 64 percent of this harvest occurred in Alaska and Canadian fisheries. Under the proposed actions, total exploitation rates for six populations (Upper Skagit, , Lower Sauk, Upper Cascade, NF Stillaguamish, Skykomish, and Snoqualmie) are below their RERs (Table 19 and Table 21). One population (Suiattle) is expected to exceed its RER by 0.1%. Therefore, NMFS considers the proposed actions to present a low risk to these 7 populations. three populations (Upper Sauk, Lower Skagit, and South Fork Stillaguamish) are anticipated to exceed their RERs by a small (0.7%) to substantial (8.1%) amount. The exploitation rates in 2019 Puget Sound fisheries are expected to be relatively low across the four management units (5%-20%) (Table 21). All populations in the region except the Snoqualmie, North and South Fork Stillaguamish are expected to exceed both their critical thresholds and rebuilding thresholds (Table 21) in 2019. For the North and South Fork Stillaguamish, if the proposed actions were not to occur in 2019, we estimate that an additional 2 natural-origin spawners would return to the South Fork and 12 natural-origin spawners would return to the North Fork, which would not provide substantive benefits by providing sufficient additional spawners to significantly change the status or trends of the population from what would occur without the fisheries.

In summary, the effects of the proposed actions in 2019 will meet the recovery plan guidance for at least 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 comparatively well relative to abundance criteria given current habitat conditions, representing a diversity of healthy populations in the region as a whole. Although exceedance of the RERs for four of the 10 populations in the region indicates some risk from the proposed fisheries, the increasing or stable trends in total escapement (hatchery and wild) and growth rate in natural-origin escapement, the robust status of the populations compared with their thresholds in 2019 and the one-year duration of the opinion should mitigate any increased risk as a result of exceeding their RERs. The continued critical status and trends for the South Fork Stillaguamish and to a slightly lesser extent, the North 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 and the North Fork Stillaguamish early life history is represented by two other healthier population in the region, which are all expected to be at low risk from the proposed fisheries in 2019. The number of additional spawners that would be gained from further fishery reductions is low and would not change the status or trend of the Stillaguamish populations.

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

The basins in the Central/South Sound region are the most urbanized and some of the most degraded in the ESU (SSPS 2005). The lower reaches of all these system flow through lowland areas that have been developed for agricultural, residential, urban, or industrial use. Much of the watersheds or migration corridors for five of the six populations in the region are within the cities of Tacoma or Seattle or their metropolitan environments (Sammamish, Cedar, Duwamish-Green, Puyallup and White). Natural production is limited by stream flows, physical barriers, poor water quality, elimination of intertidal and other estuarine nursery areas, and limited spawning and rearing habitat related to timber harvest and residential, industrial, and commercial development. The indigenous population in all but the Duwamish-Green River and White Rivers have been extirpated and the objective is to recover the populations using the individuals that best approximate the genetic legacy of the original population, reduce the effects of the factors that have limited their production, and provide the opportunity for them to readapt to the existing conditions. Managers have implemented a conservation hatchery program for the White River population. The program is essential to recovery of the population and thus to the ESU. The program regularly has met its hatchery's egg-take objectives and is expected to do so again in 2019, thus ensuring that what remains of the genetic legacy is preserved and used to advance recovery.

Except for the Sammamish population, average natural-origin escapements since 1999 are well above their critical thresholds. Rebuilding escapement thresholds were updated for the Cedar, Green, Puyallup and White River populations in 2017 and 2018 based on new spawner-recruit analyses. Average natural-origin escapement in the Cedar and White rivers exceeds those rebuilding escapement thresholds (Table 3). Observed productivity is 1.0 or more for four of the six populations (Table 3). Total escapement trends are stable or increasing for all populations within the region except for the Puyallup River, which is declining (Table 4). Growth rates for recruits and escapement are positive for the Cedar, Sammamish and White River; negative for the Duwamish-Green and Puyallup, and mixed for the Nisqually populations (Table 4). As with most populations in other Puget Sound regions, the growth rates for escapement are higher than growth rates for recruitment. The fact that growth rates for escapement (i.e., fish through the fishery) are greater than growth rates for return (i.e., abundance before fishing) indicates some stabilizing influence on escapement from past reductions in fishing-related mortality. The combination of declining growth rates and a declining trend in escapement (total and NOR) suggests that the Puyallup population is at a higher risk than other populations in the region, at least over the longer term. However, it is a Tier 3 population in terms of its role of recovery for the ESU (Table 3).

Natural-origin spawning escapements in 2019 are expected to be above the critical threshold for all of the populations except for the Sammamish River and above the rebuilding threshold for three of the six—Cedar River, Duwamish-Green, and Puyallup (Table 21). The additional contribution of hatchery spawners to natural escapement for most of these populations (Table 21) 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.

Average observed exploitation rates during 2009-2016 ranged between 22 and 52% (total) and 15 to 43% (SUS)(Table 12), above the RERs for all five management units (Table 19) with the Puyallup and White rates exceeding the management objective in three and two years, respectively, from 2010-2016. Overall, a larger proportion of the harvest of these populations occurs in SUS fisheries than for populations in other regions of Puget Sound; 18 to 48% of the harvest occurred in Alaska and Canadian fisheries depending on the population (Table 12).

Exploitation rate objectives for the Puyallup population were exceeded in all but one year since exploitation rate objectives were adopted in 2003 (Grayum and Unsworth 2015; James 2018b). In 2014, the co-managers examined the available information to identify the contributing factors and took additional management actions in 2015 and again in 2016 to provide greater assurance that the fisheries would meet the overall exploitation rate limits.[38] In 2018, the co-managers conducted another performance assessment to determine why fisheries continued to exceed their exploitation rate objective (James 2018b). More recent results of post-season FRAM validation runs, utilizing the new FRAM base period, have reduced the estimated exceedances of the annual Puyallup total ER objective (50%) to three out of the last six years available—2010-2016 (Table 18), and the exceedances are also smaller, ranging from 1-5%.

Both Canadian fisheries and a variety of Puget Sound marine sport fisheries were the most consistent contributors to the overages between 2011 and 2014 (James 2018b). Beginning in 2012, managers improved preseason models and shaped fisheries to address the problem. In recent years, the tribal net fishery has been limited to one day or a partial day during the Chinook management period and tribal managers have shaped fisheries on other salmon species to reduce incidental catch rates on Chinook. Low exploitation rates in the sport fishery are a consequence of the mark-selective fishing rules. Major sections of the river have been closed when the tribal net fisheries for pink, coho, or Chinook salmon were open to reduce impacts on Chinook.

Over the last two years, much work has been done to address the issue of exceeding the management objective for the Puyallup population. In its guidance letter to the Pacific Fisheries Council for 2018 fisheries (Thom 2018), NMFS recommended a management objective of 44 percent to account for the exceedance unless information was presented that exceedance of the objective had been addressed. The 2018 co-manager performance review found that further improvements to estimate age-2 cohort size and to better account for mortality in Canadian fisheries in the FRAM model should reduce the model bias in exploitation rate estimation from five to two percentage points (James 2018b). Correction of an error in model inputs for the terminal treaty freshwater fishery and an adjustment factor for the Area 7 marine sport fishery are (Dapp and Dufault 2018) anticipated to further reduce the bias if not eliminate it altogether (Phinney and Patten 2018). Additionally, the updated FRAM base has had the effect of lowering

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

the overall estimates of the post-season exploitation rates for the Puyallup. After considering this new information, NMFS revised its recommendation for 2018 to a 50 percent total exploitation rate based on our assessment that remedial action had been taken since 2014 to address the chronic exceedance of the management objective of 50 percent observed in earlier years.

As part of the development of revised management objectives for a new long-term Puget Sound Chinook RMP, the co-managers have produced a spawner/recruit model for the Puyallup Chinook population. This modeling has produced revised, co-manager-proposed objectives for minimum aggregate spawner escapement abundances for triggering differing levels of allowable harvest on the population, in pre-terminal SUS fisheries. For 2019, NMFS' recommendation for the Puyallup population was a fisheries regime that would result in at least 750 natural-origin adults escaping fisheries to the spawning grounds. This level of natural-origin spawner abundance would be higher than the recent 10-year average, would be well above the critical threshold, and near the rebuilding threshold (Table 3). This objective could occur through a combination of fisheries actions and, if necessary, transportation of unmarked adult Chinook from hatchery facilities within the Puyallup River basin to the spawning grounds. The proposed actions for 2019 are projected to result in 1,115 natural-origin fish escaping to the spawning grounds with an additional 1,580 hatchery origin recruits straying to the spawning grounds for a total natural escapement of 2,695. These outcomes will lower the risk to recovery for the Puyallup Chinook salmon for 2019.

Exploitation rates in 2019 for all five management units are expected to exceed their RERs or RER surrogates for the populations in those units (Lake Washington representing the Sammamish and Cedar populations, White, Puyallup, and Nisqually) (Table 21), most by substantial amounts. Exceeding the surrogate RER for the White River population, by 0.3%, will result in minimal additional risk to the pace of adaptation of the local population. Growth rates and the escapement trend for the population are positive including the effects of exploitation rates during the last decade similar to the proposed actions indicating the rates have not impeded growth of the population and would not be expected to do so in 2019. Escapement is expected to be close to the rebuilding threshold for the population. The Cedar, Samammish and Puyallup River populations are in PRA Tier 3. The populations share a common life history which is also represented by the Nisqually population in the region. It is important to remember when assessing the risks to populations like these that there is no increased risk to the indigenous populations in these watersheds because they are extirpated. The observed increasing trends in escapement and growth rate for the Cedar and Sammamish, respectively, should mitigate increased risk possible as a result of exceeding the RER in 2019. In addition, escapement for the Cedar is expected to exceed its rebuilding threshold in 2019 (Table 21). If the Puget Sound salmon fisheries closed in 2019, we estimate that an additional 16 natural-origin spawners would return to the Sammamish population. These additional spawners would not likely change the status of the population because the number of recruits produced per spawner remains low indicating that habitat conditions are limiting the population's ability to grow (Sammamish = 0.6, Table 3). The low productivity of the watersheds given the much higher level of overall escapement (Table 3 and Table 21) 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 35.7 percent for a total exploitation rate of 48.7 percent, inclusive of an additional 1.7% in-river exploitation to evaluate mark-selective removal gears added to the current 47% objective[39], for the 2019 fishing season (Table 21). This rate substantially exceeds its surrogate RER of 35 percent. Exceeding the RER infers an increased risk to the long-term survival and recovery of the Nisqually population which is also experiencing a strongly declining growth rate in natural recruitment and a relatively low abundance of natural-origin escapement. However, it is important to consider the degree to which other factors and circumstances mitigate the risk. The reduction in the total exploitation rate ceiling from 52 percent in 2014-2015, 50 percent in 2016-2017 and to 47 percent in 2017 represents steps in a long term transitional strategy designed to reduce rates over time in concert with improvements in habitat and adjustments in hatchery operations (SSPS 2005; PSIT and WDFW 2010a; Nisqually Chinook Work Group 2011; Turner 2016c; Thom 2017). The indigenous Chinook population is extirpated and the objective is to recover the populations using the individuals that best approximate the genetic legacy of the original population, reduce the effects of the factors that have limited their production, and provide the opportunity for them to readapt to the existing conditions. Currently, there is an increasing trend for natural escapement and a stable trend in growth rate for escapement (Table 4**)**. Growth rate for natural-origin escapement (i.e., fish through the fishery) is higher than growth rates for recruitment (i.e., abundance before fishing) indicating that current fisheries management is providing some stabilizing influence to abundance and productivity and thereby reducing demographic risks.

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

Managers have been working on development of a new long-term transitional strategy since fall 2015. The initial strategy focused on use of a weir to control the contribution of hatchery-origin spawners to escapement. Due to a variety of implementation factors primarily due to inhospitable river conditions, it was decided that continued use of the weir was no longer feasible. The co-managers used the phased-recovery framework developed by the Hatchery Science and Review Group (HSRG 2015; Troutt 2016; Turner 2016c) to develop a new transitional strategy. The co-managers completed the transitional strategy in December 2017 (Nisqually Chinook Work Group 2017) . The strategy is part of the proposed actions (Norton 2019). The plan now guides harvest and hatchery actions moving forward and includes timelines, performance criteria and performance goals.

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

[39] Pending NMFS review of final fishing plan prior to beginning the 2019 test fishery.

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 and the fishery regime for 2019 are a part of the longer-term transitional strategy that is being coordinated with corresponding habitat and hatchery actions (Nisqually Chinook Work Group 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. The trends in overall escapements and growth rate for natural-origin escapement are increasing and stable, the natural-origin escapement anticipated in 2019 is above its critical threshold. Therefore, the additional risks associated with exceeding the RER in the 2019 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). Tribal fisheries are estimated to account for 75 percent of the harvest of unmarked Nisqually Chinook in 2019 Puget Sound salmon fisheries.

The Duwamish-Green River population is a Tier 2 population in the ESU. A Tier 2 population must recover at a sufficient pace to allow for its potential inclusion as a "Tier 1" population if needed for recovery. The anticipated exploitation rate in the proposed Puget Sound salmon fisheries is 37 percent for a total exploitation rate of 54 percent for the 2019 fishing season (Table 21). This rate substantially exceeds its surrogate RER of 17 percent. Exceeding the RER infers an increased risk to the survival and recovery of the population which is also experiencing strongly declining growth rates in natural recruitment and escapement **(**Table 4**)**. However, it is important to consider the degree to which other factors and circumstances mitigate the risk. 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. Anticipated escapement in 2019 is above the rebuilding threshold (Table 21) and above the level of natural-origin escapement observed in most years since 2010. Escapements in 2016 and 2017 were much higher than other recent years because of higher than expected returns coupled with more constrained fisheries in those years crafted based on forecasted low abundance. Anticipated returns in 2019 for the Green River are consistent with the returns from those stronger brood year and fisheries were shaped preseason to take advantage of that higher abundance.

The co-managers have implemented several programs to bolster natural recruitment and take advantage of a gravel supplementation project in the Green River below the Tacoma Headworks Diversion Dam (RM 61.0). Beginning in 2010, adult Chinook that were surplus to Soos Creek Hatchery program needs were transferred to the spawning grounds and allowed to spawn naturally in the Green River. In 2011, a rebuilding program that acclimates and releases juveniles in the upper river (RM 56.1) was initiated. Beginning in 2014, these rebuilding program Chinook began returning to the upper watershed and increased the redd deposition to that area. The increased escapement and shift in spawning distribution to the upper watershed is hypothesized to be strongly linked to the success of the production provided by the Green River supplementation program in the upper watershed. In 2017, approximately 39% of redd production was estimated to come from supplementation returns, much of which can be attributed to redds constructed in the upper watershed. Furthermore, because supplementation program returns are relegated to spawning naturally in the river, all future progeny will be natural origin returns.

Under the proposed actions, the comanagers will use a combination of fishery and broodstock management at the Soos Creek facility to ensure an escapement of at least 1,200 natural-origin Chinook on the spawning grounds (Norton 2019) in 2019. The 1,200 escapement target is the average escapement since the fish were listed in 1999, preserving the gains made over that period, particularly the contribution of the much higher escapements observed in 2016 and 2017. Terminal fisheries are managed using an inseason update and occur contingent on confirmation of the pre-season terminal-area forecast. Initial results from the update will be available the first week of August. The co-managers will meet with NMFS by phone to discuss the initial results soon after the test fishery. If needed, up to 100% of the natural-origin adults returning to Soos Creek will be transferred to the upper Green River spawning grounds to achieve the spawning escapement goal of 1,200 natural-origin Chinook. However, the need for broodstock supplementation in 2019 is unlikely, as over the past three years the number of natural-origin spawners has been substantially larger than the pre-season forecast. Therefore, management of the fisheries in 2019 will ensure that the gains in recent years escapement are preserved, with additional opportunities to strengthen the trend[40].

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 2019. Therefore, implementation of the proposed 2019 fisheries will meet the recovery plan guidance by contributing to the viability 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 population may experience 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 2019 Puget Sound fisheries would not measurably affect the risks to survival or recovery for the Sammamish population. This population is not essential for recovery of the Puget Sound Chinook ESU (PRA Tier 3). Both the life history and Green River genetic legacy of the population are represented by other populations in the Central/South Sound Region.

Hood Canal: There are two populations within the Hood Canal Region: the Skokomish River and the Mid-Hood Canal Rivers populations (Figure 1). Each population forms a separate management unit. Both the Skokomish and Mid-Hood Canal Rivers populations are considered PRA Tier 1 populations. The original indigenous populations have been extirpated and hatchery contribution to natural escapement is significant for both populations, although available data for

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40 Noting the higher returns in 2016 and 2017 years, NMFS encourages the outplanting of additional NOR fish where available after brood stock needs are met. That would increase both the proportion and numbers of NORs on the spawning grounds thus improving the trend in natural-origin escapement and testing the capacity of habitat.

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 an independent population (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). There is evidence to suggest that the declines in abundance in the early to mid- 2000’s 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; 2000).

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 spawners from the Hamma Hamma River, in the Mid_Hood Canal Rivers, population is not distinct from spawners returning to the Skokomish Rivers or George Adams or Hoodsport hatcheries (Marshall 1999; 2000). The degree to which this result 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 within the Mid-Hood Canal Rivers population, and other Hood Canal natural and hatchery stocks 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; providing 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.

As described in the environmental baseline, historically, low flows resulting from operation of the Cushman dams and habitat degradation of freshwater and estuarine habitat have adversely affected the Skokomish population. A settlement agreement finalized 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, reduce Chinook hatchery production at the George Adams Hatchery and adjust fisheries off of the peak Chinook timing. By selectively managing broodstock, the program seeks to re-establish a later-timed fall Chinook population, similar to the dominant life-history that existed historically in the Skokomish watershed. As described in the Environmental Baseline, there can be adverse effects from hatchery programs from competition, predation, genetics, and other factors depending on the specific circumstances. The comanagers' program does not include a new hatchery or enlarge the current program, but uses a component of the existing program to reduce demographic risks and improve the long-term prognosis for recovery. The first broodstock for the program was collected in 2014 and the progeny were released in the spring of 2015. Returns from that first release group have been collected in the recent years with full program being collected in 2018 and the expectation of full program in 2019. Additional review and development of the late-timed hatchery program was undertaken in 2015 and 2016. The late-timed hatchery program complements a similar conservation hatchery program that seeks to reintroduce spring Chinook into the Skokomish River. That program was also initiated in 2014 with the transfer of the first brood stock for spawning and subsequent release. Both the spring and late-fall programs are included as part of the proposed actions in 2019 (Unsworth and Grayum 2016; Speaks 2017; Shaw 2018; Norton 2019). In addition, significant work is occurring to stabilize river channels, restore riparian forests, improve adult Chinook access to the South Fork Skokomish, and improve and restore estuarine habitat through land acquisition, levee breaching and similar projects (PSIT and WDFW 2010a; Redhorse 2014; PSIT and WDFW 2017). 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 from 1999-2017, for both the Skokomish and Mid-Hood Canal 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. As a result, 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 Hamma Hamma restoration program was to restore a healthy, natural-origin, self-sustaining population of Chinook salmon to the Hamma Hamma River. This hatchery production is generally responsible for the increased escapement observed in the Hamma Hamma River. From 2010 to 2016, on average 76% of the Chinook salmon spawning in the Hamma Hamma River were of hatchery origin (WDFW and PSTIT 2009; 2011; 2012; 2013; 2014; 2015b; 2016b; 2017b). The juveniles from brood year 2014 were the last releases from the program and it was discontinued because of the poor returns from the program, indicating additional uncertainty for this population in the future. Adult returns from prior releases contributed to mid-Hood Canal escapements through 2019. 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 2009-2016 were 23 and 58 percent for the Mid-Hood Canal and Skokomish populations, respectively (Table 12), both well above their RERs (Table 19). Southern U.S. exploitation rates during the same period averaged 11 and 46 percent for the Mid-Hood Canal and Skokomish River populations, respectively (Table 12). Alaska and Canadian fisheries accounted for 52 and 20 percent of the harvest of the Mid Hood Canal and Skokomish rivers populations (Table 12).

Under the proposed actions, escapement for both populations is expected to be below the critical thresholds (Table 21). Total exploitation rates for both populations are expected to exceed their RER or RER surrogate (Table 21). For the Mid-Hood Canal population, the exploitation rate in 2019 Puget Sound salmon fisheries under the proposed actions is expected to be low (6%; Table 21). If Puget Sound salmon fisheries were closed in 2019 we estimate that two additional natural-origin spawners would return to the Mid-Hood Canal population. Approximately 193 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 2019 relative to its critical and rebuilding thresholds but would change the status of the Skokomish population by increasing spawning escapement above its critical threshold.

For the Skokomish population, the anticipated exploitation rate in 2019 under the proposed actions from Puget Sound salmon fisheries is 32 percent with a total exploitation rate in 2019 of 48 percent. Exceeding the RER infers an increased risk to the survival and recovery of the Skokomish population which is experiencing declining growth rate in natural-origin recruitment and escapement, a stable trend in total escapement, low abundance of natural-origin escapement and is essential to the recovery of the ESU. Modelling suggests that a 50 percent 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 35 percent and a very small change (1 percentage point) in the probability that the population falling below the critical level (NMFS 2011b).

Available information indicates that observed exploitation rates have exceeded the management objective of 50 percent in all but two years since its adoption in 2010, likely resulting in an even greater risk to rebuilding a sustainable population (Table 20). The ceiling was exceeded by 3 percent to 13 percent (average 8%) with virtually all of the overage attributable to Hood Canal terminal net fisheries. Areas 6 and 7 marine sport fisheries consistently contributed to a lesser extent (James 2018b). Post season estimates of exploitation rates in preterminal fisheries were generally below expected levels. In a 2014 performance review, errors in forecasting terminal abundance and estimating catch per unit effort were identified as the primary contributing factors. In response, managers tackled the problem on two fronts; improving forecast methods and making changes in both the terminal tribal net and sport fisheries in 2013-2017. 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 12 days in 2017 with additional delays in the coho fishery. The lower Skokomish River was closed during the Chinook management period (Bowhay and Warren 2016; James 2016; Rose 2018). The 2019 schedule results in no treaty net fishing in the Skokomish River mainstem over six continuous weeks; the last two weeks of the Chinook management period and the first three weeks of the coho management period. Changes also have been made in the management of the sport fishery in the Skokomish River. The harvest rate on unmarked Skokomish Chinook in the sport fishery was reduced from about 14% to an average of less than 3% with the implementation of mark selective fishing beginning in 2010. Skokomish River sport fisheries were closed in 2016, 2017, and 2018 (Bowhay and Warren 2016; Speaks 2017; Shaw 2018) and may continue to be closed in 2019 (Norton 2019).

The co-managers presented additional information that indicated some reduction in the chronic exceedance of the exploitation rate had probably occurred as a result of the modifications to the fishery described above, but results were mixed indicated that additional caution was still warranted. The 2018 performance review indicated errors in FRAM model inputs for Canadian fisheries were corrected, reducing the previous underestimate of fishing mortality by 0.8 percent (James 2018b). Two of the last four years' estimates of exploitation rates were equal to the objective and two were higher (James 2018b; Rose 2018). Post-season estimates of natural-origin escapement were high in 2017 but low in previous years under the new forecast method. The shaping of treaty terminal fisheries and additional actions to improve forecasting and model performance should improve the likelihood that the exploitation rate objective will be met in 2019. The NMFS conservation objective for Skokomish, in the NMFS 2019 guidance letter to the PFMC, was for a 50 percent exploitation rate ceiling. The proposed 2019 Puget Sound fisheries are forecasted to achieve a 48% ER, again allowing some room under the objective for harvest rate underestimation error.

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 Indian Tribe and WDFW 2010; Redhorse 2014; Skokomish Indian Tribe and WDFW 2017). 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. 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 to manage broodstock from the existing George Adams Chinook hatchery program to establish a late-timed Skokomish fall Chinook run similar to the historic run timing (see above) (Redhorse 2014). This action is in addition to the program to reintroduce spring Chinook, that was initiated in 2014 and as discussed above, has been developed further as part of the proposed actions in 2018 (Shaw 2018) and 2019 (Norton 2019). 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 Indian Tribe and WDFW 2010; 2017) 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 level of the rebuilding threshold, the escapement trend of natural spawners is at least stable and, in particular, growth rates for natural-origin escapement are slightly higher than growth rates for recruitment. This indicates that current fisheries management is providing some stabilizing influence to abundance and productivity; reducing demographic risks. However, the low productivity, continued critical status of natural-origin escapement and negative growth rates in natural-origin recruitment and escapement for the Skokomish Chinook population underscore the importance of meeting the exploitation rate objective such that fisheries do not represent more of a risk than is consistent with a transitional strategy to recovery.

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

Given the condition of salmon habitat in the Dungeness watershed and the significant disruption to the Elwha system as a result of dam removal, the conservation hatchery programs currently operating in the Dungeness and Elwha will be key to protecting for the near-term, and ultimately restoring the Chinook populations in the Strait of Juan de Fuca Region. Analyses of the growth rate of recruitment demonstrates a relative lack of response in natural-origin production by either population (Dungeness=1.03 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 for both 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 (HOR+NOR) is increasing 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 2009-2016 were 15 and 14 percent (total) and 4 and 5 percent (SUS) for the Dungeness and Elwha River populations, respectively Table 12, both above their RERs (Table 19). However, Under the proposed actions, natural-origin escapement is expected to be below the critical threshold for the Dungeness and above the critical threshold for the Elwha (Table 21). However, when hatchery spawners are taken into account, escapements are much higher, more than double recent year average for Dungeness and several times the recent-year average for Elwha (Table 3 and Table 21). Total exploitation rates for both populations are expected to exceed their RER surrogates by only 0.5 and 0.8 percent, indicating minimal additional risk. A significant majority of the harvest occurs outside the jurisdiction of the co-managers (Table 12 and Table 21) and exploitation rates in 2019 Puget Sound salmon fisheries are expected to be about 1% (Table 21). If Puget Sound salmon fisheries closed in 2019 we estimate that no additional and two additional natural-origin spawner would return to the Dungeness and Elwha escapements, respectively. Therefore, further constraints on 2019 Puget Sound fisheries would not substantively affect the persistence of either population by providing sufficient additional spawners to significantly change its status or trends than what would occur without the fisheries.

2.5.1.3 Effects on Critical Habitat

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

Most of the harvest related activities in Puget Sound occur from boats or along river banks, with most of the fishing activity in the marine and nearshore areas. Effects of these activities likely include loss of some fishing gear that will become derelict gear, impacts to riparian vegetation and habitat from human traffic, boats and gear operating along the shore or in the nearshore, and a reduction in the number of adults returning to the spawning grounds which could in turn reduce the nutrient contribution from decaying fish carcasses. Impacts to the substrate are generally not a result of the proposed fishing activities. 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.

The proposed action is likely to result in some increase in derelict gear in the action area, however, due to recent additional outreach and assessment efforts (i.e. Gibson 2013), and recent lost net inventories (Beattie and Adicks 2012; Beattie 2013; James 2017) it is likely that fewer nets will become derelict in the upcoming 2019/20 fishing season compared to several years and decades ago (previous estimates of derelict nets were 16 to 42 annually (NRC 2010)). In 2017, an estimated 11 nets became derelict (though not all of them may have been associated with a salmon fishery) and 10 were recovered (James 2018a). In 2016, an estimated 14 nets became derelict, and nine of them were recovered (James 2017), in 2014 an estimated 13 nets became derelict, 12 of which were recovered (James 2015), and in 2013 and estimated 15 nets were lost, 12 of which were recovered (Beattie 2014) 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 2019/2020 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. 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.

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

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

2.5.2 Puget Sound Steelhead

2.5.2.1 Assessment Approach

As discussed in the Environmental Baseline (Section 2.4.1), 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). These rates averaged 4.2% from 2001-2007, across the index populations in Puget Sound (Table 15). A key consideration in recent biological opinions was therefore whether catch rates had continued to decline since listing which would reinforce the conclusion that the threat harvest posed to the DPS continued to be low. To assess this premise, in these opinions NMFS first compared the average catch of steelhead in mixed stock marine area fisheries (Table 13); at the time of listing to catches in more recent years and concluded that catch had declined by an average of 48%, Table 13. In the opinions issued prior to 2018 NMFS then compared the harvest rates in terminal area fisheries (freshwater) for a set of five index populations (Skagit, Puyallup, Nisqually, Snohomish Green) for the same set of years and concluded that the average harvest rate had declined by 66%, Table 15. In April of 2018 NMFS approved an individual harvest plan for one of the index populations, the Skagit River, (NMFS 2018a; discussed in Section 2.4.1). As a result, the index populations used for calculating appropriate terminal harvest rates are now limited to the Puyallup, Nisqually, Snohomish, and Green rivers.

Available information on harvest rates continues to be limited. In the recent status review, NMFS concluded that the status of Puget Sound steelhead has not changed significantly since the time of listing (Ford et al. 2011a; NWFSC 2015; NMFS 2017a) and reaffirmed the observation that harvest rates on natural-origin steelhead continue to decline and are unlikely to substantially affect the abundance of Puget Sound steelhead (NWFSC 2015). Consequently, NMFS continues to rely on the logic described above. In this opinion, NMFS supplements the earlier analytic method for marine fisheries by comparing the estimated catch from the proposed action 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 assess the harvest rates in freshwater fisheries, NMFS considered the harvest rates for the five (at the time) index populations associated with the proposed actions. In this supplemental analysis, NMFS therefore considers how the impact in marine areas and the terminal harvest rates under the proposed actions compare to the rates at the time of listing and in more recent years, i.e., do the harvest rates under the proposed actions continue to be low?

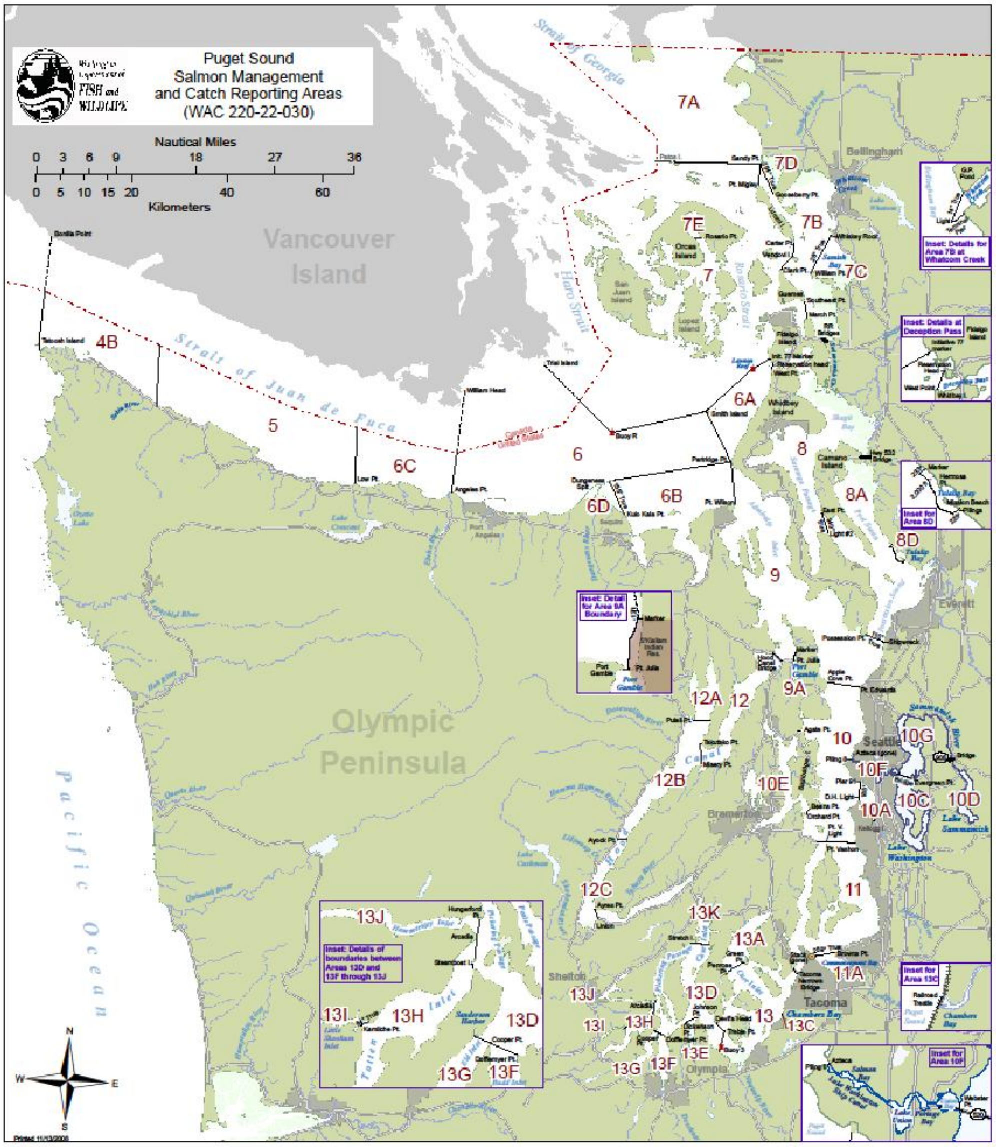

Figure 16. Puget Sound Commercial Salmon Management and Catch Reporting Areas (WAC 220-22-030).

2.5.2.2 Effects on Species

Due to data limitations for nearly all Puget Sound steelhead populations, it is not possible to determine the total abundance of steelhead within the DPS at this time. However, it is possible to provide a minimum estimate that includes information for the populations that are available. The annual minimum average abundance of 23,241 steelhead includes listed and unlisted hatchery fish, and listed natural-origin fish based on fisheries data provided by co-managers (Leland 2018). 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 2013). 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 23,241 is a partial and very conservative estimate of the overall abundance of Puget Sound steelhead that are available to marine area fisheries. Nonetheless, it provides some useful perspective about the likely impact of marine area fisheries.

Previous biological opinions have assessed fisheries impacts of up to 325 steelhead in Puget Sound marine waters as described in Section 2.4.1; Table 13 (NMFS 2011a; 2014b; 2015c; 2016c; 2017b; 2018b). This number represents unlisted and listed steelhead taken in tribal and non-tribal marine area salmon fisheries under fishing regimes that had eliminated the directed harvest of wild steelhead. This estimate is consistent with the assessment of impacts at the time of listing that provided the basis for the conclusion that the regime had largely addressed the threat of decline to the listed DPS posed by harvest. Under the proposed actions, the expected impact on Puget Sound steelhead in marine fisheries from implementation of the proposed fisheries could be as high as this level during the 2019-2020 season (Norton 2019). Impacts of up to 325 steelhead would represent an overall harvest rate on Puget Sound steelhead of 1.4% (325/23,241 = 1.4). As described above, because the estimate of overall abundance is low, this is a very conservative estimate of what the harvest rate to Puget Sound steelhead in marine area fisheries is likely to be. More likely, the catch of steelhead in marine area fisheries in recent years (averaging 169 from 2007/08 – 2017/18) has been well below the 325 reported at the time of listing and better represents what the expected catch is likely to be, and this would likely continue under the proposed action. As described in Section 2.4.1 and summarized in Table 13, this represents a 48% decline in recent years.

The average harvest rate in terminal area fisheries for the index populations (i.e. Snohomish winter run; Green winter run; Puyallup winter run; and Nisqually winter run) under implementation of the proposed actions is anticipated to be below 4.2 percent based on the similarity of catch patterns and fishing regulations in each of the four river systems (Norton 2019). This expectation is substantiated by the consistent pattern of significantly lower harvest rates observed in recent years, described in Section 2.4.1 and summarized in Table 15, which represents a 66% reduction in the average terminal harvest rate for the index populations. As described in the Assessment Approach Section (2.5.2.1), above, the harvest rate of 4.2 percent was the assessment of impacts, at the time of listing, that provided the basis for the conclusion that the regime had largely addressed the threat of decline to the listed DPS posed by harvest.

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

2.5.2.3 Effects on Critical Habitat

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

Most of the harvest related activities in Puget Sound occur from boats or along river banks with the majority of the fishing activity occurring in the marine and nearshore areas. Effects of these activities likely include loss of some fishing gear that will become derelict gear, impacts to riparian vegetation and habitat from human traffic, boats and gear operating along the shore or in the nearshore, and a reduction in the number of adults returning to the spawning grounds which could in turn reduce the nutrient contribution from decaying fish carcasses. Impacts to the substrate are generally not a result of the proposed fishing activities. 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. 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. As a result, fishermen endeavor to keep gear from being in contact or entangled with substrate and habitat features because of the resultant interference with fishing and potential loss of gear. Derelict fishing gear can affect habitat in a number of ways including barring passage, harming eelgrass beds or other estuarine benthic habitats, or occupying space that would otherwise be available to salmon.

The proposed action is likely to result in some increase in derelict gear in the action area, however, due to recent additional outreach and assessment efforts (i.e. Gibson 2013), and recent lost net inventories (Beattie and Adicks 2012; Beattie 2013; James 2017) it is likely that fewer nets will become derelict in the upcoming 2019/20 fishing season compared to several years and decades ago (previous estimates of derelict nets were 16 to 42 annually (NRC 2010)). In 2017, an estimated 11 nets became derelict (though not all of them may have been associated with a salmon fishery) and 10 were recovered (James 2018a). In 2016, an estimated 14 nets became derelict, and nine of them were recovered (James 2017), in 2014 an estimated 13 nets became derelict, 12 of which were recovered (James 2015), and in 2013 and estimated 15 nets were lost, 12 of which were recovered (Beattie 2014) 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 2019/2020 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. 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.

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.

Any impact to water quality from vessels transiting critical habitat areas on their way to the fishing grounds or while fishing would be short term and transitory in nature and minimal compared to the number of other vessels in the area (NMFS 2004c). Construction activities related to salmon fisheries are limited to maintenance and repair of existing facilities (such as boat launches), and are not expected to result in any additional impacts on riparian habitats. Also, these activities would occur to some degree through implementation of fisheries or activities other than the Puget Sound salmon fisheries (i.e., recreational boating and marine species fisheries).

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

2.5.3 Puget Sound/Georgia Basin Rockfish

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

Hook and Line Fishing

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

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

In our consultation on the WDFW Incidental Take Permit and halibut fishery for the recreational bottom fish fishery in Puget Sound we were able to estimate the proportion of listed rockfish killed as a result of the state regulation limiting gear above 120 feet deep (consultation number F/NWR/2012/1984/ and WCR-2017-8426). This allowed us to use similar methods as the PFMC (2008) to estimate the mortality rate for yelloweye rockfish and bocaccio by fishermen targeting bottom fish. The recreational salmon fishery does not have a 120-foot rule, complicating the assessment of survival estimates of listed rockfish caught at various depths while targeting salmon. Recent research found that short term (48 hours) survival for recompressed yelloweye rockfish was 95.1 %, (Hannah et al. 2014) and there is emerging evidence that female yelloweye rockfish can remain reproductively viable after recompression. A 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 adopted new mortality estimates for recreationally caught and released yelloweye rockfish, canary rockfish (and cowcod) based on the depth of capture and use of descending devices (Table 35 in PFMC (2014a))(Table 22).

Table 22. Mortality estimates (%) by depth bin for canary rockfish and yelloweye rockfish at the surface, from PFMC (2014a).

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

Though some anglers, and presumably most fishing guides, will release listed rockfish with barotrauma with descending devices, there is no rule to do so while targeting salmon. As such we make the conservative assumption that for the 2019/20 fishing season listed rockfish caught in salmon fisheries would not be recompressed, but rather released at the surface. As such we use the "current surface release mortality" estimates in (PFMC 2014a) as described in Table 23 to estimate mortality rates for caught and released yelloweye rockfish to estimate mortality rates in Puget Sound fisheries targeting salmon. There are no analogous release mortality estimates for bocaccio, thus for this species we use the same release mortality estimates as for canary rockfish because of generally similar life history and physiology between the two species. The above-reference report estimated mortality rates for surfaced released fish from the surface to over 600 feet deep. There is no reported depth of capture from anglers targeting salmon that incidentally catch rockfish for us to partition mortality rates for each depth range, as done by the PFMC. To estimate mortalities by anglers targeting salmon we use the release mortality rates estimates from the 120 to 180 feet depth range. We choose this depth range as a conservative estimate for bycaught listed rockfish given that most anglers likely target salmon at shallower depths than 180 feet deep, but note that bycatch in depths greater than 180 feet deep may nonetheless occur.

Fishing with Nets

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

1,500 feet along the northern shore of Orcas Island, and (3) a closure of waters three miles from the shore inside the Strait of Juan de Fuca (WDFW 2010).

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

Reef nets are deployed near rockfish habitat in the San Juan Islands, and are subject to the same area closures as gill nets and purse seines. Beach seines are used next to sandy or gravely beaches, and in each fishery all non-targeted fish are released. Because most adult yelloweye rockfish and bocaccio occupy waters much deeper than surface waters fished by reef nets and beach seines, the bycatch of adults is likely minimal to non-existent. Similarly, such nets are not likely to catch juvenile rockfish because many are small enough to pass through the mesh. Moreover, juvenile yelloweye rockfish and bocaccio are unlikely to be caught in beach seines because the seines are generally not used along kelp areas where juvenile bocaccio could occur in appreciable numbers (WDFW 2010). If adult or juvenile yelloweye rockfish and bocaccio were to be caught, the released fish would have a large chance of survival because they would not be brought to the surface from extreme depths thus avoiding barotrauma.

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.

2.5.3.1 Bycatch Estimates and Effects on Abundance

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

Many methods of recreational salmon fishing in marine waters have the potential to encounter

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

In our previous consultations on the salmon fisheries, we used WDFW bycatch estimates from the 2003 through 2009 time period[41] and supplemented our analysis when the WDFW provided us catch estimates for the 2003 through 2011 time period (WDFW 2014b). In 2017, WDFW estimated that anglers targeting salmon caught zero bocaccio and five yelloweye rockfish. All five yelloweye were reported as caught in Hood Canal (WDFW 2018). In 2018, WDFW estimated that anglers targeting salmon caught zero bocaccio and two yelloweye rockfish (WDFW 2019).

The WDFW estimates are highly variable, thus we use the highest available catch estimates for bocaccio and yelloweye rockfish from anglers targeting salmon to form a precautionary analysis. We consider bycatch estimates from previous years useful because we anticipate that recreational salmon fisheries proposed for 2019/20 will result in generally similar fishing techniques, locations, and anticipated numbers of angler-trips as in the past 10 to 15 years. WDFW estimated that from 2010 to 2015 there were approximately 415,000 recreational fishing trips targeting salmon annually within the Puget Sound (WDFW 2016). They further estimated that 143,823 fishing trips targeting salmon occurred in 2016 (WDFW 2017b), and 295,000 fishing trips targeted salmon in 2017 (WDFW 2018) and 177,925 trips in 2018 (WDFW 2019).

As described above in Section 2.2.1.3, Status of Puget Sound/Georgia Basin Rockfish, the best available abundance data for each species come from the WDFW ROV surveys (Pacunski et al. 2013; WDFW 2017b), and we use these surveys as a fundamental source to understand the total abundance of the U.S. portion of the DPSs. The structure of this analysis likely underestimates the total abundance of each species within the U.S. portion of the DPS because: (1) we use the lower confidence interval population estimates available for yelloweye rockfish, and (2) we use the WDFW population estimate of bocaccio for the San Juan Island and Eastern Strait of Juan de Fuca area and note that it is generated within only 46 percent of the estimated habitat of bocaccio within the U.S. portion of the DPS. The rest of the area, including the Main Basin, South Sound and Hood Canal, were likely the most historically common area used by bocaccio (Drake et al. 2010). The structure of these assessments likely underestimates the total abundance of each DPS,

[41] WDFW 2011: Unpublished catch data 2003-2009

resulting in a conservative abundance scenario and evaluation of cumulative fishery bycatch mortality for each species.

2.5.3.1.1 Yelloweye Rockfish

We use annual estimated bycatch of yelloweye rockfish from salmon anglers of 4 (WDFW 2014b) to 117[42] fish (Table 23). These fish would be released, and using the PFMC methodology we estimate that 56% would likely perish from barotrauma and related hooking injuries and/or predation induced by injury.

Table 23. Yelloweye rockfish bycatch estimates.

Species	Low Estimate (number mortalities)	High Estimate (number mortalities)	Estimated Percent Mortality	Abundance Scenario	Percent of DPS killed (low estimate)	Percent of DPS killed (high estimate)
Yelloweye Rockfish	4 (2)	117 (66)	56	143,086	>0.00001	0.005

2.5.3.1.2 Bocaccio

We use annual estimated bycatch of bocaccio from salmon anglers from 2 (WDFW 2014b) to 145 (WDFW 2015) fish (Table 24). These fish would be released, and using the PFMC methodology we estimate that 53% would likely perish from barotrauma and related hooking injuries and/or predation induced by injury.

Table 24. Bocaccio bycatch estimates.

Species	Low Estimate (number mortalities)	High Estimate (number mortalities)	Estimated Percent Mortality	Abundance Scenario	Percent of DPS killed (low estimate)	Percent of DPS killed (high estimate)
Bocaccio	2 (1)	145 (77)	53%	4,606	0.002	1.7

In addition to fishery mortality, rockfish are killed by derelict fishing gear (Good et al. 2010), though we are unable to quantify the number of yelloweye rockfish and bocaccio killed by pre-existing derelict gear or new gear that would occur as part of commercial fisheries addressed in the proposed actions. As elaborated in Section 2.4.3.4, due to 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 (likely six to 20 annually) will become derelict in the upcoming 2019/20 fishing season compared to several years and decades ago. Because of the low number of anticipated derelict gill nets, it is likely that few (if any) yelloweye rockfish and bocaccio mortalities will occur from new derelict gill nets, and that any additional mortality would not induce additional risk to any population.

[42] WDFW 2011: Unpublished catch data 2003-2009

2.5.3.2 Effects on Spatial Structure and Connectivity

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

2.5.3.3 Effects on Diversity and Productivity

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

2.5.3.4 Effects on Critical Habitat

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

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

Effects to listed-rockfish critical habitat come from lost commercial salmon gill nets. Nets are lost due to inclement weather, tidal and current action, catching upon the seafloor, the weight of catch causing submersion, vessels inadvertently traveling through them, or a combination of these factors (NRC 2008). Nets fished in rivers and estuaries can be lost from floods and/or as large logs are caught moving downstream, and a few of these nets can drift to the marine environment. Nets can persist within the marine environment for decades because they do not biodegrade and are resistant to chemicals, light, and abrasion (NRC 2008). In some cases, nets can drift relatively long distances before they catch on the bottom or wash up on the shore (NRC 2008). When derelict nets drift, they can entangle crab pots, thereby recruiting more derelict gear (NRC 2008). Most nets hang on bottom structure that is also attractive to rockfish. This structure consists of high-relief rocky substrates or boulders located on sand, mud or gravel bottoms (Good et al. 2010). The combination of complex structure and currents tend to stretch derelict nets open and suspend them within the water column, in turn making them more deadly for marine biota (Akiyama et al. 2007; Good et al. 2010)(Figure 17).

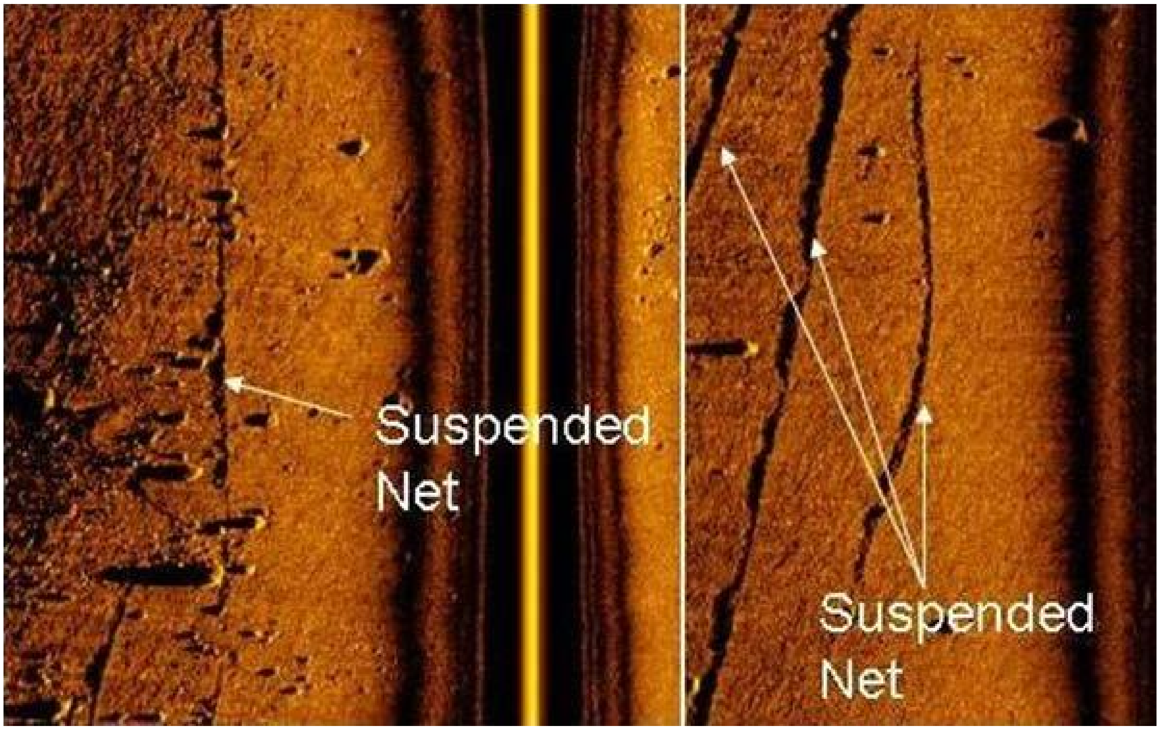

Figure 17. Sidescan sonar images of derelict nets located on Point Roberts Reef of the San Juan basin. Suspended nets have a larger acoustic shadow than nets flush with the bottom. Image used by permission of Natural Resource Consultants (NRC).

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).

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

Due to additional outreach and assessment efforts (i.e. Gibson 2013), and recent lost net inventories (Beattie and Adicks 2012; Beattie 2013; James 2017) it is likely that fewer nets will become derelict in the upcoming 2019/20 fishing season compared to several years and decades ago (previous estimates of derelict nets were 16 to 42 annually (NRC 2010)). In 2017, an estimated 11 nets became derelict (though not all of them may have been associated with a salmon fishery) and 10 were recovered (James 2018a). In 2016, an estimated 14 nets became derelict, nine of which were recovered (James 2017). In 2014, an estimated 13 nets became derelict, and 12 of them where recovered (James 2015), in 2013 an estimated 15 nets became derelict, 12 of which were recovered (Beattie 2013), and in 2012 eight nets were lost, and six were recovered (Beattie and Adicks 2012). A separate analysis from June 2012 to February 2016 a total of 77 newly lost nets were reported, and only 6 of these were reported by commercial fishermen (Drinkwin 2016). We do not have estimates of the number of nets lost in the 2018/2019 salmon fisheries. Based on this new information we estimate that a range of six to 20 gill nets may be lost in the 2019/2020 fishing season, but up to 75% of these nets would be removed within days of their loss and have little potential to damage rockfish critical habitat. In the worst-case analysis assuming that 20 nets are lost and five of these become derelict they would damage up to 35,000 square feet (0.8 acre) of habitat (assuming an average of 7,000 square feet). Even presuming that all lost nets would be in critical habitat (438.45 square miles for yelloweye rockfish and 1,083.11 square miles for bocaccio), they would damage a fraction of the area proposed for listed rockfish and not degrade the overall condition of critical habitat.

2.5.4 Southern Resident Killer Whales

2.5.4.1 Effects on the Species

The proposed fishing may affect Southern Resident killer whales through direct effects of vessel activities and gear interactions, and through indirect effects from reduction of their primary prey, Chinook salmon. This section evaluates the direct and indirect effects of the proposed action on the Southern Resident killer whale DPS as well as the effects of other activities that are interrelated or interdependent with the action, and determines how effects of the proposed action, and of interrelated and interdependent actions, interact with the environmental baseline (50 CFR 402.02).

Following the independent science panel approach on the effects of salmon fisheries on Southern Resident killer whales (Hilborn et al. 2012), NMFS and partners have actively engaged in research and analyses to fill data gaps and reduce uncertainties raised by the panel in their report. To date the data and analyses have not supported a quantitative process for killer whales that directly links effects of an action to survival and recovery (i.e., mortality and reproduction). In the absence of a comprehensive quantitative tool to evaluate proposed actions, we use a weight of evidence approach to consider all of the information we have- identifying a variety of metrics or indicators (some quantitative and some qualitative) with varying degrees of confidence (or weight)- in order to formulate our biological opinion. We assess risk by evaluating uncertainty for lines of evidence to determine if our estimates underestimate or overestimate the status or effect.

Vessel activities and gear interactions

There is potential for direct interaction between Southern Resident killer whales and fishing vessels and gear in the action area because of the high degree of spatial and temporal overlap between the whales' distribution throughout the inland waters and the distribution of the proposed fisheries. Southern Residents occur in inland waters throughout the year (Table 25) and spend the large majority of their time in the summer months along the west side of San Juan Island (Hauser et al. 2007, Whale Museum sightings database), Whale Museum sightings database). This area has been identified as an important foraging area for Southern Residents in the summer months (Figure 18 and Figure 19) (Hanson et al. 2010; Shedd 2019)). This analysis considers how effects from vessel activities and gear interactions associated with the proposed fishery may impact the fitness of Southern Resident killer whales.

Table 25. . Monthly pod occurrence in inland waters (Olson 2017).

J, K & L-PODs Annual Monthly Arrivals & Departures from the Salish Sea

Year	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1976	?	?	?	J & K	J			J, K & L			?	J
1977	?	?	?	?	?	?		J, K & L				
1978	J	J	J & K	J	J	J		J, K & L			J	J
1979	J	J	J	J	J			J, K & L			J & K	J
1980	J	J	J	J	J			J, K & L			J	J
1981	J	J	J	J & K	J			J, K & L				J
1982	J	J	J	J	J	J & K		J, K & L		J & K	J	J
1983	J	J	J	J	J			J, K & L			J & K	J
1984	J	J	J	J	J	J & K		J, K & L		J	J	J
1985	J	J	J	J	J	J & K		J, K & L			J	J
1986	J	J	J	J	J & K			J, K & L		J	J	J
1987	J	J	J	J				J, K & L			J & K	
1988	J	J	J	J	J & K			J, K & L			J	J
1989	J	J	J & K	J				J, K & L			J & K	
1990	J	J	J	J				J, K & L			J	J
1991	J	J	J	J	J & K			J, K & L		J & K	J	J
1992	J	J	J	J				J, K & L				
1993	J	J	J	J	J & K			J, K & L		J	J	J
1994	J	J	J	J	J			J, K & L		J & L	J	J
1995	J	J	J	J				J, K & L		J	J	J
1996	J	J	J	J	J			J, K & L			J & K	J
1997	J	J	J	J				J, K & L		Dyes Inlet	J & L	J & K
1998	J	J	J	J				J, K & L			J & K	J
1999	J	J	J	J	J			J, K & L				
2000	J,K & L	J	J	J	J			J, K & L				
2001		J,K & L	J	J				J, K & L				
2002	J,K & L	J	J,K & L ?	J				J, K & L				
2003	J,K & L	J	J	J	J			J, K & L				J & K
2004	J,K & L	J	J	J	J & L	J & L		J, K & L				
2005	J,K & L	J ?	J	J	J & L			J, K & L				J & K
2006	J ?	J	J, K & L	J				J, K & L				
2007	J ?	J	J	J	J	J & L		J, K & L			J	J, K, & L
2008	J, K, & L	J & L	J	J	J			J, K & L				J, K, & L(p)
2009	J ?	J,K & L	J	NONE	J & K			J, K & L			J & K	
2010	J	J,K & L	J	J	J & L			J, K & L				J, K & L
2011	J, K, & L(p)	J & K	J	J	J & L (p)	J, K, & L(p)		J, K & L				J & K
2012	J & K	J & K	J					J, K & L				
2013	J	J & L	J, K, & L	NONE	J	J & L		J, K & L				J & K
2014	J, K, & L(p)	J	J & K	K	J	J & L		J, K & L				
2015	J,K & L	J,K & L	J	J & L?	J			J, K & L				
2016	J,K & L	J & L	J & L	J	J & K	J, K, & L	J & L	J, K & L			J & K	J & K

(Compiled by TWM staff from records maintained by Orca Survey, C.W.R.(1976-82),The Whale Museum's Whale Hotline (1978-present), the Marine Mammal Research Group's Hotline (1985-2003); Bob Otis's Lime Kiln Lighthouse records (1990-present); Soundwatch field data (1993-present); SeaCoast Pager Records (1996-2007), Orca Network (2000-present); SPOT recorder data (2008-present); and BCCSN data (1975-present))

UPDATED: 4/10/2017 (JKO) ["?" means no positive identification on the sightings]

J-Pod= K-Pod= J&K-Pod= J&L-Pod=

J,K & L-Pods= (p) = partial

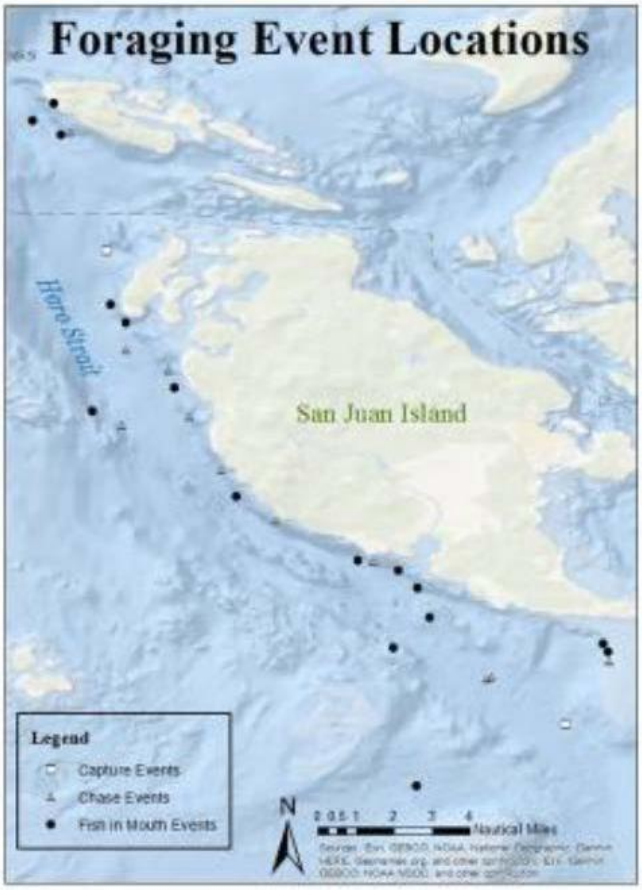

Figure 18. Foraging events observed in the Salish Sea in September 2017 (Shedd 2019).

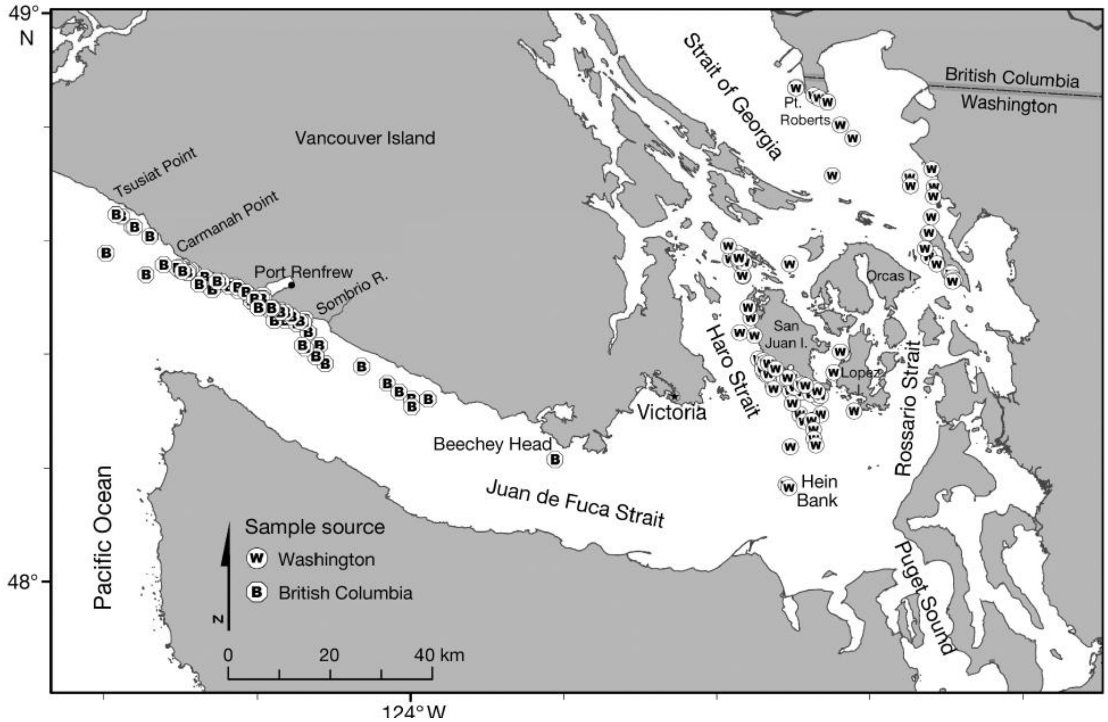

Figure 19. Foraging events observed in the Salish Sea from May to September 2004 to 2008 (Hanson et al. 2010).

Interactions with vessels could occur while vessels are fishing or while they are transiting to and from the fishing grounds. Vessel strikes have not been observed in association with salmon fisheries and although interactions of killer whales and fishing gear have been observed (as described in the Environmental Baseline), entanglements are rare. Commercial fishers in all categories (with the exception of tribal treaty fisheries, but tribes voluntarily report such interactions) participating in U.S. fisheries are required to report incidental marine mammal injuries and mortalities. Although vessel strikes and gear entanglement are unlikely, NMFS will evaluate the need for observers to cover the proposed fisheries if fishery interactions with Southern Residents are reported (in accordance with provisions of the MMPA, 50 CFR 229.7).

The most likely vessel interactions are the disruption of Southern Resident killer whale behavior and acoustic interference. Several studies have addressed the potential consequences, both physiological consequences and the increase in energetic costs, from the behavioral responses of killer whales to vessel presence, including changes in behavior state, swimming patterns and increased surface active behaviors. Williams et al. (2006) estimated that changes in Northern Resident killer whale activity budgets in the presence of vessels resulted in a higher increase in energy expenditure compared to when vessels were not present. Other studies measuring metabolic rates in captive dolphins have shown these rates can increase during the more energetically costly surface behaviors (Noren et al. 2012) that are observed in killer whales in the wild, as well as during vocalizations and the increased vocal effort associated with vessels and noise (Noren et al. 2013; Holt et al. 2015). These studies that show an increase in energy expenditure during surface active behaviors and changes in vocal effort may negatively impact the energy budget of an individual, particularly when cumulative impacts of exposure to multiple vessels throughout the day are considered.

Even more of a concern for Southern Residents than an increase in energy expenditure from increased surface active behaviors and increased vocal effort is the cost of the loss of foraging opportunities and the probable reduction in prey consumption (Ferrara et al. 2017). Several cetacean species worldwide forage less in the presence of vessels (Senigaglia et al. 2016). Southern Residents spent 17 to 21% less time foraging in the presence of vessels depending on the distance of vessels (Noren, unpubl data). An increase in energetic costs because of behavioral disturbance or reduced foraging can decrease the fitness or health of individuals (Dierauf and Gulland 2001; Trites and Donnelly 2003; Lusseau and Bejder 2007). Currently, the degree of impact of repeated disruptions from vessels on Southern Residents foraging and energy intake is unclear. However, reducing repeated disruptions from vessels will likely reduce the impact on foraging and, in turn, reduce the potential for nutritional stress.

Recreational vessels commonly come within a ½ mile of the whales (Shedd 2019), and some recreational vessel users are likely to be recreational fishers associated with the proposed fishing. We have no information about the numbers of recreational fishers who would not engage in recreational boating if the proposed fishery were not authorized, and therefore we cannot quantify the increase in recreational vessels around the whales likely to result from the proposed action. It is reasonable to expect that authorization of the proposed fisheries will result in more recreational vessels in proximity to the whales than there would be if no fishing is authorized, and therefore we expect that the proposed action will result in some additional exposure of Southern Resident killer whales to the physical presence or sound generated by these vessels.

The vessels associated with the fishing activities overlap with the whales, particularly in Marine Area (MA) 7 (Figure 19) in July through September, and their presence and sound in a key foraging area can impact the ability of Southern Residents to effectively locate and consume sufficient prey through acoustic interference. The primary acoustic disturbance from fishing vessels is from propulsion, sonar, and depth finders. However, standard practice for tribal pre-terminal fishing does not generally include sonar and depth finders (Loomis 2019). Vessel sounds may mask or partially or completely prevent the perception of clicks, calls, and whistles, including echolocation used to locate prey, potentially reducing foraging efficiency (Holt 2008; Ferrara et al. 2017). Since 2005 when Southern Residents were listed as endangered, the number of angler trips in MA 7 (i.e., the area with the highest degree of spatial and temporal overlap between the proposed fishing and the whales geographic distribution during the July – September fishing) has ranged from 19,445 to 41,307 (WDFW email dated April 1, 2018). Tribal fisheries averaged approximately 2.5 boats per day in the same area during the summer months, and a 5-year average tribal fleet size of 755 (Loomis 2019).

The Soundwatch Boater Education Program collects data on the number and types of vessels within ½ mile of the whales during the summer months. This long-term data set provides insight into annual trends of vessel activity near the whales. For example, recreational fishing vessels in neutral gear around killer whales were observed to increase from 2016 to 2017, most likely as a result of a fishery closure in June of 2016 that was not enacted in 2017 (Seely 2017). Although whale watching vessels are more likely to interact with Southern Residents than fishing vessels, recreational fishing activities do significantly influence trends in vessel presence near the whales.

For example, the maximum number of vessels with the whales in 2017 occurred on a sport fish opener in September, when 69 vessels were observed within ½ mile radius of the whales (Figure 21)(Seely 2017). The annual variations in the maximum number of recreational vessels near the whales are dependent largely on fishing season and the presence of killer whales in popular fishing locations (Shedd 2019). An increase in the number of incidents of noncompliance with the federal vessel regulations and Be Whale Wise guidelines were committed by recreational fishing vessels in 2018. Whereas fishing vessels were only responsible for 4% of the incidents in 2017, they were accountable for 26% in 2018. This may be in part due to the increase in the size of the voluntary no-go zone in a popular fishing area off the west coast of San Juan Island and an increase in incidents related to the zone. However, 11% of the total incidents recorded in 2018 were for vessels fishing within 200 yards of the whales (Figure 22)(Shedd 2019).

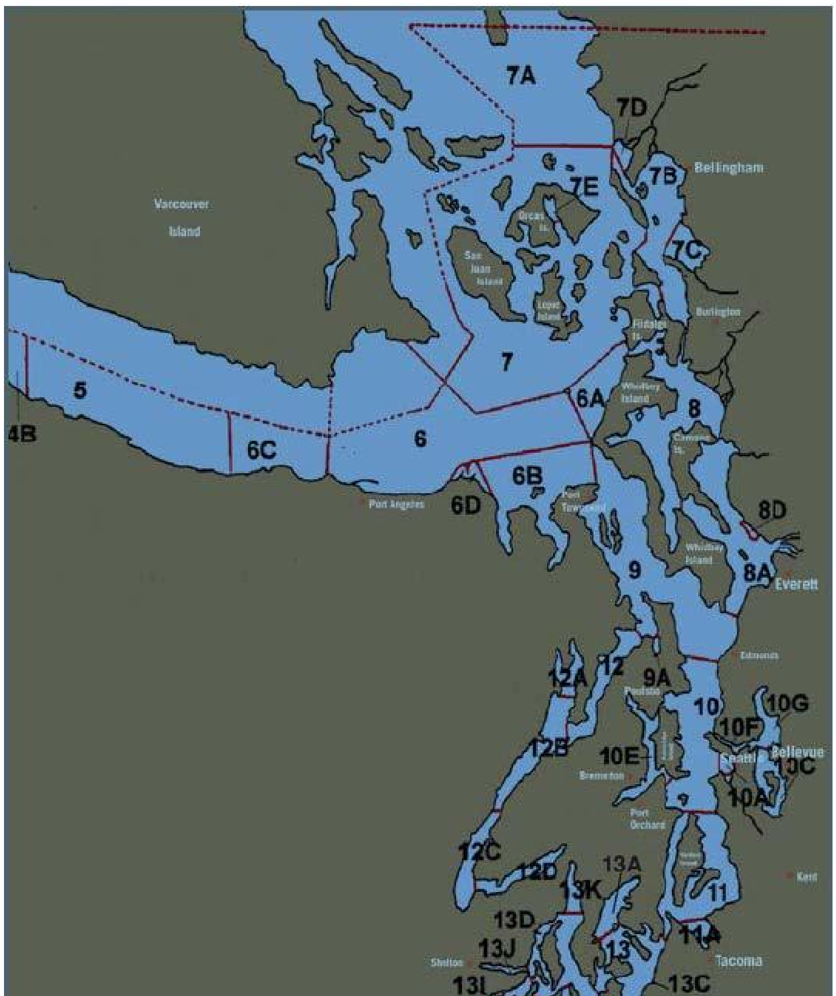

Figure 20. Puget Sound Fishing Zone Map and Catch Reporting Areas (Source: 2006 WDFW commercial salmon regulations, Prepared by Preston Gates & Ellis LLP).

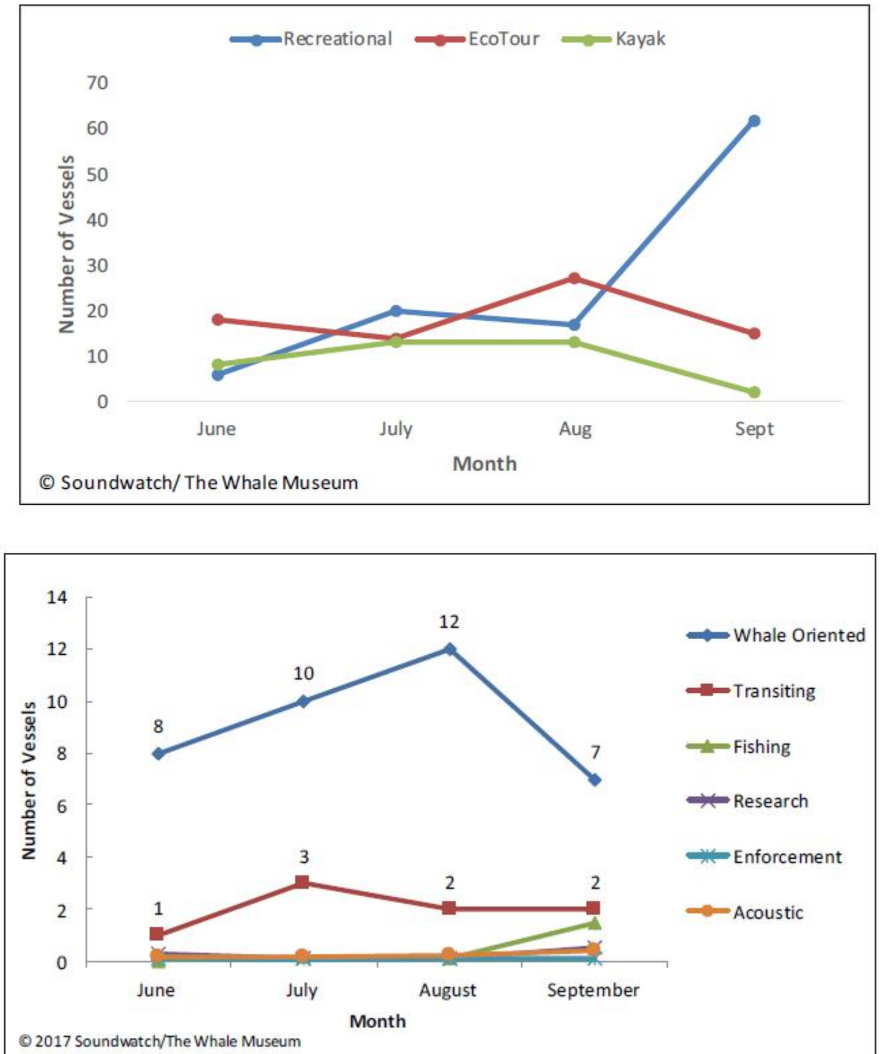

Figure 21. 2017 monthly average numbers of vessels near Southern Resident killer whales by vessel type and activity (Figures from Seely (2017)).

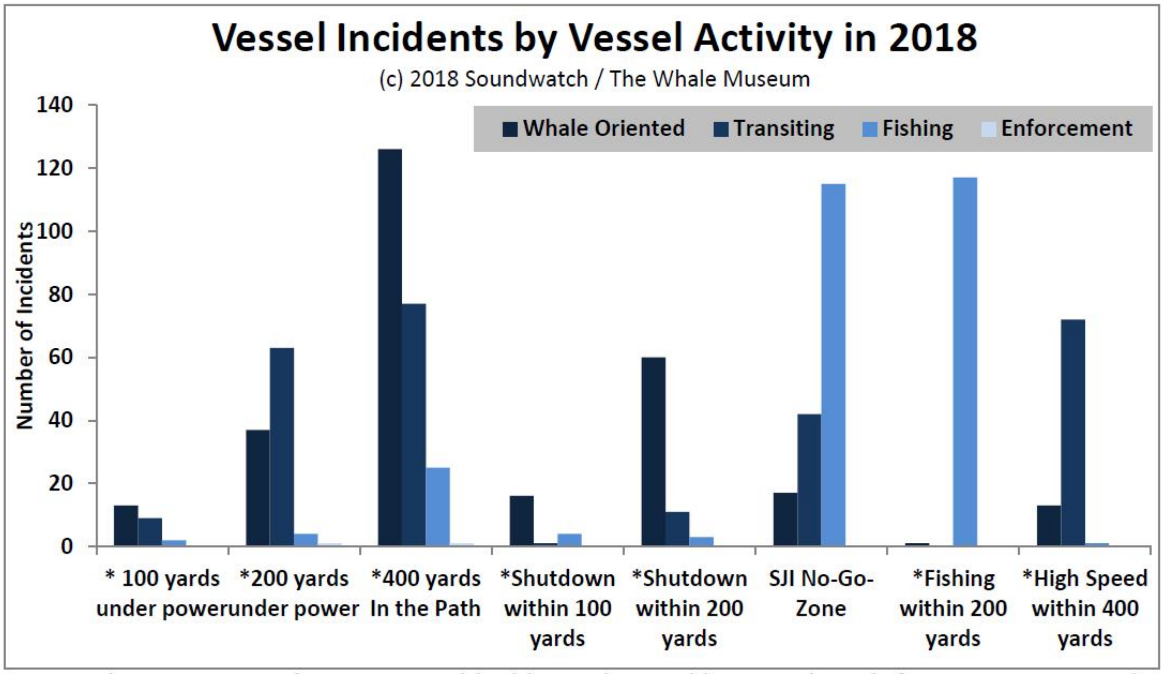

Figure 22. Vessel incidents observed by Soundwatch from May-September 2018 by vessel activity (from Shedd (2019)).

WDFW described in a letter to NMFS dated April 22, 2019 (Warren 2019) that reductions in fisheries were considerable this year and greatly reduced from the average in many areas. The changes for 2019 include the closure of MA 7 to salmon fishing during the month of August and no Chinook salmon retention in September. This area is a key foraging area for the whales during summer months and the closure and non-retention requirements are anticipated to substantially reduce impacts from vessels and to prey available (discussed further below) to Southern Residents in the times and areas of high importance.

The winter sport fisheries in 2019-2020 have also been reduced relative to recent years in several MAs (Figure 23). Some of these fisheries represent a potential spatio-temporal overlap with SRKW distribution (particularly with J pod). Notably for 2019-2020 there are no Chinook directed fisheries in May - June and September - January or later in the Strait of Juan de Fuca, San Juan Island, Georgia Strait and Admiralty Inlet and Port Susan/Port Gardner areas (MAs 5-9). Additionally, recreational salmon fishing closures in MA 7 will occur in October, December and January.

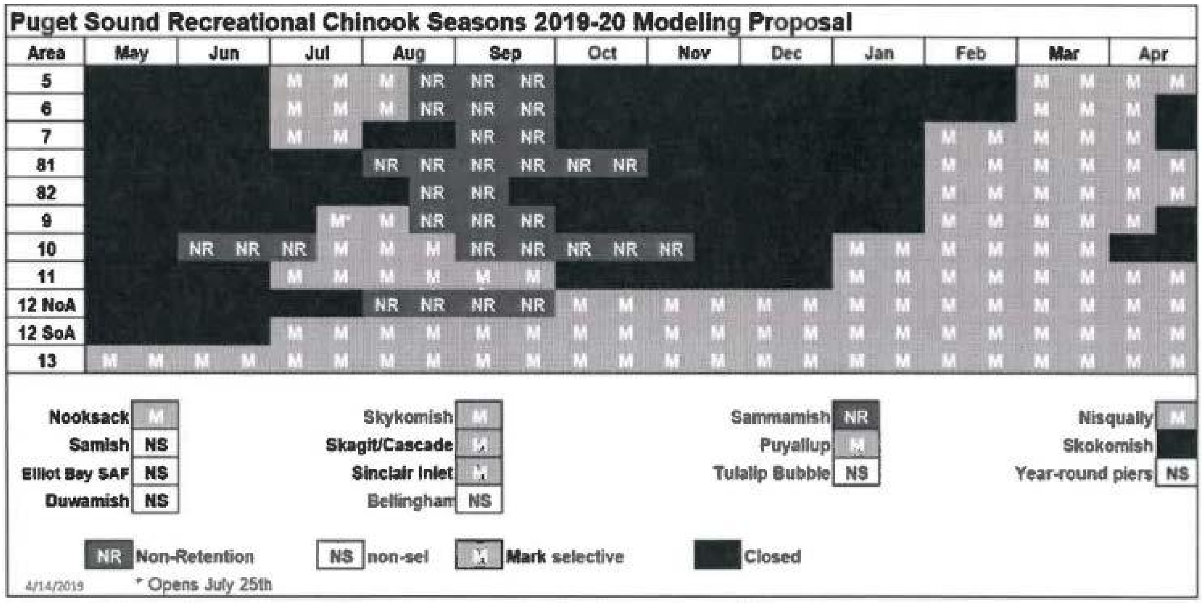

Figure 23. Puget Sound recreational salmon fisheries for the 2018/2019 season (Warren 2019).

Commercial salmon fishing vessels licensed by WDFW also operate in MA 7 in the vicinity of San Juan Island (Warren 2019). These fisheries are under the regulatory control of the Pacific Salmon Commission's Fraser River Panel. For the most part, commercial vessels operating within ¼ mile of San Juan Island utilize purse seine gear. Beyond ¼ mile of the island there is a mix of gillnet and purse seine vessels. These vessels target sockeye returning to the Fraser River. Specific to these gear types for 2019 fisheries in MA 7 and 7A targeting Fraser River sockeye, effort is likely to be reduced in comparison to recent years. It is anticipated that the Fraser River Panel will authorize vessels licensed by WDFW to fish in as many as 3 to 4 openings during 2019 (approximately 1 - 3 days in August and 3 - 5 days in September), half the number of openings that occurred during 2018. The number of days fished in WDFW-managed commercial purse seine and gillnet fisheries in US waters of the San Juan Island and Strait of Georgia during 2006, 2010, and 2014 averaged a total of 10 days in August and early September combined (Shaw 2018).

Fishing vessels operate at slow speeds, in idle, or the engine is off when actively fishing. When in transit, vessels would likely travel at faster speeds with the potential to affect the whales' behavior. For fishing vessels, it is likely that some of the vessel and acoustic disturbances, while vessels are either fishing or transiting, will cause behavioral changes, avoidance, or a decrease in foraging (as described above). It is likely that some of the disturbances will result in less efficient foraging by the whales than would occur in the absence of the vessel effects. It is difficult to estimate the number of disturbances likely to result in behavioral changes or avoidance, and not possible to quantify effects on foraging efficiency. As described in the Status section, Lacy et al. (2017) considered sub-lethal effects and the cumulative impacts of threats (including acoustic disturbance from vessels) and suggested in order for the population to reach the recovery goals, the acoustic disturbance would need to be reduced in half and the Chinook abundance would need to be increased by 15%.

In addition to the area closures described above and in Warren (2019) that are likely to reduce impacts from vessels on Southern Residents, WDFW included additional measures as part of the proposed action to further reduce impacts from vessels on Southern Resident killer whales including:

1. Continuing implementation of a package of outreach and education programs. This will include educational material for boating regulations, Be Whale Wise guidelines, the voluntary no-go zone, and the adjustment or silencing of sonar in the presence of SRKWs. Education and outreach efforts would be focused at boat launches and marinas in the San Juan Islands and key access points for vessels intending to travel to the islands, as well as commercial and recreational fishing vessels.
2. Continuing the promotion of adhering to a voluntary "No-Go" Whale Protection Zone along the western side of San Juan Island in MA 7 for all recreational boats—fishing and non-fishing—and commercial fishing vessels (with the exception of the Fraser Panel sockeye fisheries[43]) (Figure 24). The geographic extent of this area will stretch from Mitchell Bay in the north to Cattle Point in the south, and extend offshore ¼ mile between these locations. The voluntary "No-Go" Zone extends further offshore—out to ½ mile—from a point centered on Lime Kiln Lighthouse. This area reflects expansion of the San Juan County Marine Stewardship Area[44] currently being considered and the full protected area identified by the Pacific Whale Watch Association[45] and is consistent with that proposed by NOAA Fisheries as *Alternative 4* in the 2009 Environmental Assessment on New Regulations to Protect SRKWs from Vessel Effects in Inland Waters of Washington and represents the area most frequently utilized for foraging and socialization in the San Juan Islands. WDFW will continue to work with San Juan County and will plan to adjust their outreach on a voluntary zone to be consistent with any outcomes of the current marine spatial planning process. To improve conditions for the whales, WDFW will ask all vessels to stay out of this key area to provide the full benefits of a quiet foraging area free from disturbance.

[43] These fisheries utilize purse seine gear within ¼ mile of San Juan Island and are required to release non-target species (Chinook and coho); the total estimated release mortalities of Chinook and coho resulting from these fisheries are 2,823 and 1,033 respectively (Shaw 2018).
[44] http://www.sjcmrc.org/projects/marine-stewardship-area/
[45] https://www.pacificwhalewatchassociation.com/guidelines/

Figure 24. An approximation of the Voluntary "No-Go" Whale Protection Zone, from Mitchell Bay to Cattle Point (Shaw 2018).

3. Currently WDFW enforcement conduct coordinated patrols with the U.S. Coast Guard year-round that include monitoring and enforcement of fisheries and Marine Mammal Protection Act requirements related to vessel operation in the presence of marine mammals throughout Puget Sound. Patrols in the marine areas of northern Puget Sound, particularly MA 7 are specifically targeted to enforce regulations related to killer whales. WDFW plans to increase their enforcement emphasis in these areas. WDFW is planning a minimum of 80 patrols during the summer months to focus in MA 7 when SRKWs are known to frequent the area, and plans to conduct a total of 180 - 210 patrols.

In summary, the proposed action includes recreational and commercial vessels fishing in areas known to be important to Southern Resident killer whales. Vessels affect whale behavior and reduce effectiveness in locating and consuming sufficient prey through acoustic interference. These impacts may increase energy and reduce overall foraging and energy intake at times, however, the fishing vessels do not target the whales and their effects are expected to be short-term. Overall, the direct impacts from fishing vessels are expected to be lower in 2019 compared to recent years based on the reduced presence of fishing vessels in the key foraging areas (e.g. the reduction of vessel impacts in August and September and the reduced vessel impacts likely to occur in foraging hotspots along the west side of San Juan Island), and mitigation efforts such as increased outreach and education efforts, including to the fishing community, and increased enforcement. Therefore, we do not anticipate that effects from fishing vessels in 2019 will impact individuals at levels that cause injury or impact reproduction. Ongoing monitoring of vessel activities near the whales will allow for tracking reductions in fishing vessel activity when whales are in key foraging areas.

Reduction of primary prey

Relationship between Southern Resident killer whales and Chinook salmon

Several studies have found correlations between Chinook salmon indices and Southern Resident killer whale demographic rates (Ford et al. 2005; Ford 2009; Ward et al. 2009; Ward et al. 2013). Although these studies examined different demographic responses related to different Chinook abundance indices, they all found significant positive relationships (high Chinook abundance coupled with high Southern Resident killer whale growth rates). However, there are several challenges to this relationship and uncertainty remains. This relationship is statistically challenging because of demographic stochasticity, Southern Residents have a small population size (not many births or deaths in a year to correlate with salmon abundance), these whales are long-lived making it more challenging to predict interactions with the environment, there are other primary threats (disturbance from vessels and sound and high levels of toxic pollutants) that can also influence demographic rates, the inherent uncertainties in the annual Chinook salmon abundance estimates, and there is currently no metric for prey accessibility (i.e., abundance and availability) to the whales.

Largely, attempts to compare the relative importance of any specific Chinook salmon stocks or stock groups using the strengths of these statistical relationships have not produced clear distinctions as to which are most influential and most Chinook salmon abundance indices are highly correlated with each other. It is also possible that different Chinook salmon populations may be more important in different years and that the relative importance of specific Chinook salmon stocks in the whales' diet changes over time. If anything, large aggregations of Chinook salmon stocks that reflect abundance on a coast-wide scale appear to be as equally or better correlated with Southern Resident killer whale vital rates than smaller aggregations of Chinook salmon stocks, or specific stocks such as Chinook salmon originating from the Fraser River that have been positively identified as key sources of prey for Southern Residents during certain times of the year in specific areas (see Hilborn et al. 2012; Ward et al. 2013). Although it is clear Southern Residents need improvements to their prey base to have a higher chance of improving their own status, these challenges may mask our ability in some years to accurately predict the relationship between Southern Resident killer whale demographic rates and Chinook salmon abundance.

When prey is scarce, whales likely spend more time foraging than when it is plentiful. Increased energy expenditure and prey limitation can cause nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources and as a chronic condition can lead to reduced body size and condition of individuals and lower birth and survival rates of a population (e.g., Trites and Donnelly 2003). Food scarcity could also cause whales to draw on fat stores, mobilizing contaminants stored in their fat and potentially affecting reproduction and immune function. Increasing time spent foraging during reduced prey availability also decreases the time spent socializing and reduces reproductive opportunities. Good fitness and body condition coupled with reproductive opportunities is important for reproductive success.

Recent evidence has indicated pregnancy hormones (progesterone and testosterone) can be detected in Southern Resident killer whale feces and have indicated several miscarriages, particularly in late pregnancy (Wasser et al. 2017). The authors suggest this reduced fecundity is largely due to nutritional limitation. As described in the Status section, the Southern Resident killer whale population is expected to decline over the next 50 years if there is no change in their fecundity or survival (NMFS 2016g). Between 2011 and 2016, fecundity rates declined. There are currently 26 reproductive age females (aged 11 – 42 years), of which only 14 have successfully reproduced in the last 10 years, and there have been no viable calves between the beginning of 2016 and December 2018 (CWR unpubl. data). Vélez-Espino et al. (2014) estimated an extinction risk of 49% in 25 years, and an expected minimum abundance of 15 individuals during a 100-year period. They found the survival of young reproductive females has the largest influence on population growth and population variance. Given killer whale gestation is approximately 18 months (Robeck et al. 2015), it is important to have multiple years of sufficient Chinook prey availability to improve fecundity.

Effects of Prey Reduction Caused by the Proposed Action

We evaluated the potential effects of the proposed fishing on Southern Residents based on the best scientific information about the whales' predominant consumption of large Chinook salmon, their Chinook food energy needs, the Chinook food energy available, and the reduction in Chinook food energy caused by the proposed fishing. We compared prey available to Southern Resident killer whales with and without the proposed fishing and found that the proposed fishing will reduce prey available to Southern Residents when they are in inland waters, described in more detail below. Similar to past biological opinions where we assessed the effects of fisheries (NMFS 2018b; 2019b), our analysis of Puget Sound fisheries focuses on effects to Chinook salmon availability because the best available information indicates that Southern Residents prefer Chinook salmon (as described in the Status of the Species) and this provides a conservative approach to assessing impacts from prey reductions. This analysis considers whether effects of that prey reduction may impact the fitness of individual whales or effect population growth.

We analyzed the effects of prey reduction in two steps. First, we estimated the magnitude of reductions in prey available to the whales expected from the proposed fisheries based on pre-season forecast of Chinook salmon abundance for 2019 (e.g. percent reduction in overall abundances from the fisheries). Second, we considered information to help put the reduction in context including 1) comparisons to past years, 2) translating the reductions of Chinook salmon from the proposed fishing into biological context by relating it to the whales' energy requirements, 3) considering the ratio of Chinook prey available to the whales' Chinook needs, based on diet studies of Southern Residents and their predominant consumption of large Chinook, and 4) considering the potential for reductions to result in localized depletions. This analysis highlights our level of confidence in the available data, and identifies where there is uncertainty in light of data gaps and where we made conservative assumptions.

Estimated Prey Reduction: In order to estimate how prey reduction from Puget Sound fisheries affects Southern Residents, we considered prey reduction specific to the whales' needs, which are dependent on when the whales occur in particular areas of their range. Therefore, Chinook salmon abundance and prey reductions from fisheries were evaluated by time (FRAM time steps include October – April, May – June, and July – September) and area (inland waters; as described in the Environmental Baseline section). Our analysis is limited to these seasons and updated information on average number of days when the whales are in inland waters because more fine scale temporal and spatial stratification for whales and Chinook salmon stocks is not currently available.

The FRAM model pre-season estimates for abundance of age 3-5 Chinook in inland waters will be approximately 950,585 (using the new Chinook base period), slightly higher than the 2018 pre-season estimate of 853,000 (using the same base period[46]). However, there are some uncertainties in the pre-season estimates, which can be over- or under-estimated but are based on the best available scientific information (Peterman et al. 2016). The 2019 estimate represents an increase of approximately 76,000 Chinook from the recent 10-year average (2007-2016) estimated post-season abundance of approximately 874,000. In addition, the 2019 predicted return of adult hatchery-origin Puget Sound Chinook escaping pre-terminal fisheries is approximately 250,000 Chinook salmon, a 28% increase over the most recent ten-year average (Warren 2019).

In order to isolate percent prey reduction caused by the proposed action, we estimated the abundance of prey available taking into account all fisheries (including Canadian fisheries, U.S. fisheries, and the proposed fishery) and compared it to the estimated abundance of prey available taking into account all fisheries except the Puget Sound fisheries. Using this comparison, we determined that the proposed fishing will reduce the abundance of Chinook salmon in inland waters during the months of July through September by 5.4%. As described in the Status of the Species section, NMFS and WDFW identified Chinook salmon stocks that are thought to be most important to Southern Resident killer whales. Some of the highest priority stocks are caught in the Puget Sound salmon fisheries (e.g. North and South Puget Sound fall run stocks). Our analysis focuses on the July through September time frame because this is the time frame with larger reductions and more overlap of fisheries and whale foraging. During the remainder of the year there is generally less fishing and therefore minimal reductions in abundance absent the proposed fishery.

Comparison to previous year: NMFS is currently reviewing past years of data on Chinook salmon abundance and percent reductions from fisheries to develop a risk assessment and adaptive management framework (RAAMF) that could help inform a fisheries management response in the future when conditions are present that pose a risk to the recovery of the whales. An example of a situation where fisheries management response could potentially be needed would be a year with relatively low Chinook salmon abundance coupled with relatively large percent reductions from fisheries in SRKW prey availability. While this adaptive approach is still in development, we considered the retrospective data for 1992-2016 compiled to inform RAAMF for this analysis. We compared pre-season estimates of Chinook salmon abundance anticipated in 2019 and percent reductions in Chinook salmon prey availability from the proposed action to abundance and percent reductions for the retrospective time period. Specifically, we consider whether the prey reduction percentages and Chinook salmon

[46] NMFS 2018 used the old FRAM base period and therefore is not comparable to the new base period estimates.

abundances fall with the upper, mid, or lower quartiles derived from evaluating the retrospective time period. Lower and upper quartile boundaries were estimated for the prey reduction percentages and inland and coastal abundance estimates to identify relatively small and large percent reductions and relatively low and high abundance years, respectively.

Using the retrospective analysis for comparison, the pre-season forecast for 2019 indicates an above average return year for inland stocks, which falls in the mid quartile range of abundances derived from the retrospective time period. The estimated 5.4% reduction in Chinook salmon in inland waters July through September falls within the lower quartile derived from the retrospective analysis (less than or equal to 6.2% is the cutoff for the lower quartile). Therefore, 2019 is anticipated to be a year with above average mid-range Chinook salmon abundance and low reductions from Puget Sound fisheries compared to previous years. As described above, there are additional overall changes to fishery management expected in 2019 compared to previous years including an area closure in August in a SRKW foraging hotspot.

The refined approach to Chinook salmon management under the Pacific Salmon Treaty Agreements of 2008 and 2018 to address conservation concerns for several Chinook stocks resulted in a larger portion of total run size being transferred to terminal areas (areas close to the river mouths or in-river beyond the areas where killer whales forage) (Loomis 2019). In general, Puget Sound tribal fisheries on Chinook salmon has been higher in terminal areas compared to pre-terminal areas (tribal pre-terminal fisheries primarily target sockeye, pink or chum salmon). Puget Sound fisheries (tribal and non-tribal) from 2010 - 2018 were estimated to take on average 119,771 adult Chinook salmon (ranging from 100,039 - 139,960). Of those, approximately 70,860 were taken in pre-terminal fisheries on average (ranging from 60,165 - 78,516) (Loomis 2019).

Biological context: It is helpful to consider the magnitude of prey reductions, such as the 5.4% reduction estimated for inland waters July through September in 2019 compared to the energetic needs of the whales. This reduction represents approximately 464,841,178 kcal which roughly translates to 28,399 adult Chinook salmon (assuming large adult Chinook equals 16,368 kcal) and equates to feeding all individuals in the population for 31 days (J pod DPER is 4,268,459 kcal per day; K pod DPER is 3,890,287 kcal per day; L pod DPER is 6,666,766 kcal per day). In comparison to the past, the average pre-terminal catch numbers identified above, 70,860 adult Chinook roughly translates to 1,159,836,480 kcal (assuming a large adult Chinook equals 16,368 kcal). This equates to feeding all individuals in the Southern Resident killer whale population for approximately 78 days. There are two primary assumptions we make here that are important to consider. One is that all the fish caught and consumed are large fish (similar to larger Fraser River Chinook salmon). However, recent evidence indicates adult Chinook salmon (ocean ages 4 and 5) along most of the eastern North Pacific Ocean are becoming smaller (Ohlberger et al. 2018). This would likely mean the whales need more fish on a daily basis to meet their metabolic needs. The second assumption is that all the fish removed by the fishery would be consumed by the whales. However, this is likely an overestimate of the number of feeding days because it is extremely unlikely that the whales would have consumed all fish caught in the fishery. Both the Chinook salmon prey and the whales are highly mobile, so it is unlikely that Southern Residents would encounter and consume all the Chinook salmon.

Prey ratios: To consider the prey reduction from the proposed actions in context of the energetic needs of the whales, we estimated the ratio of Chinook food energy available to the whales compared to their needs and evaluated the change in the ratio with those reductions (that is, with the proposed fishing). In general, ratios greater than 1 indicate there is more prey available than the whales need to meet metabolic requirements. If there are 10 times the number of kilocalories (kcal) available than the metabolic needs of the whales based on the amount of time they spend in a location, the ratio is 10. As described in the Environmental Baseline, because there is no available information on the whales' foraging efficiency, it is unknown how much more fish need to be available in order for the whales to consume enough prey to meet their needs and it is difficult to evaluate the impacts of changes in the ratios to the whales' ability to forage to meet their energy requirements.

Because of the data gaps around foraging efficiency we have low confidence in our understanding of how the change in ratios affect the whales, however, we consider them as an indicator to help focus our analysis on the time and location where prey availability may be lowest and where the action may have the most significant effect on the whales. Hilborn et al. (2012) cautioned that forage ratios provide limited insight into prey limitations without knowing the whale fitness/vital rates as a function of the supply and demand, however, they suggested ratios may be informative in an ecosystem context (by species or region). In response to the latter point, Chasco et al. (2017b) compared forage ratios across regions, from California to Southeast Alaska. They found that the forage ratios (Chinook salmon available compared to the diet needs of killer whales) were useful to estimate declines in prey over the last four decades and to compare forage ratios across geographic areas. They found forage ratios were consistently higher in coastal waters of British Columbia and southeast Alaska than estimated ratios in Washington waters.

For 2019, we determined that with the proposed fishing the ratio for July through September would be 12.87. The ratio for this time period, with or without the proposed fishing, is relatively low compared to October through April and May through June. The baseline ratio is between 8.28 and 16.89 times the whales' estimated needs during July through September in inland waters (see the Environmental Baseline section). During October through April, and May through June, these energy ratios almost double the ratios estimated for July through September. The ratios ranged over different years (1992-2016) with different salmon abundances. The current estimated ratios are not directly comparable with ratios described in previous fisheries consultations, limiting our interpretation and the weight of confidence in the ratios, because of the updates to FRAM. For example, in NMFS (2011a), the FRAM model produced stock and age specific cohort abundance for several stages: initial, after natural mortality, after fishing in mixed stock marine areas (preterminal), and mature run. The ratio for July-Sept in inland waters estimated in NMFS (2011a) was between 3.2 and 7.9 times the whales estimated needs. For the 2019 analysis, the cohort abundance is estimated before natural mortality and the base period changed.

The proposed fishing would reduce the available prey and lower the ratio of available prey compared to needs of the whales. Because we consider the ratio of Chinook prey available to meet the whales' needs to be relatively low for inland waters July through September, any additional measurable reduction during these months when the ratios are relatively low is a concern. However, due to the limitations in interpreting these ratios, we are unable to quantify how this reduction affects foraging efficiency of the whales. The proposed fishing reduces the ratio of available prey during other times of year, but there is generally less fishing at other times of year, less overlap with the whales, the reductions are much smaller and the ratios are higher.

Localized depletions: Because of their life histories and the location of their natal streams, adult salmon are not evenly distributed across inland waters during the summer and early-fall months when Southern Residents occur in this general area. Therefore, the overall reduction in prey could cause local depletions, further affecting the ability of the whales to meet their bioenergetic needs. Reducing local abundance of prey from the proposed fishing could result in the whales leaving areas in search of more abundant prey. This could result in a potential increase in energy demands which would have the same effect on an animal's energy budget as reductions in available energy, such as one would expect from reductions in prey. The Southern Residents regularly make trips to coastal waters during the summer months and have access to additional prey in nearby waters. This was particularly true in 2017 and 2018 when the whales spent more time off the coast than in inland waters.

It is difficult to assess potential for localized depletions because the prey reduction during July through September throughout the action area or in inland waters may not accurately predict reductions in prey available in known foraging hotspots. For example, a 5.4% reduction in food energy in the inland waters applies to a broad area with varying overlap with the whales. A reduction in Chinook salmon in south Puget Sound during summer months when the whales are primarily off the west side of San Juan Island will have a different effect on reduced prey availability than that same percent reduction off the west coast of San Juan Island. While we have detailed information on the whales' distribution, unfortunately, FRAM is not able to analyze prey reductions at a finer scale.

We can also look at the proposed fisheries in 2019 and compare to previous years to evaluate potential for more localized depletion. As described above, the 2019 fishery includes some changes in recreational fishing to reduce impacts to Chinook salmon including a closure in MA 7 in August and non-retention Chinook fisheries in September (along with other closures in other areas; Figure 23). Although difficult to quantify, these actions should reduce the removal of potential prey in important foraging areas of Southern Residents, and should therefore have a reduced impact on the amount of Chinook prey available to Southern Resident killer whales than fisheries in previous years. In particular, this may reduce potential local prey depletions in MA 7, an important foraging area for the whales, during the months of August and September in addition to reducing interference with foraging through reduced vessel presence.

In summary, the proposed actions are expected to cause a 5.4% reduction in abundance of age 3-5 Chinook salmon during the July through September months in inland waters in 2019. Overall, the number of fish is a meaningful reduction in the number of feeding days to the Southern Resident killer whale population, however, not all of the fish caught in the fishery would have been intercepted and consumed by the whales. The estimated reduction is highest in inland waters during July through September compared to the other seasons and likely an overestimate based on the conservative assumptions in the analysis. Although some of the reduction occurs in an area known for its high use and is considered a foraging hotspot, a fishery closure in August and non-retention in September will likely reduce the impacts in this hotspot. Small percent reductions can lead to reduced fitness, increased foraging effort, and less energy acquired. We anticipate smaller reductions in prey in 2019 than in previous years, in part because of reduction in fishing to protect vulnerable salmon populations and also because of the above average total Chinook salmon abundance available. Changes in the fishery and efforts to reduce fishing in the primary foraging area along the west side of San Juan Island will reduce the potential for prey reductions to result in significant localized depletions or prey depletions at levels that would cause injury or impair reproduction.

2.5.4.2 Effects on Critical Habitat

In addition to the direct and indirect effects to the species discussed above, the proposed action affects critical habitat designated for Southern Resident killer whales. 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. This analysis considers effects to these features.

The proposed actions have the potential to affect the quantity and availability of prey and passage conditions in critical habitat. Although Southern Resident killer whale critical habitat remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers, we do not expect the proposed fisheries to impact water quality because fishing vessels do not carry large amounts of oil, making the risk from spills minor. Therefore, we do not anticipate adverse effects to water quality.

Effects of the proposed fishing reduce prey quantity and availability in critical habitat resulting from the harvest of adult salmon. As described previously, several studies have correlated Chinook salmon abundance indices with Southern Resident killer whale population growth rates (Ford et al. 2005; Ford 2009; Ward et al. 2009; Ward et al. 2013). However, uncertainty remains because there are several challenges to understanding this relationship. The pre-season estimates for abundance of age 3-5 Chinook in designated critical habitat will be approximately 950,585 (in the mid quartile of abundance) and the proposed action is likely to result in reductions in prey quantity and availability by 5.4% (in the lower quartile of percent reductions). The reduction in prey quantity and availability from the proposed fisheries roughly translates to 31 days of enough prey to feed all individuals in the population. It is difficult to assess how reductions in prey abundance may vary throughout critical habitat and we have less confidence in our understanding of how reductions could result in localized depletions in the three different core areas of designated critical habitat. Furthermore, seasonal prey reduction throughout critical habitat may not accurately predict reductions in prey available in their summer core area, a known foraging hotspot.

As described above, we also estimated the Chinook food energy available to the whales and compared available kilocalories to needs and evaluated the ratio after reductions from the proposed fishing. The baseline ratios (i.e. what actually occurred from 1992 to 2016 and is based on post season information, see Environmental Baseline) in critical habitat ranged between 8.28 and 16.89 times the whales' estimated needs during July through September. With the proposed fishing, the ratios would be reduced to 12.87 (within the range of the baseline from 1992 to

2016) during this time. Because we consider the ratio of Chinook prey available to meet the whales' needs to be relatively low in critical habitat in July through September, the additional reduction in these ratios is a concern. However, we are unable to quantify how this reduction affects foraging efficiency of the whales and therefore apply a lower weight to this part of the analysis.

As described in the Effects section, we anticipate a higher abundance of Chinook in 2019 compared to last year. Furthermore, impacts are expected to be lower in 2019 based on the reduced fishing (i.e., closure of recreational fishing in August and non-retention of Chinook in September in Marine Area 7, and a closure in the winter sport fisheries in several months that may benefit the whales). With higher prey abundance and lower fishing effort in 2019, prey quantity and availability in critical habitat are anticipated to be improved compared to the last several years.

Effects of the proposed fishing include exposure of whales to the physical presence and sound generated by vessels associated with the proposed action. This increase in vessel presence and sound in critical habitat and in a key foraging area, contribute to total effects on passage conditions. As described above, the vessels associated with the fishing activities overlap with the whales, particularly in July through September in MA 7, an area defined as the whales' summer core area in Haro Strait and waters around the San Juan Islands. Although we cannot quantify the increase in vessels around the whales likely to result from the proposed action, it is reasonable to expect that authorization of the proposed fishery will result in more vessels in core areas of the whales' critical habitat than there would be if no fishing is authorized.

For reasons described above, it is likely that the amount of disturbance caused by the fishing vessels will affect whale behavior including spending more time traveling and performing surface active behaviors and less time foraging and resting in their critical habitat. The fishing vessels will also reduce effectiveness in locating and consuming sufficient prey through acoustic and physical interference. These impacts may also reduce overall foraging at times and may cause whales to move to areas with less disturbance outside of currently designated critical habitat. However, as described above, vessel impacts are expected to be lower in 2019 based on the reduction in overlap of fisheries and whales in the summer core area (e.g. closure in August and non-retention in September in MA 7, which includes the summer core area), and WDFW will continue to promote the adherence to a voluntary "No-Go" Whale Protection Zone along the western side of San Juan Island in Marine Area 7, extending from Mitchell Point to Cattle Point, for all recreational boats—fishing and non-fishing—and commercial fishing vessels (with the exception of the Fraser Panel sockeye fisheries). In addition, conservation efforts by WDFW will include education to fishing vessels to maintain slow transit speeds (restricted to 7 knots or less) at a minimum and potentially reduce transit speeds in critical habitat and to silence vessel sonar in the presence of Southern Residents and when fishing gear is deployed (especially those transmitting at 83 kHz). Therefore, we anticipate adverse effects to passage conditions from fishing vessels is expected to be small and mitigated by several conservation efforts.

2.5.5 Central America and Mexico DPSs of Humpback Whales

Humpback whales (Central America DPS, Mexico DPS) may be directly affected by the proposed action by interaction with vessels or gear, or indirectly affected by reduced prey availability.

Humpback whales consume a variety of prey such as small schooling fishes, krill, and other large zooplankton. Because the proposed fishing targets species that are not the primary prey for humpback whales, it is not expected to reduce their prey. Any reduction in prey would be extremely minor and an extremely small percent of the total prey available to the whales in the action area and therefore insignificant.

Vessel traffic and fishing effort associated with the proposed fisheries are anticipated to be similar or less than past levels in inland waters of Washington. Between 2007 and 2017, there have been two recorded vessel strikes to humpback whales that occurred off of Clallam County, WA. However, fishing vessels were not tied to either of these encounters. Vessels and gear would have a short-term presence in any specific location and any disturbance from vessels would be minimal. Furthermore, the vessels involved in the proposed fishing activities will not target marine mammals. Because collisions between vessels and large whales mostly occur with shipping traffic, and because we have no recorded evidence of a collision between a salmon fishing vessel and humpback whales in the action area, we consider the potential for effects to be discountable. This analysis will therefore focus on the interactions between Puget Sound salmon fisheries and ESA-listed humpback whales. We first summarize available information on these interactions, then we assess the magnitude of these interactions that may occur for ESA-listed populations of humpback whales.

Entanglement of ESA-listed marine mammals is known to be an issue with commercial fishing gear on the U.S. West Coast (Saez et al. 2013). For humpback whales that may co-occur with the proposed fisheries, there is a risk of becoming captured/entangled in the proposed fishing gear (herein referred to generally as "interactions"). Humpback whales could unknowingly swim into the gear and become entangled.

Considering the limited extent of observer data that are available from many commercial fisheries, including Puget Sound salmon fisheries, NMFS also relies upon other records of entanglements/interactions that are reported to Marine Mammal Stranding Programs to evaluate the relative impact of interactions by marine mammal stocks with commercial fisheries and other human sources. The most current information on these data on the West Coast is available in the marine mammal SARs and a Serious Injury and Mortality Report published annually (Helker et al. 2018). These data are collected opportunistically and typically have not been extrapolated within the SARs into more comprehensive estimates of total strandings or human interactions that may have occurred, and we understand these totals to represent minimum totals of overall impacts. Below we describe the available information on humpback whale interactions with Puget Sound fisheries that can be found in NMFS's entanglement response database and the Serious Injury and Mortality Reports. We acknowledge uncertainty around the most recent reports because they have not yet gone through the serious injury designation process.

Bycatch of marine mammals in all commercial fisheries is monitored and categorized according to relative risks of mortality and serious injury (M/SI) for marine mammal stocks by NMFS through the List of Fisheries (LOF) as required by the MMPA. The LOF lists U.S. commercial fisheries by categories (I, II, and III) according to the relative levels of interactions (frequent, occasional, and remote likelihood of interaction or no known interactions, respectively) that result in M/SI of marine mammals. The List of Fisheries for 2018 classified the Washington salmon purse seine, WA salmon reef net, and CA/OR/WA salmon troll fisheries all as a category III (i.e., III (i.e., remote likelihood of/no known incidental mortality or serious injury of marine mammals) (83 FR 5349, February 7, 2018). The prediction of future events occurring that have never occurred before, given that no incidental captures or entanglements with ESA-listed marine mammals has ever been documented, is challenging because these risks cannot be completely eliminated. At this time, we conclude that the lack of historical incidental capture or entanglements between purse seine and troll gear and humpback whales or other marine mammals, even when risks of such interactions have been and continue to remain possible, is a reflection of the low co-occurrence of the species and the fishing effort. In 2018, the Puget Sound region salmon drift gillnet fishery was listed as a Category II fishery, meaning they have occasional likelihood of marine mammal interactions that can result in M/SI. However, humpback whales were not one of the species driving this classification.

From 2007 to 2016, there were no documented humpback whale entanglements in salmon fishing gear in Puget Sound. In 2017, there was one humpback reported entangled in gillnet gear off of San Juan Island, although the gear was not recovered and therefore was not identified. In 2018, three humpback whales were reported entangled in sockeye gillnet gear in inland Washington waters. One additional entangled humpback was reported off the coast of Port Angeles, WA that was also confirmed to have a gillnet entanglement, but the specific fishery is unknown. Of the three sockeye gillnet entanglements in 2018, one resulted in the death of the whale, and the status of the other two are unknown. As described in the humpback whale status section, when assessing humpback whale interactions, NMFS will use proportions estimated for humpback whales found off the coast of Washington and South British Columbia for inland waters as well: 15% estimated from the Central America DPS and 42% to be from the Mexico DPS. The remaining 43% are considered to be from the unlisted Hawaii DPS.

Under the MMPA, PBR is used to assess appropriate levels of human-caused mortality and serious injury stocks can withstand. It is important to note that while PBR serves as a useful metric for gauging the relative level of impact on marine mammal stocks as defined in the MMPA, PBR by itself does not equate to a species or population level assessment under the ESA where analyses are conducted at the level of the species, subspecies or DPS listed as threatened or endangered. However, the concept of managing impacts to marine mammal populations to levels that do not significantly affect recovery times shares the general intent of the jeopardy standard of the ESA in terms of looking at both the continued existence and recovery of a population. Therefore, we use the PBR concept from the MMPA to help characterize the relative impact of the Puget Sound fisheries on the Central America and Mexico DPSs, and then relate those findings to the species as a whole under the jeopardy standard of the ESA.

The current stock structure for humpback whales as defined under the MMPA does not match up with the DPS structure as defined under the ESA, which presents challenges in directly relating between the two statutes. In keeping with our general convention to look at the status of marine mammal stocks under the MMPA to help inform our ESA analyses where appropriate, we will review and incorporate information about current estimates of human impact relative to PBR from each MMPA stock that is relevant to the ESA-listed DPSs to ultimately assist with characterizing the relative impact of the Puget Sound fisheries on the Central America and

Mexico DPSs.

PBR for the CNP stock of humpback whales is 83 in U.S. waters and PBR for the CA/OR/WA stock is 16.7 per year (Carretta et al. 2018a; Muto et al. 2018b). There are no PBR levels associated with the DPSs. It is unlikely that the total level of human-caused mortality and serious injury (26) exceeds the PBR level for the CNP stock (Muto et al. 2018a); however, the minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (9.9 whales) is more than 10% of the calculated PBR for the entire stock and, therefore, cannot be considered to be insignificant and approaching a zero mortality and serious injury rate. A small portion of this stock likely includes whales from the Mexico DPS.

In contrast, the observed annual mortality and serious injury of CA/OR/WA humpback whales due to commercial fishery entanglements, non-fishery entanglements, recreational crab pot fisheries, serious injuries assigned to unidentified whale entanglements, plus observed ship strikes, equals 18.8 animals, which exceeds the PBR of 16.7 animals (Carretta et al. 2018a). The Mexico DPS constitutes a significant portion of the humpback whales in the CA/OR/WA stock and the Central America DPS constitutes a smaller portion off of Washington and British Columbia, although the specific proportion varies along the coast (Wade et al. 2016b) and is currently unknown for inland waters of WA. Observed annual humpback whale M/SI in commercial fisheries (14.1/yr) is greater than 10% of the PBR; therefore, total fishery mortality and serious injury is not approaching zero mortality and serious injury rate (Carretta et al. 2018a). In total, it appears that the Mexico and Central America DPSs may have been experiencing relatively high rates of documented M/SI in some portions of their range, however, available data indicate a small number of total fishery interactions or ship strikes are detected or reported in inland waters of Washington compared to other portions of the range.

Changing ocean conditions and prey distribution could be an additional factor leading to increased co-occurrence between humpbacks and fisheries in the action area in recent years. Warmer ocean conditions in the last 5 years have been hypothesized to be causing an atypical community of zooplankton (such as krill) in the North Pacific (DFO 2018). Furthermore, recent research found that humpback whales were largely feeding on krill in the Salish Sea in 2018 (John Calambokidis, pers comm, March 5, 2019). Environmental changes could be impacting the distribution of humpback whale prey, but research into the implications of recent changes in oceanographic conditions is still ongoing.

Pre-season estimates of sockeye abundance for 2019 in Puget Sound are low, particularly in regards to the numbers of fish traveling through U.S. waters. For example, the Fraser River sockeye forecast is predicted to be significantly lower than last season (DFO 2018). We therefore expect decreased fishing effort in the upcoming season, which could potentially reduce the likelihood of co-occurrence of humpback whales and the fisheries and thus reduced likelihood of entanglements in sockeye gear. However, as humpback whales are beginning to return to the Salish Sea in increasing numbers (Calambokidis et al. 2017), we can likely expect similar levels of interactions in the future. We can therefore expect between 1-2 interactions with these fisheries each year, ranging from not serious injury to mortality. These interactions would likely be from the unlisted Hawaii DPS, as they likely have the highest abundance in Washington waters. These 1-2 interactions could represent between 0.15 and 0.3 interactions with individuals from the endangered Central America DPS and between 0.42 and 0.84 from the threatened

Mexico DPS during the 2019-2020 fishing season. These estimates represent very small proportions of the entire populations of each DPS and if only a portion of those interactions would be expected to result in serious injury or mortality, the risks to both populations are very low.

In summary, NMFS finds impacts from prey reduction and vessel collisions to be very minor, while the proposed action may result in 1-2 interactions between fishing gear and humpback whales within the action area. Although there may be decreased fishing effort in 2019, the continually increasing presence of humpback whales in inland WA waters may cause similar levels of interactions in 2019 when compared with what occurred last year. These interactions would most likely impact the unlisted Hawaii DPS, and any impacts to the Central America or Mexico DPSs would be extremely small when compared to the population of each DPS. We acknowledge uncertainty around which DPSs are found within the action area, and therefore used a conservative approach when assessing the number of possible interactions with whales from these DPSs.

2.5.6 Fishery Related Research Affecting Puget Sound Chinook Salmon and Steelhead

Four research projects are included under the proposed actions. Each test fishery study has the potential for incidental take of Puget Sound Chinook salmon and steelhead. These research projects are described and their impacts summarized below.

PSC Fall Chum Salmon Study

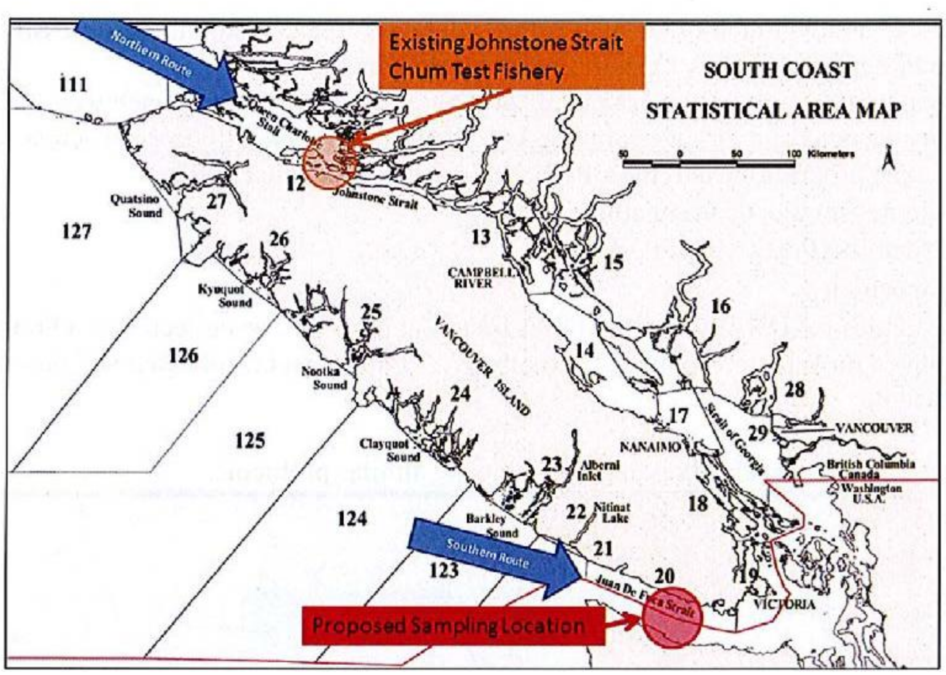

Figure 25. Location of proposed sampling site for PSC chum genetic sampling study.

A PSC Chum Technical Committee has received funding from the Southern Endowment Fund to implement a fall chum salmon genetic stock composition research test fishery study on fall chum salmon migrating through the Strait of Juan de Fuca in 2019. The fall chum research proposal is included in BIA's proposed action for 2019 and is summarized here (Norton 2019). This is the third year of the study and follows the same methodology as in 2016. The proposed study will use one purse seine vessel four days per week for five weeks during October and November in Area 5 (U.S. territory) (Figure 25). Catch per Unit Effort information will be collected as well as biological samples for stock identification purposes. Sampled chum will be removed by dipnet from the seine, all other fish will be released directly from the seine while still in the water, by submerging the cork line (Norton 2019).

There is the potential to encounter small numbers of non-listed and ESA-listed Puget Sound natural and hatchery steelhead and Chinook during implementation of the study. Anticipated steelhead encounters would be no more than 10 adult steelhead, released in-water, alive, with minimal handling, and with a potential mortality of 2 steelhead of unknown origin and listing status. Given the study would occur in a pre-terminal area, some portion of the encountered fish could be Canadian or coastal steelhead from outside the Puget Sound DPS. Implementation of the study in 2016-18 has resulted in only 1 encounter with potentially ESA-listed steelhead (Norton 2019).The fish are not sampled for marks (Section 2.4.1) so it is not possible at this time to assign harvest encounters to specific populations. As described earlier, in Section 2.5.2, the estimate of 23,241 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 0.04% of the total natural-origin abundance of Puget Sound steelhead assuming all encountered steelhead were of natural origin and from the Puget Sound DPS. This research impact is therefore considered to have a very minor effect on natural-origin steelhead abundance, productivity, spatial structure, and diversity and is unlikely to impede the Puget Sound Steelhead DPS from reaching viability.

The study is also expected to encounter no more than 200 immature Chinook, some of which may be listed. Additionally the study expects the potential for incidental mortality of no more than 60 immature Chinook. These level of encounters and incidental mortalities would result in an extremely small increase in the total exploitation rate on individual Puget Sound populations, ranging from 0 to 0.08%. For most populations, the increase would be 0.01% or less (Norton 2019). These low exploitation rates when combined with other research fishing activities are expected to fall below the 1% exploitation rate per Puget Sound Chinook management allowance reserved for this type of activity as described in the 2010 RMP and therefore part of the proposed actions (PSIT and WDFW 2010b; Norton 2019). Based on the results of the 2018 study in which few listed Chinook were encountered (69 immature Chinook, 0 adult Chinook), we expect the impacts would be less. This research impact is considered to have a minimal effect on natural-origin Chinook abundance, productivity, spatial structure, and diversity and is unlikely to impede the Puget Sound Chinook ESU from reaching viability.

Lake Washington/Lake Sammamish Predator Removal Test Fisheries

Two studies are proposed to occur within the Lake Washington area. Both studies are designed to remove warm water fish species that prey on salmon and steelhead although the focus of the studies differ. Both proposals are summarized here and incorporated by reference (Norton 2019).

The Muckleshoot Indian Tribe (MIT) proposes to implement a test fishery to collect information on the feasibility and potential impacts of a directed ceremonial, subsistence, and commercial warm water fish species fishery in the Lake Washington Basin. The MIT proposed warm water test fishing study area is divided into eight zones (Figure 26). The test fishery timing and locations will decrease encounters of ESA-listed species, including steelhead, and will use gear designed to avoid these species as well (Norton 2019). During the first two years of the study, 2017 and 2018, no steelhead were encountered (Warner 2018). Nonetheless the warm water test fishery includes a precautionary estimate that it may impact up to 3 Puget Sound adult steelhead and 5 adult, natural-origin Chinook salmon. The test fishery would immediately shut down upon encountering either the third adult steelhead or the fifth adult, natural-origin Chinook salmon (Norton 2019).

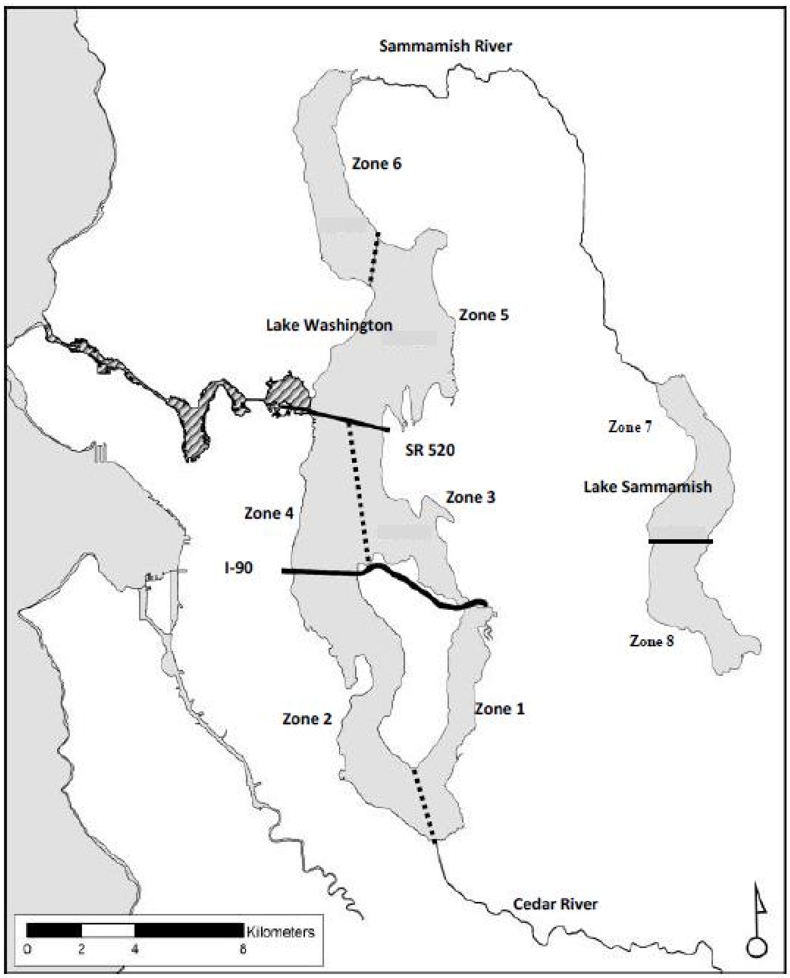

Figure 26. Muckleshoot Indian Tribe proposed warm water test fishery zones (1-8) and exclusion areas (cross-hatched) that will not be fished in order to minimize the potential for adult steelhead encounters (Norton 2019).

The WDFW proposes a study to implement a gillnet test fishery in the Lake Washington Shipping Canal (LWSC). The objective of the proposed study is to (1) describe the relative abundance and size structure of piscivorous fishes inhabiting the LWSC during the salmon smolt out-migration period and (2) determine the relative proportion of juvenile salmonids in the stomach contents of piscivorous fishes that inhabit different habitat types within the LWSC (Garret and Bosworth 2018). Gill netting would occur from early-May to early-July 2019, during the salmon smolt out-migration period, and would consist of multiple sampling days (Norton 2019). Nets will be deployed at night with 12-16 hour set times. A range of mesh sizes (2-inch, 2.5-inch, 3-inch, and 4-inch) will be used in an effort to capture a broad range of fish species and sizes. All species will be measured to the nearest millimeter. Stomachs of predatory fishes >150 mm TL will be pumped using gastric lavage; stomach contents will be stored in a -80F freezer until they can be processed by NMFS (Roger Tabor). Nets will be deployed at selected stations within the study area (Figure 27).

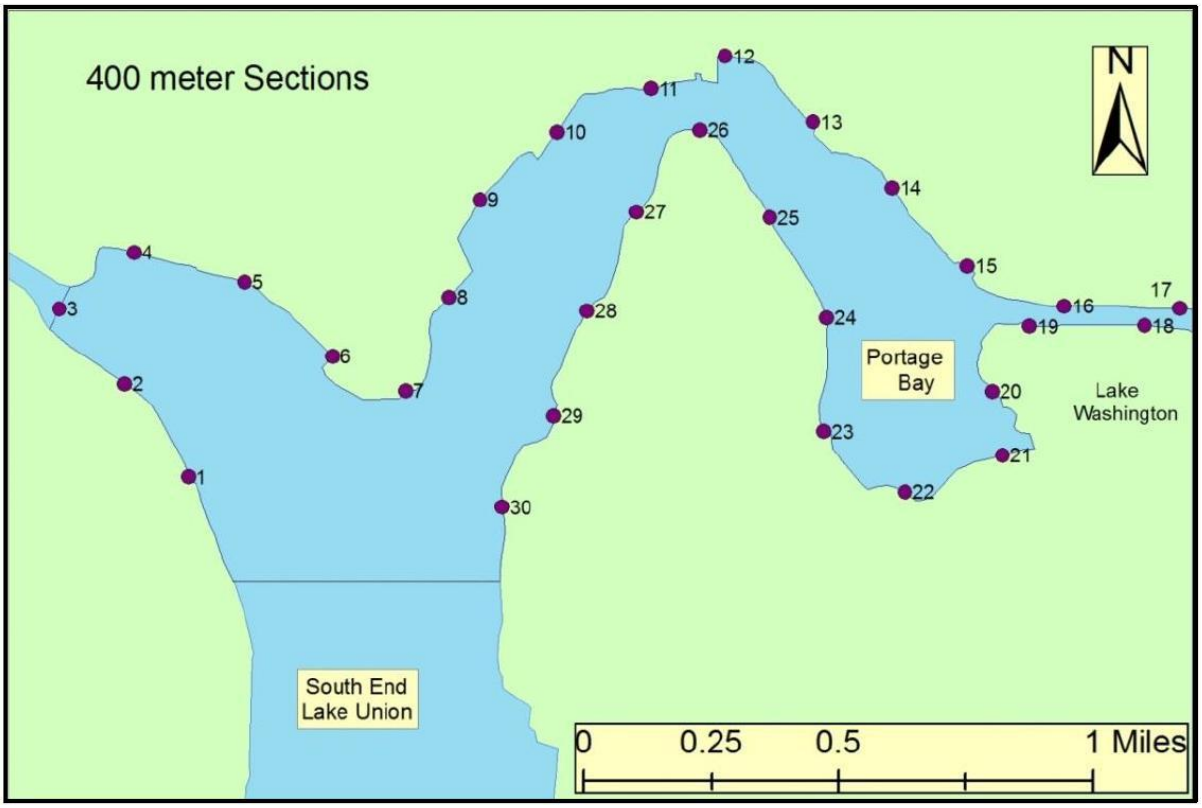

Figure 27. Designated study area within the Lake Washington Shipping Canal (492 acres) including 400-meter sampling sections (Garret and Bosworth 2018).

WDFW does not anticipate encountering adult or juvenile steelhead during the proposed study. Generally, adult steelhead would not be migrating during the periods of the study and Juvenile steelhead are anticipated to have migrated through the system already and would not be present in the study area (Garret and Bosworth 2018). Additionally, neither steelhead life stage has been encountered in either 2017 or 2018, the two previous years of the work (Norton 2019). Although the study proponent expects that no steelhead will be encountered, WDFW estimates precautionary impacts to Puget Sound steelhead of up to one adult, and zero juvenile steelhead.

The PSSTRT identified two steelhead populations in the proposed test fishing area: North Lake Washington/Lake Sammamish winter-run and Cedar River winter-run (PSSTRT 2013). These DIPs are part of the Central and South Puget Sound MPG. In the 5-year status review update for Pacific Northwest Salmon and Steelhead listed under the ESA (NWFSC 2015), the 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 26). No estimates were available for the North Lake Washington/Lake Sammamish winter-run DIP for the 2010-2014 time period. Cedar River and North Lake Washington / Lake Sammamish winter-run steelhead are already estimated to be below their Quasi-extinction Threshold (QET) abundances of 35 and 36 fish, respectively (PSSTRT 2013). However, the 95% confidence intervals around these estimates were generally wide over the 100-year time frame (Myers et al. 2015). There is no doubt that productivity of the Cedar River and North Lake Washington / Lake Sammamish winter-run steelhead populations are below replacement (Section 2.2.1.2; Figure 5).

Table 26. 5-year geometric mean of raw natural spawner counts for the Lake Washington/Lake Sammamish watershed, where available (NWFSC 2015).

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

The total anticipated research incidental mortality would be up to three adult Puget Sound steelhead for the MIT test fishery and one adult and zero juvenile steelhead for the WDFW predator removal study. Based on steelhead abundance data from (NWFSC 2015) for the Cedar River winter-run DIP during the 2010-2014 time period, should the impacts occur it could result in potentially large negative effects to its abundance, productivity, spatial structure, and diversity. However, there is a very small to zero potential impact for the studies to interact with adult or juvenile steelhead in Lake Washington for reasons described above and discussed in detail in Speaks (2017). These reasons are supported by the lack of steelhead encounters during the 2017-2018 MIT test fisheries. Current data from the MIT suggests that natural-origin steelhead have already been extirpated from the Lake Washington watershed (MIT 2016).

The PSSTRT (Myers et al. 2015) 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 (Myers et al. 2015). 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 (Myers et al. 2015). 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 (Myers et al. 2015).

Despite the potential for negative effects to occur to the Lake Washington/Lake Sammamish and Cedar River winter-run DIPs, encounters with natural-origin adult or juvenile steelhead are unlikely to occur and the high presence of resident *O. mykiss* in the Lake Washington watershed may assist in guarding the DIP from potential extirpation. Four out of eight DIPs in this Central and South Puget Sound MPG are required for viability and two of these DIPs demonstrate recent increasing trends (18% Nisqually River; 136% White River; Section 2.2.1.2, Table 7). Precautionary measures such as important exclusion zones, timing of the fishery, immediate reporting, careful release measures for encounters, and close research monitoring by Tribal and WDFW members, technical staff, and enforcement staff will guard against potential natural-origin steelhead mortalities from the Lake Washington/Lake Sammamish and Cedar River DIPs. After considering the above factors, effects from the test fishery proposals are largely negative on the population level, but these effects are considered rare and unlikely to occur. Both studies will reduce predator populations that could be a substantial mortality factor on salmonids and provide future evidence to resolve questions regarding the presence of ESA-listed steelhead in Lake Washington.

Chinook adults typically begin migrating through the LWSC in mid-June with the peak migration period occurring in mid to late August (Norton 2019). Relatively small numbers of adult Chinook would be migrating through the LWSC while the proposed sampling would occur, however some adult Chinook may encounter the sampling gear as they migrate through the action area. Chinook adults migrating through the LWSC are likely to use deep-water offshore habitats where sampling gear is less likely to be deployed. Most sampling effort will occur in near-shore or off-channel, weedy habitats where adult Chinook are less likely to migrate. Adult Chinook were not encountered during previous sampling efforts (conducted in 2017 and 2018) in the LWSC. Due to the early timing of the proposed sampling and the off-channel areas where sampling will occur, the number of adult Chinook encountering sampling gear will likely be small. A combined gear take of 5 Chinook adults (NOR and/or HOR) is estimated. Juvenile Chinook salmon will actively be migrating through the LWSC during the proposed sampling period (early-May through early-July). Small numbers of juvenile Chinook smolts may encounter the sampling gear, however the mesh size (2 to 4 inch stretch mesh) is too large to entangle a Chinook juvenile and poses very little threat. Juvenile Chinook were not encountered during previous sampling efforts (conducted in 2017 and 2018) in the LWSC. The take is estimated as zero juvenile Chinook.

As outlined above, in Section 2.5.1, the Puget Sound Chinook Resource Management Plan (PSCRMP), as extended, provides coverage allotment for take of both Puget Sound Chinook and steelhead. Expected steelhead take is zero fish and Chinook take (HOR and NOR combined) may not exceed a level equivalent to 1% of the estimated annual abundance (i.e. 1% ER). Average total abundance for Lake Washington Chinook was 7952 adults during a recent (2010-2017) 8-year time period (Norton 2019). The estimated take of 5 adult Chinook for these two Lake Washington research studies represents an exploitation rate of 0.06% (5/7952=0.0006), which is well below the 1% ER limit.

Nooksack River Spring Chinook Telemetry Study – Lummi Nation

The Lummi Natural Resources Department has received funding to implement a radio tag study to evaluate spatial distribution, temporal distribution and post release mortality of natural and hatchery origin South Fork Nooksack spring Chinook entering the Nooksack River between April and June. No data currently exist on holding area preferences or Nooksack River-specific thermal preferences of SF Chinook, which has a significant bearing on future broodstock collection efforts and habitat restoration projects. Additionally, it is hypothesized that a seasonal thermal barrier may be creating vulnerability to SF Chinook by affecting entry to the South Fork Nooksack which may be delaying spawn timing and inducing temperature related pre-spawn mortality.

A tangle net (4.75" gill net mesh size) will be used to capture Chinook in the Nooksack River below the Slater Road Bridge. Three boats are used in this process: The primary fishing boat to deploy and manage the net, a tail boat to control the tail board end of the net, and a recovery boat. all natural-origin Chinook, all suspected SF hatchery Chinook (CWT only), and some hatchery origin NF/MF Chinook (identified with a adipose mark) will be tagged with radio transmitters and tracked using ground and aerial surveys on a weekly basis. A portion of the marked hatchery Chinook will be harvested for C&S use.

Up to 50 Lotek MCFT2 radio transmitters will be deployed each year using esophageal deployment. All released fish will receive a metal jaw tag with a unique identification number, will be tissue sampled for genetic stock assignment, be measured for fork length, sampled for scales, and sexed. For evaluating temporal and spatial distribution, weekly ground surveys in road-accessible areas of the main stem and forks will be conducted. Ground surveys will be used for accurately estimating entry timing to sub-basins, estimating spawn timing, pinpointing preferred holding areas, and recovering tags from mortalities. Weekly aerial surveys will be used to track spatial distribution throughout the entire Nooksack basin.

For 2019, this radio tag study will be limited to no more than 10 natural origin encounters. Applying the co-manager agreed 30% release mortality to these 10 encounters results in 3 natural-origin mortalities. These 3 mortalities result in a 0.82 ER on natural-origin Nooksack spring Chinook. Five steelhead are also anticipated to be encountered during this research. Applying an 18.5% release mortality rate, the same rate as applied to steelhead released during the Lummi spring Chinook C&S fishery with tangle-net gear, results in approximately one steelhead mortality as a result of these research efforts.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR 402.02). Future Federal actions that are unrelated to the proposed actions and that have undergone section 7 consultation are considered in the Environmental Baseline.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to determine which of the action area's future environmental conditions caused by global climate change are caused by activities in the action area versus activities elsewhere in the world. We describe all relevant future climate-related environmental conditions in the action area in the environmental baseline (Section 2.5).

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

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 adapted in 2007 (SSPS 2005; NMFS 2006b). Puget Sound steelhead recovery planning is underway. A Recovery Plan for Puget Sound/Georgia Basin Yelloweye Rockfish and Bocaccio was completed in 2017 (NMFS 2017e) and implementation with state and other partners is ongoing. In 1991, a Recovery Plan for humpback whales was published (NMFS 1991). A Final Recovery Plan for Southern Resident killer whales was published January 24, 2008 (NMFS 2008f). Rules on vessel traffic to protect Southern Residents from vessel effects were adopted in 2011 (76 FR 20870). Outreach and enforcement of these regulations will reduce the vessel effects (as described in Ferrara et al. (2017)) of recreational and commercial whale watching vessels in U.S. waters of the action area. There is currently a ¼ mile "Whalewatch Exclusion Zone" along the west side of San Juan Island from Mitchell Bay to Eagle Point (and ½ mile around Lime Kiln) as part of the San Juan County Marine Resources Committee Marine Stewardship Area. San Juan County is in the process of expanding this area to include a ¼ mile no vessel zone to Cattle Point with additional recommendations for speed. As described in the Effect Section, WDFW formally extended the voluntary no-go zone from Mitchell Point all the way to Cattle Point in 2018. This zone extends a quarter mile seaward along its entire length, except for the area around Lime Kiln where it extends a half mile seaward. The voluntary speed limit applies to the area within 400 yards of the whales, beyond the voluntary no-go zone. In 2018, the Pacific Whale Watch Association updated their industry guidelines stating "Vessels will remain a minimum of 1⁄2 mile (880 yards) from the light beacon of the Light House at Lime Kiln State Park on San Juan Island when whales are in the vicinity. Vessels will remain a minimum of 1⁄4 mile (440 yards) from the main shoreline of the west side of San Juan Island when between Mitchell Point to Cattle Point (facing south)." The Canadian Fisheries Minister is also considering new regulations to protect killer whales in Canadian waters.

On March 14, 2018, WA Governor's Executive Order 18-02 was signed and it orders state agencies to take immediate actions to benefit Southern Resident killer whales and established a Task Force to identify, prioritize, and support the implementation of a longer term action plan need for Southern Resident killer whale recovery. The Task Force provided recommendations in a final report in November 2018. A "No Go" Whale Protection Zone was considered by the Task Force as a proposed long-term solution. Although this zone was not formally supported by the Task Force, several other recommendations were proposed to the State Legislature as bills. Four of these bills passed in April 2019 and pending signature by the Governor, thus these measures are reasonably certain to be implemented.

One of these new state laws increases the viewing distance from 200 to 300 yards to the side of the whales and reduces vessel speed within ½ nautical mile of the whales to seven knots over ground. This legislation also specifies that commercial fishing vessels are not exempt from this requirement (2SSB 5577). SB 5918 amends RCW 79A.60.630 to require the state's boating safety education program to include information about the Be Whale Wise guidelines, as well as all regulatory measures related to whale watching. Two other pieces of legislation are aimed at reducing the risk of oil spills to the whales by requiring more oil tankers to be escorted by tugs as well as reducing the level of contaminants in SRKW critical habitat through the use of a stricter chemical classification system (ESHB 1578 and SSB 5135). Finally, the last piece of legislation relates to protection of Chinook habitat and prey in order to support recovery of Chinook salmon and improve prey availability for SRKWs (2 SHB 1579). In addition to the legislative actions, Washington State agencies are awaiting information on resources to support implementation of additional recommendations from the Task Force.

A joint DFO-NOAA Prey Availability Workshop was held in November 2017 that focused on identifying short-term management actions that might be taken to immediately increase the abundance and accessibility of Chinook salmon. Priority management actions identified in the workshop that should be considered included 1) targeted, area-based fishery management measures designed to improve Chinook salmon availability, and 2) reducing acoustic and vessel disturbance in key Southern Resident foraging areas. There was little support for broad scale coast-wide reductions in fishing to increase the prey available to the whales, which was consistent with the findings of the previous transboundary panel. Following some fishery closures in 2018, for the 2019 salmon fishing season, the Department of Fisheries and Oceans Canada is considering fisheries management measures including closure of the commercial troll fisheries for Chinook until August 20 in Northern BC, and August 1 on the West Coast of

Vancouver Island. Recreational opportunities could be provided later in the season but the 2019 potential measures include non-retention areas throughout the inland waters (e.g. Johnstone Strait and Northern Strait of Georgia until July 14; the Strait Juan de Fuca and Southern Strait of Georgia until July 31; and West Coast Vancouver Island offshore areas until July 14. Fraser River recreational fisheries will remain closed to salmon fishing until at least August 23. Canada is also considering additional measures to protect Southern Resident killer whales from vessel disturbance.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed actions. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed actions is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat for the conservation of the species.

2.7.1 Puget Sound Chinook

NMFS describes its approach to the analysis of the proposed actions in broad terms in section 2.1, and in more detail as NMFS focuses on the effects of the action in Section 2.4.1. The approach incorporates information discussed in the Status (Section 2.2.1.1), Environmental Baseline (Section 2.4.1), and Cumulative Effects (Section 2.6) 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 viability through harvest reductions alone without also taking substantive action in other areas to improve the survival and productivity of the populations. Recovery of the Puget Sound Chinook ESU depends on implementation of a broad-based program that addresses the identified major limiting factors of decline.

The analysis is unavoidably complex. It involves 22 populations spread across five geographic regions. NMFS uses a variety of quantitative metrics (e.g., RERs, critical and rebuilding thresholds, measures of growth rate and productivity) and qualitative considerations (e.g., PRA designation, whether a population is essential to a recovery scenario, the need for and status of a long-term transitional adaptation and recovery plan where the indigenous population has been extirpated, the magnitude of harvest in SUS fisheries, treaty fishery contribution) in its assessment of the proposed actions. These are discussed in Sections 2.4.1 (Environmental Baseline) and 2.5.1 (Effects of the Action). The Integration and Synthesis section summarizes and explains the considerations that lead to NMFS' biological opinion for the proposed actions. In the following, NMFS summarizes the considerations taken into account for each population in a discussion that is organized by region. The same information is displayed and summarized in Table 27 which may help navigate the complexities of the narrative.

Both Chinook populations in the Georgia Basin Region are near or below critical status. This is cause for concern given their role in recovery of the ESU. However, impacts from the proposed actions in Puget Sound fisheries are low (<8%), and our analysis indicates that further harvest reductions in 2019 Puget Sound fisheries would not measurably affect the risks to viability for either Nooksack population. This result is consistent with information that indicates system productivity is low and that past harvest constraints have had limited effect on increasing escapement of returning natural-origin fish. Total (natural origin and hatchery) escapement and growth trends are positive for the North Fork Nooksack and stable for the South Fork Nooksack population. The conservation hatchery programs that are designed to buffer demographic and genetic risks are key components in restoring viability of the Nooksack early Chinook populations. Measures to minimize fishery impacts to Nooksack early Chinook, particularly the South Fork population, are part of the proposed actions.

For the Whidbey/Main Basin Region, the effects of the proposed actions in 2019 will meet the recovery plan guidance of not impeding achievement of viability for two to four populations representing the range of life histories displayed in this region 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 the effects of the action on six of these are below their RERs with only four of the ten exceeding the RERs (Upper Skagit, Upper Sauk, Suiattle, South Fork Stillaguamish). Of these four populations, three exceed their RERs by less than one percent. Collectively the populations in this Region represent a diversity of healthy populations in the region as a whole. NMFS considers the proposed fisheries to present a low risk to populations where their estimated impacts are less than or equal to the RERs. The overall stable or increasing escapement trends, positive growth rates, and, in particular, the relatively robust status of the populations compared with their abundance thresholds should mitigate the risk that results from exceeding the RER in 2019 for the two Skagit spring, one Skagit fall, and one Stillaguamish populations. Although the South Fork Stillaguamish population is in critical condition and declining, the population is a PRA Tier 2 and its life history type is represented by other healthier populations in the region which are expected to be below their RERs (Table 21). Exploitation rates in 2019 Puget Sound fisheries are expected to be relatively low across the four management units (5%-20%) (Table 21). If the proposed actions were not to occur in 2019, we estimate that an additional 2 natural-origin spawners would return to the South Fork Stillaguamish River, which would not provide sufficient additional spawners to significantly change the status or trends of the populations from what would occur without the fisheries. Growth rates for natural-origin escapement are consistently higher than growth rates for natural-origin recruitment for most populations within the Region, including the South Fork Stillaguamish population. This indicates that sufficient fish are escaping the fisheries to maintain or increase the number of spawners from the parent generation; providing some stabilizing influence for abundance and reducing demographic risks.

For the Central/South Sound Region, implementation of the proposed 2019 fisheries is consistent with the recovery plan guidance of not impeding achievement of viability for two to four populations representing the range of life histories displayed by the populations in that region including those specifically identified as needed for recovery of the Puget Sound Chinook ESU (White River and Nisqually). Most populations in the region are doing relatively well compared to abundance criteria (Table 27). However, harvest impacts on all populations are anticipated to exceed their RERs in 2019.

The additional risks associated with exceeding the RER in the 2019 fishing year should not impede achievement of viability by the White, Nisqually, Puyallup or Green, and Cedar River populations. The White and Nisqually populations are in Tier 1 watersheds and essential to recovery of the ESU. The White River is expected to exceed its RER by only 0.3%, presenting minimal additional risk The growth rates and the escapement trend for the population are positive and this trend has occurred with the effects of exploitation rates during the last decade similar to the proposed actions; indicating the rates have not impeded growth of the population and would not be expected to do so in 2019. Natural-origin escapement for the White River is anticipated is close to its rebuilding threshold. For the Nisqually population, the conclusion stated above is based on four considerations: (1) the extirpated status of the indigenous Chinook population, (2) the increasing trend in overall escapements and stable growth rate for natural-origin escapement, (3) the natural-origin escapement anticipated in 2019, and (4) the implementation of a new long-term transitional strategy for the population, which began in 2018 and will continue in 2019. The additional actions being taken by the co-managers as part of the proposed actions described in Section 2.5.1.2 will also help improve the status of the Nisqually Chinook population. Natural-origin returns for the Green River have substantially increased in recent years and the population will be managed in 2019 to ensure that the gains are preserved, maintaining the abundance with additional opportunities to strengthen the trend. Growth rates for natural-origin escapement are consistently higher than growth rates for natural-origin recruitment in the Green River. 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. Average escapement for the Cedar River population is above its rebuilding escapement threshold and escapement in 2019 is expected to be above its rebuilding threshold. Trends for escapement (total and NOR) and growth rate are increasing. Average escapement for the Puyallup population has been more than three times its critical threshold and is near the rebuilding threshold. Escapement in 2019 is expected to be well above the rebuilding threshold. As with the Green River above, the Puyallup growth rates for natural-origin escapement are higher than growth rates for natural-origin recruitment indicating 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 population may experience some increased risks to the pace of adaptation of the existing local stock as a result of fisheries impacts exceeding the applicable RERs. The observed increasing and stable trends in escapement and growth rate for the Sammamish should mitigate the increased risk that could result of from fisheries exceeding the RER. For the Sammamish population, the additional spawners from further fishery reductions would not change the status of the population. The Sammamish population is a PRA Tier 3 and its life history and Green River genetic legacy are represented by other populations in the Central/South Sound region. The indigenous Chinook population has been extirpated, and potential improvement in natural-origin production is limited by the existing habitat. This population is not essential for recovery of the Puget Sound Chinook ESU.

In summary, given the information and context presented above, the fishing regime represented by the proposed actions for 2019 should not impede achievement of viability of five (White, Cedar, Duwamish-Green, Puyallup, and Nisqually) of the six populations in the Region in 2019. Therefore, implementation of the proposed 2019 fisheries is consistent with the recovery plan guidance that 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), should reach viability.

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 for the Skokomish population is on a long-term transitional strategy to rebuild one or more locally adapted Chinook populations in that watershed. 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 2019, while below the critical threshold, is higher than in most recent years, and the co-managers have proposed additional actions as part of the proposed hatchery-related actions to bolster recovery of the population (Skokomish Indian Tribe and WDFW 2010; Redhorse 2014; Grayum and Unsworth 2015; Unsworth and Grayum 2016; Skokomish Indian Tribe and WDFW 2017; Unsworth and Parker 2017; Shaw 2018; Norton 2019). 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 2017 update of the Skokomish Recovery Plan described a myriad of on-going habitat restoration and protection activities designed to contribute to recovery of the population. 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 in all but two of the years since 2010, where estimates are available (Table 20). Substantial changes in management were made in 2015-2017 but it is yet unclear whether the changes will fully address these overages, over the long term. In 2018, the comanagers agreed to manage fisheries to not exceed a 48 percent management objective, which should have improved the likelihood that the exploitation rate objective of 50 percent would be met in 2018, however, exploitation rates are not yet available for the 2018 fishery year. As part of the proposed actions for 2019, the fisheries put forward by the co-managers are again expected to result in a total exploitation rate near 48% (Table 21). 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. With the actions being taken to move the actual exploitation rate closer to the objective, and the other factors discussed above, exceeding the RER in 2019 should not impede the long-term persistence of the Skokomish Chinook 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 in the short term. The total escapement, inclusive of the hatchery fish, is expected to exceed the critical abundance threshold, reducing short-term demographic risk to the population. The available information indicates further constraints on 2019 Puget Sound fisheries would not measurably affect the risks to survival or recovery of the spawning aggregations within the Mid-Hood Canal population.

In the Strait of Juan de Fuca Region, the Dungeness population is expected to be in critical status, while the Elwha population is expected to exceed its critical threshold by more than 100 natural-origin spawners in 2019. Total fishery impacts on both are expected to exceed their RERs in 2019, although by less than 1% in both cases. Impacts from the proposed actions in Puget Sound fisheries are very low (<2%) and analysis suggests further harvest reductions in 2019 Puget Sound fisheries would not measurably affect the risks to survival or recovery for either population. Under the proposed action, escapements of natural-origin fish in the Dungeness and Elwha are expected to remain below and above their critical thresholds, respectively. When hatchery-origin spawners from the two conservation programs are taken into account, anticipated escapement in the Dungeness is more than four times the magnitude of its critical threshold and escapement in the Elwha is expected to greatly exceed the magnitude of the rebuilding threshold. The growth rate for escapement and recruitment are positive for the Dungeness. The growth rate for escapement and recruitment are both strongly negative 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. Projects have been implemented to improve flow conditions and to contribute to restoration of the flood plain for the Dungeness River population. Dam removal on the Elwha River was completed in 2014 and a full-scale restoration and recovery program is now underway which will likely, substantially improve the long-term status and trajectory for that population.

In summary, under the proposed action, the combined ocean and Puget Sound exploitation rates for the 2019 fishing year for one of the 14 management units (Snohomish) and 6 of 22 total populations (Upper Skagit, Lower Sauk, Upper Cascade, NF Stillaguamish, and Skykomish, and Snoqualmie) are expected to be under their RER or RER surrogates (Table 27). The Skagit summer/fall MU, White, Dungeness, and Elwha populations are each expected to exceed their respective RERS by less than 1%. NMFS considers the proposed action 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 2019 and stable or positive trends in escapement and growth rate alleviated concerns about additional risk (Lower Skagit, Upper Sauk, Suiattle, Cedar, Green, Puyallup, White);

(2) anticipated impacts from the proposed 2018 Puget Sound fisheries are low and the effect on the population is negligible (North Fork Nooksack, South Fork Nooksack, Sammamish, Mid-Hood Canal Rivers, Dungeness, Elwha, South Fork Stillaguamish);

(3) indigenous populations in the watershed have been extirpated and the proposed fisheries and additional actions proposed by the co-managers are consistent with long-term strategies for local adaptation and rebuilding of the remaining populations (Nisqually, Skokomish); and,

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

Fourteen of the 22 populations in the ESU are expected to exceed their critical thresholds for escapement and ten of those are expected to exceed their rebuilding thresholds (Table 27). Eight populations are expected to be below their critical thresholds (North and South Fork Nooksack, North and South Fork Stillaguamish, Sammamish, Mid-Hood Canal, Skokomish, and Dungeness). For the latter populations, the fisheries resulting from implementing the proposed actions in 2019 would not meaningfully affect the persistence of the populations under the recovery strategies in place or the indigenous population has been extirpated and a long-term transition strategy is in place.

Table 27. Summary of factors considered in assessing risk by population in the Puget Sound Chinook ESU. The colors denote the status of the parameter in each column for each population. Red = higher risk, yellow = medium risk, green = low risk.

Region	Population	≤ RER[1]	Population Status[2] (Avg/2019)	Escapement Trend[3]	Growth Rate Recruitment/ Escapement[3]	Exploitation Rate in PS fisheries[4]	Approach consistent with transitional strategy[4]	PRA Tier
Strait of Georgia	N.F. Nooksack early							**1**
	S.F. Nooksack early							**1**
Whidbey/Main Basin	Upper Skagit moderately early							1
	Lower Skagit late							1
	Lower Sauk moderately early							1
	Upper Sauk early							1
	Suiattle very early							1
	Upper Cascade moderately early							1
	N.F. Stillaguamish early							2
	S.F. Stillaguamish moderately early							2
	Skykomish late							2
	Snoqualmie late							3
South Sound	Sammamish							3
	Cedar							3
	Duwamish-Green							2
	White							1
	Puyallup							3
	Nisqually							1
Hood Canal	Mid-Hood Canal							1
	Skokomish							1
Strait of Juan de Fuca	Dungeness							1
	Elwha							1

[1]Table 19. NMFS considers fisheries to present a low risk to populations where estimated impacts of the proposed fisheries are less than or equal to the RERs,
[2] Tables 3
[3] Table 4
[4] Described in text of Section 2.5.1.2 for each MPG in the ESU: Green=low, yellow=moderate, red=high

NMFS noted a particular need for caution for the populations in the Hood Canal. There are only two populations in the Hood Canal Region so both are essential for recovery of the ESU. Although we concluded that, given the available information, additional risks associated with implementation of the proposed actions in 2019 will not impede the long term persistence of the Skokomish population, progress of the long-term transitional strategies in these areas should be closely watched given the status of the Skokomish population, potential long-term effects on survival and recovery suggested by modeling associated with the exploitation rate objective compared with the RER or RER surrogate, and the pattern of exceeding the exploitation rate objective for the Skokomish River population. Continued adaptive management and implementation of the long-term transition strategy in the watershed together with the additional management measures described in the proposed actions will be key to recovery of the populations in those watersheds.

As described in the previous sections, NMFS, in reaching its determination of effects on the Puget Sound Chinook ESU, based on the available scientific evidence, also weighs its trust responsibility to the tribes in evaluating the proposed actions and recognizes the importance of providing tribal fishery opportunity, as long as it does not pose a risk to the species that rises to the level of jeopardy. This approach recognizes that the treaty tribes have a right and priority to conduct their fisheries within the limits of conservation constraints.

We also assessed the effects of the action on Puget Sound Chinook critical habitat in the context of the status of critical habitat, the environmental baseline, and cumulative effects, to evaluate whether the effects of the proposed fishing are likely to reduce the value of designated critical habitat for the conservation of listed Puget Sound Chinook salmon. The PBFs most likely to be affected by the proposed actions are (1) water quality, and forage to support spawning, rearing, individual growth, and maturation; and, (2) the type and amount of structure and rugosity that supports juvenile growth and mobility. Fishermen in general actively avoid contact of gear with the substrate because of the resultant interference with fishing and potential loss of gear so would not disrupt juvenile habitat. Derelict fishing gear can affect habitat in a number of ways including barrier to passage, physical harm to eelgrass beds or other estuarine benthic habitats, or occupying space that would otherwise be available to salmon. These impacts have been reduced through changes in state law and active reporting and retrieval of lost gear as described in the Effects analysis. Any impact to water quality from vessels transiting critical habitat areas on their way to the fishing grounds or while fishing would be short term and transitory in nature and minimal compared to the number of other vessels in the area participating in activities un-related to the proposed actions. Also, these effects would occur to some degree through implementation of fisheries or activities other than the Puget Sound salmon fisheries. Fisheries under the proposed actions will occur within many areas designated as critical habitat in Puget Sound. However, fishing activities will take place over relatively short time periods in any particular area. As discussed in Section 2.2, Rangewide Status of the Species and Critical Habitat, and Section 2.4, Environmental Baseline, of this opinion, critical habitat features in the action area (i.e., forage, water quality, and rearing and spawning habitat) have been and continue to be affected by forestry; grazing; agriculture; channel/bank modifications; road building/maintenance; urbanization; sand and gravel mining; dams; irrigation impoundments and withdrawals; river, estuary, and ocean traffic; wetland loss; forage fish/species harvest; and climate change. For the reasons described, we would expect the proposed actions to result in minimal additional impacts to these features although we cannot quantify those impacts because of their transitory nature.

2.7.2 Puget Sound Steelhead

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

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

The expected impact on Puget Sound steelhead in marine fisheries from implementation of the proposed fisheries during the 2019-2020 season is below the level noted in the listing determination. We reached this conclusion based on the similarity of expected catch patterns and fishing regulations for 2019-20 to fishery regulations and catch patterns for years since the listing, which resulted in a 48% decline in marine area catches in recent years as described in Section 2.4.1 and summarized in Table 15.

Under the proposed actions, the harvest rate in freshwater fisheries is expected to be below that observed at the time of listing. NMFS compared the average harvest rates for a set of index populations at the time of listing (4.2%) and more recent years (1.4%) and concluded that the average harvest rate had declined by 66% (Table 13).

We do not anticipate impacts to steelhead from research test fisheries discussed in this opinion because of the timing, gear and area of the studies relative to the timing and area of steelhead migration in the study areas. However, to be conservative we estimated potential encounters of 14 adults and 2 potential adult mortalities just in case encounters were to occur (Section 2.5.2.2). When the research related impacts are added to those resulting from the proposed fisheries, they do not change the conclusion that take associated with the proposed actions continues to be low and well below the levels reported at the time of listing.

Critical habitat for steelhead is located in many of the areas where Puget Sound recreational and commercial salmon fisheries occur. However, fishing activities will take place over relatively short time periods and thus have a very limited opportunity to impact critical habitat. The PBFs most likely to be affected by the proposed actions are (1) water quality, and forage to support spawning, rearing, individual growth, and maturation; and, (2) the type and amount of structure and rugosity (NWFSC 2015) that supports juvenile growth and mobility. Fishermen endeavor to keep gear from being in contact or entangled with substrate and habitat features because of the resultant interference with fishing and potential loss of gear. This would result in a negligible effect on the PBFs. Any impact to water quality from vessels transiting critical habitat areas on their way to the fishing grounds or while fishing would be short term and transitory in nature (NMFS 2004c).

The environmental baseline for listed steelhead in Puget Sound and their critical habitat includes the ongoing effects of past and current development activities and hatchery management practices. Development activities continue to contribute to the loss and degradation of steelhead habitat in Puget Sound such as barriers to fish passage, adverse effects on water quality and quantity associated with dams, loss of wetland and riparian habitats, and agricultural and urban development activities. Extensive propagation of out-of-basin stocks (e.g., Chambers Creek and Skamania hatchery stocks) throughout the Puget Sound DPS, and increased predation by marine mammals and birds are also sources of concern. Development activities and the ongoing effects of existing structures are expected to continue to have adverse effects similar to those in the baseline. Hatchery production has been modified to some extent to reduce the impacts to ESA-listed steelhead, but is expected to continue at lower levels with lesser impacts. NMFS expects that both Federal and State steelhead recovery and management efforts will provide new tools, data and technical analyses, refine Puget Sound steelhead population structure and viability, and better define the role of individual populations in the DPS. The recovery plan, which is expected to be completed in 2019, 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 ongoing activities detailed above are expected to continue to affect steelhead and their critical habitat. However, as described above the impacts of the proposed action on Puget Sound steelhead DPS are expected to be minimal, and below the level identified as limiting improvements in status. When added to the baseline, and cumulative effects, these impacts are not expected to reduce the likelihood of survival and recovery of the DPS, or to adversely modify their critical habitat.

2.7.3 Puget Sound/Georgia Basin Rockfish

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

To assess the effect of the mortalities expected to result from the proposed actions on population viability, we adopted methodologies used by the PFMC for rockfish species. The decline of West Coast groundfish stocks prompted the PFMC to reassess harvest management (Ralston 1998;

Ralston 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 (PFMC 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 (PFMC 2000) (Walters and Parma 1996), and guide rockfish conservation efforts in British Columbia, Canada (Yamanaka and Lacko 2001; Department of Fish and Oceans 2010). 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 (Walters and Parma 1996; PFMC 2000).

Given the similar life histories of yelloweye rockfish and bocaccio to coastal rockfish managed by the PFMC, we concluded that these methods represent the best available scientific information for assessing the effects of fisheries-related mortality on the viability of the ESA-listed rockfish.

Outside of the Puget Sound/Georgia Basin, yelloweye rockfish and bocaccio are managed under the provisions of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), and yelloweye rockfish and bocaccio have been designated as "overfished." While ESA-listed rockfish in the Puget Sound/Georgia Basin are not managed under the provisions of the MSA, the Rebuilding Plans for coastal yelloweye rockfish and bocaccio nonetheless provide insight into implementing fisheries management in Puget Sound, and we continue to assess ways to improve our ability to use similar methodologies to assess risk from fisheries (NMFS 2017e).

To assess the population-level effects to yelloweye rockfish and bocaccio from the proposed salmon fisheries, and identical to our analysis in section 2.5.3, we calculated the range of total anticipated annual mortalities (Table 28).

Table 28. Estimated total annual lethal take for the salmon fisheries and percentages of the listed-rockfish.

Species	Range of Estimated Lethal Take	Abundance Scenario	Range of Percent of DPS Killed
Bocaccio	1 to 77	4,606	0.0002 to 1.7
Yelloweye rockfish	2 to 66	143,086	>0.00001 to 0.05

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

Annual natural mortality rate for bocaccio is approximately 8 percent (as detailed in Section 2.4.2) (Palsson et al. 2009); thus, the precautionary level of fishing would be 4 percent and risk-neutral would be up to 6 percent. Lethal takes from the proposed salmon fisheries would be well below the precautionary and risk-neutral levels for each of the abundance scenarios.

Annual natural mortality rates for yelloweye rockfish range from 2 to 4.6 percent (as detailed in Section 2.4.2) (Yamanaka and Kronlund 1997; Wallace 2007); thus, the precautionary range of fishing and research mortality would be 1 to 2.4 percent and risk-neutral would be 1.5 to 3.45 percent. Lethal takes from the salmon fisheries in the DPS would be below the precautionary and risk-neutral level for each of the abundance scenarios.

To assess the population-level effects to yelloweye rockfish and bocaccio from activities associated with the research permits within the environmental baseline, fishery take associated with the proposed actions, and fishery take within the environmental baseline, we calculated the total mortalities for all sources (Table 29).

Table 29. Estimated total takes for the salmon fishery and percentages of the listed-rockfish covered in this Biological Opinion in addition to takes within the environmental baseline.

Species	Total Take in Baseline (plus salmon fishery high estimate)	Total Lethal Take in Baseline (plus salmon fishery high estimate)	Abundance Scenario	Percent of DPS Killed (total lethal takes)
Bocaccio	131(+77)	83[a](+77)= 160	4,606	3.5
Yelloweye rockfish	497(+66)	386[b](+66)= 452	143,086	0.32

[a] This includes the following estimated bocaccio mortalities: 40 from the halibut fishery, 26 during research, and 17 in other fisheries.
[b] This includes the following estimated yelloweye rockfish mortalities: 270 from the halibut fisheries, 51 during research, and 65 in other fisheries.

Lethal takes are most relevant for viability analysis. For yelloweye rockfish and bocaccio, the takes from the salmon fishery, in addition to previously assessed lethal scientific research and fishery bycatch (fishermen targeting bottom fish and halibut) (detailed in Section 2.4, Environmental Baseline), would be within or below the risk-neutral and/or precautionary level for each of the abundance scenarios. The low number of anticipated takes in Hood Canal would also protect this population of yelloweye rockfish. Our analysis of potential bycatch for each species uses precautionary assumptions and thus would likely be lower than estimated. These precautionary assumptions include that, of the previously analyzed research projects, all of the take permitted will actually occur, when in fact the actual take of yelloweye rockfish and bocaccio is well below the permitted take. As an example, since bocaccio were listed in 2010, only 3 fish have been taken in research projects (compared to the permitted take of 58 fish, and 27 mortalities in 2017 alone) within the U.S. portion of the DPS area. An additional precautionary factor for bocaccio is the population estimates that only include the San Juan Island area, which is less than half of their habitat area within U.S. waters of the DPS (Marine Catch Area 7). Recent ROV surveys and genetic research projects have documented bocaccio in Central Sound.

In addition to fishery mortality, rockfish are killed by derelict fishing gear (Good et al. 2010), though we are unable to quantify the number of yelloweye rockfish and bocaccio killed by pre-existing derelict gear or new gear that would occur as part of commercial fisheries within the proposed actions. Despite these data limitations, it is unlikely that mortality associated with derelict gear would cause mortality levels of yelloweye rockfish and bocaccio to exceed the precautionary or risk-adverse levels. This is because: (1) the removal of thousands of nets has restored over 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 programs to provide outreach to fishermen to prevent net loss.

We also assessed the effects of the action on yelloweye rockfish and bocaccio critical habitat in the context of the status of critical habitat, the environmental baseline, and cumulative effects to evaluate whether the effects of the proposed fishing are likely to reduce the value of proposed critical habitat for the conservation of each species. The main potential effect of the proposed fishing on listed rockfish critical habitat would be derelict fishing nets. As discussed in Section 2.2, Rangewide Status of the Species and Critical Habitat and Section 2.4, Environmental Baseline, of this opinion, critical habitat features in the action area (i.e., prey resources, water quality, and complex bottom habitats) may be affected by non-point source and point source discharges, hypoxia, oil spills, dredging projects and dredged material disposal activities, nearshore construction projects, renewable ocean energy installations, and climate change. We would expect the proposed fishing to result in minimal additional impacts by the loss of some gill nets to a subset of these features. Thus, the proposed fishing is not likely to reduce the value of critical habitat for the conservation of yelloweye rockfish and bocaccio of the Puget Sound/Georgia Basin DPSs.

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

Because most adult yelloweye rockfish and bocaccio occupy waters much deeper than surface waters fished by commercial nets, the bycatch of adults in commercial salmon fisheries is likely extremely low to non-existent. However, new derelict gear is a source of potential incidental mortality. The recreational bycatch levels from the 2019/20 salmon fishery season are expected to be quite low, within the risk-neutral or precautionary mortality rates identified for overfished rockfish of the Pacific Coast. Concerns remain about fishery-mortality effects to spatial structure, connectivity and diversity for each species. These concerns are partially alleviated because of the low bycatch rates for each species, and considering that the abundance of each species is likely higher than assessed within our analysis. The structure of our analysis provides conservative population scenarios for the total population of each DPS, and likely overestimates the total mortalities of caught and released fish. Thus taken together, the effects of the proposed actions on ESA-listed rockfish in Puget Sound, in combination with anticipated bycatch from other fisheries and research, their current status, the condition of the environmental baseline, and cumulative effects are not likely to reduce appreciably the likelihood of survival and recovery of yelloweye rockfish and bocaccio.

2.7.4 Southern Resident Killer Whales and Critical Habitat

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.

Critical habitat includes approximately 2,560 square miles of inland waters of Washington in 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. 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. Revisions to critical habitat to include coastal areas are currently in development. This action has the potential to affect prey quantity and availability and passage, which are also impacted by a variety of other threats to Chinook salmon and from vessel activity.

Following the independent science panel report on the effects of salmon fisheries on Southern Resident killer whales (Hilborn et al. 2012), NMFS and partners have actively engaged in research and analyses to fill gaps and reduce uncertainties raised by the panel in their report. While in the past we have used correlations to estimate the effects of an action on population growth (NMFS 2011a), the data and analyses do not currently support a quantitative process for killer whales that directly links effects of an action, such as a reduction in prey, to survival and recovery (i.e., mortality and reproduction). In the absence of a comprehensive quantitative tool to evaluate proposed actions, we use a weight of evidence approach to consider all of the information we have- identifying a variety of metrics or indicators (some quantitative and some qualitative) with varying degrees of confidence (or weight)- in order to formulate our biological opinions. We assess risk by evaluating uncertainty for lines of evidence to determine if our estimates underestimate or overestimate the status or effect.

The Southern Resident killer whale DPS is composed of one small population that is currently at most half of its likely previous size (140 to an unknown upper bound). We have high confidence in the annual census and population trends. The overall population increased slightly from 2002 to 2010 (from 83 whales to 86 whales). Since then, the population has decreased to only 75 whales, a historical low in the last 30 years. Based on an updated pedigree from new genetic data, many of the offspring in recent years were sired by two fathers, meaning that less than 30 individuals make up the effective reproducing portion of the population. Some offspring were the result of matings within the same pod raising questions and concerns about inbreeding effects. The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated their population viability analyses. The data now suggest a downward trend in population growth projected over the next 50 years and the uncertainty in the projections increases the further out the analysis projects. This downward trend is in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (Figure 12). With such a small population, even small changes in this rate and other parameters can affect the projections.

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. New comparisons of the contribution of different threats (Lacy 2017), support an approach to address all of the threats. Vessel disturbance and prey reduction are the primary pathways for impacts from this action. Under the existing management and recovery regimes over the last decade, salmon abundance and vessel disturbance reduction has not been sufficient to support Southern Resident population growth.

During the spring, summer, and fall months, the whales spend a substantial amount of time in the action area, with strong site fidelity shown to the region as a whole and high occurrence in the San Juan Island area. We have high confidence in the data on distribution, particularly in inland waters in summer months and have updated the information in our analysis regarding where the whales spend their time and co-occurrence with fisheries. Over a decade of scale, tissue and more recent fecal sampling give us high confidence that the whales' diet consists of a high percentage of Chinook salmon, especially in the summer months in the action area. NOAA Fisheries and WDFW recently released a priority stock report identifying the Chinook salmon stocks believed to be of most importance to the health of the Southern Resident populations along the West Coast (NOAA and WDFW 2018).

When prey is scarce, Southern Residents likely spend more time foraging than when prey is plentiful. Increased energy expenditure and prey limitation can cause poor body condition and nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources. Several studies have found correlations between Chinook salmon indices and Southern Resident killer whale demographic rates (e.g. high Chinook abundance coupled with high Southern Resident killer whale growth rates). Recent evident has indicated the whales have experienced several miscarriages, particularly in late pregnancy; this reduced fecundity was suggested to be largely due to nutritional limitation but we are not able to quantify effects to reproduction from changes in Chinook salmon abundance. There are several challenges to this relationship and uncertainty remains because of demographic stochasticity. The small population size makes correlating births and deaths with salmon abundance challenging and the whales are long-lived making it more challenging to predict interactions with the environment. There are other primary threats that can also influence demographic rates, uncertainties in the annual Chinook salmon abundance estimates, and no clear quantitative metric for assessing prey accessibility (i.e., abundance and availability) to the whales. A recent population viability assessment found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate (Lacy et al. 2017). Since 2008, aerial photogrammetry studies have been used to assess the body condition and health of Southern Resident killer whales. More recent annual aerial surveys of the population have provided evidence of a general decline in Southern Resident killer whale body condition since 2008, and documented members of J pod being in poorer body condition in May compared to September. Although body condition in whales can be influenced by a number of factors, including disease, physiological or life history status, prey limitation is the most likely cause of observed changes in body condition in wild mammalian populations. The methods for detecting changes in body condition have been well established and we will continue to refine our understanding of annual and seasonal changes as indicators of the nutritional status and overall health of individual whales and the status of the population. Additional studies to link body condition to mortality, reproduction and variables, such as Chinook salmon abundance, are ongoing and may provide new tools for evaluating changes in actions, including fisheries, which affect prey abundance for the whales.

As described in the Effects Section, we focused our analysis on their primary prey, Chinook salmon, and impacts in inland waters in summer months where the fisheries overlap with foraging areas. The proposed actions will result in an increase in vessel activity across the whales' range in inland waters (including their critical habitat), and likely some level of exposure of individual whales to the physical presence and sound generated by vessels associated with the proposed fisheries, particularly where MA 7 overlaps with the highest number of sightings and foraging observations along the west side of San Juan Island. Some of the exposures to fishing vessels are likely to result in less efficient foraging by the whales than their foraging efforts would be in the absence of vessel effects. In addition to the amount of disturbance caused by fishing vessels from the proposed action, vessel disturbance is also part of the environmental baseline, which includes the near-constant presence of the whale watching fleet and other recreational vessels in inland waters in summer months. We expect the total impact of all vessel disturbances from the environmental baseline, proposed action, and cumulative effects is likely to continue to affect the whales' energetic needs and impair foraging efficiency, particularly during the height of the summer season in the core summer feeding area, which is specifically designated as critical habitat. Based on monitoring data, we conclude that fishing vessels contribute to the total effects of direct disturbance (including effects on passage conditions) from vessels, although it is difficult to assess cumulative impacts and population level consequences of vessel disturbance. The combined impact on the whales when vessel disturbance and prey reduction occur simultaneously in the whale's primary foraging areas is a cause for concern. While some trends in vessel activities that could disturb the whales have declined in recent years (Ferrara et al. 2017) vessels continue to operate out of compliance with guidelines and regulations. There are a number of mitigation efforts in place to reduce vessel disturbance from all vessel sources, including the state and federal regulations discussed earlier in this opinion, education efforts on and off the water to increase awareness and compliance, and voluntary areas with limited or no vessel traffic adopted by San Juan County and the whale watch industry. New state regulations described in the cumulative effects section of this opinion will increase protection for the whales in 2019 and increased enforcement presence in 2019 is expected to improve compliance by vessel operators and reduce overall vessel impacts that may impact foraging or passage.

We compared the direct impacts from fishing vessels from the proposed action analyzed in this opinion to such impacts in previous years and impacts are expected to be lower in 2019 based on the reduced presence of fishing vessels in the key foraging areas. This reduction in fishing vessel impacts is expected because of closure of recreational fishing in August and non-retention of Chinook salmon in September in MA 7 (including Southern Resident killer whale foraging hotspots along the west side of San Juan Island). In addition, WDFW will continue to promote the Be Whale Wise guidelines, and voluntary No-Go zone, and continue conservation efforts including education to fishing vessels to maintain slow transit speeds (restricted to 7 knots or less) at a minimum and potentially reduce transit speeds in areas frequently utilized by Southern Residents in the summer season (specifically off the west coast of San Juan Island) and to silence vessel sonar in the presence of Southern Residents and when fishing gear is deployed (especially those transmitting at 83 kHz). Ongoing monitoring of vessel activities near the whales by the Soundwatch Boater Education Program and WDFW vessel patrols a part of the proposed action will allow for tracking reductions in fishing vessel activity when whales are in key foraging areas.

Under the existing management and recovery regimes over the last decade, Chinook salmon availability has not been sufficient to support Southern Resident population growth. Based on the biological information described in the Effects Section, our effects analysis focused on the likely reduction in Chinook prey available to the whales as a result of the proposed fishing. To put that reduction in context, we evaluated a range of metrics and information, including comparing the 2019 proposed fisheries and Chinook abundance to recent years when the whale population has declined. Using updated FRAM models, the pre-season estimates for abundance of age 3-5 Chinook in inland waters will be approximately 950,585, which is greater than the 2018 pre-season estimate of 853,000 (using the same base period[47]) and slightly above average. The proposed fishing is expected to reduce the abundance of prey in inland waters during the months

[47] NMFS 2018 used the old FRAM base period and therefore is not comparable to the new base period estimates.

of July through September by 5.4%, which is in the lower quartile of reductions derived from the retrospective time period. Some of these Chinook salmon stocks caught during this time are considered highest priority prey for the whales.

To put this into biological context, the 5.4% reduction in prey availability roughly translates to 28,399 adult Chinook salmon (assuming large adult Chinook equals 16,368 kcal) and equates to feeding all individuals in the population for 31 days. In comparison, the average pre-terminal catch numbers from the Puget Sound fisheries from 2010 – 2018 was 70,860 adult Chinook, which equates to feeding all individuals in the Southern Resident killer whale population for approximately 78 days. We have medium level confidence in the metabolic needs estimates for the whales since they have not yet been validated by prey consumption rates and use the maximum estimates which may be an overestimate. The reduction in prey is calculated using a robust model and we anticipate this is likely an overestimate of the number of feeding days because it is extremely unlikely that the whales would have consumed all fish caught in the fishery. The reduction in food energy in the inland waters applies to a broad area with varying overlap with the whales. It is difficult to assess how reductions in prey abundance may vary throughout inland waters and we have less confidence in our understanding of how reductions could result in localized depletions. Seasonal prey reduction throughout the action area may not accurately predict reductions in prey available in known foraging hotspots.

We estimated the Chinook food energy available to the whales and compared available kilocalories to needs and evaluated the ratio after reductions from the proposed fishing. We have low confidence in the ratios, but consider them as an indicator to help focus our analysis on the time and location where prey availability may be lowest and where the action may have the most significant effect on the whales. We have also used updated information to refine the bioenergetics including metabolic needs of the whales and caloric content of different runs of Chinook salmon. The ratios during the retrospective time period ranged between 8.86 and 17.44 times the whales' estimated needs during July through September in inland waters, and with the proposed fishing the ratios would reduce the available prey and lower the ratio of available prey compared to the whales needs to be 12.87. Because we consider the ratio of Chinook prey available to meet the whales' needs to be relatively low for inland waters July through September, any additional measurable reduction is a concern. However, we are unable to quantify how this reduction affects foraging efficiency of the whales and therefore apply a lower weight to this part of the analysis.

We have evaluated the best available information on the status of the species, the environmental baseline, the effects of the action and cumulative effects status of the whales. The status of the whales is compromised and multiple factors and threats are limiting their population growth. The whales have declined in recent years likely in part due to reduced prey. The effects of the action add a measurable but small adverse effect in addition to the existing conditions. The most significant impacts of the action will occur where the fishery overlaps with key foraging areas for the whales and prey abundance is generally lower. While the fishing proposed in 2019 will add some vessel disturbance and reduce available prey for the one year fishing period, we anticipate an increase of Chinook salmon abundance in inland waters during July through

September for 2019, which is above average and in a mid-range compared to previous years. The increase compared to 2018 is a meaningful improvement in prey abundance. In addition, a number of conservation measures identified by WDFW as part of the action are expected to reduce the severity of the prey reduction and reduce the effects from fishing vessels, including in key foraging areas. It will be important to monitor and evaluate the effectiveness of protective measures, particularly voluntary measures, to ensure they are effective in reducing impacts to the whales. Changes in the fishery and efforts to reduce fishing in the primary foraging area along the west side of San Juan Island, particularly the closure of MA 7 during August, will reduce the potential for prey reductions to result in significant localized depletions or prey depletions at levels that would cause injury or impair reproduction. Although any reduction in prey or interference with foraging is a concern for the Southern Residents because of their status, with higher prey abundance, lower fishing effort and new protective measures in 2019 conditions are anticipated to be improved for the whales compared to the last several years. Additional protective measures in U.S. and Canadian waters are being implemented to reduce impacts from fisheries and vessels in key foraging areas as described in the Cumulative Effects section. In addition, the action will also not jeopardize the listed salmon that the whales depend on over the long term. The reductions in harvest levels in Puget Sound fisheries and other fisheries under the 2019 PST Agreement are intended to support recovery of the whales' Chinook salmon prey, increase prey abundance available to the whales, and reduce impacts to the whales' survival and reproduction.

We note that this proposed action is very limited in duration (one year) and that Chinook abundance is forecast to be higher than in the past several years. Combined with the conservation measures discussed above, particularly those aimed at reducing impacts in key foraging areas, these factors lead us to conclude that the incrementally small increase in extinction risk from the proposed action is not likely to cause a meaningful change to the viability of the SRKW population, and therefore is not likely to reduce, appreciably, the likelihood of survival and recovery of the species.

Critical habitat includes water quality, prey and passage as features that are essential to the conservation of Southern Residents. We do not expect the proposed fisheries to impact water quality. As described above the abundance of prey is projected to be slightly above average in 2019 and the reduction in quantity and availability of prey from fishery removals and disturbance from fishing vessels is expected to be small and mitigated by several conservation efforts and therefore, is not expected to appreciably diminish the value of critical habitat. While vessels could result in the whales moving to areas with higher levels of prey or less disturbance, a number of activities to decrease effects from all vessels are ongoing and the action includes specific outreach to fishing vessels to reduce their impacts and vessel presence and sound is not expected to block passage of the whales.

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS's biological opinion that the proposed action is unlikely to reduce the likelihood of either survival or recovery of the Southern Resident killer whales or adversely modify its designated critical habitat

2.7.5 Central America and Mexico DPSs of Humpback whales

As described in Section 2.2.1.5, there are three humpback whale DPSs found off the U.S. West Coast. These DPSs include the Central America DPS, which is listed as endangered under the ESA and is found predominately off the coasts of California and Oregon; the Mexico DPS, which is listed as threatened and is found along the entirety of the U.S. West Coast; and the Hawaii DPS, which is not listed under the ESA and is found predominately off of Washington and southern British Columbia. Humpback whales found in the Puget Sound action area may be from any of these DPSs.

NMFS takes a proportional approach to assign estimates of each DPS that are applied off the West Coast. 15% of humpback whales found off of Washington and British Columbia are considered to be from the Central America DPS, while 42% are considered to be from the Mexico DPS. It is currently unknown which DPSs spend time in Puget Sound, so NMFS uses the same conservative estimates when assessing potential impacts to each DPS within the action area. Critical habitat is currently under development and has not yet been formally proposed or designated for humpback whales.

Under the MMPA, PBR is a metric used to assess levels of human-related mortality a marine mammal stock can sustain. PBR does not equate to a species or population level assessment under the ESA where analyses are conducted at the level of the species listed as endangered or threatened. As such, we reviewed human impacts to the CA/OR/WA and CNP stocks of humpback whales when compared to PBR for these stocks, and characterized this information in relation to impacts to the Mexico and Central America DPSs.

Humpback whales face many threats anthropogenic threats including vessel strikes and disturbance, fishery interactions, and pollution. The main threats to humpback whales from the proposed action include entanglement in fishing gear, vessel strike, and prey reduction. As described in Section 2.5.5 Effects Analysis, NMFS considers the threat of prey reduction to be insignificant, since the proposed fishing does not target species that are prey for humpback whales. Similarly, NMFS considers the risk of collision with a fishing vessel to be discountable because of no previously confirmed collisions between humpback whales and fishing vessels within the action area.

Entanglement in fishing gear presents a serious source of mortality and serious injury to humpback whales on the U.S. West Coast, and there is a risk of humpback whale interactions with fishing gear within the action area. There were three sockeye gillnet entanglements in the action area in 2018, and one additional gillnet interaction with an unknown fishery. These were the first fishery interactions reported for this fishery and the specific DPS interacting with the fishery is unknown. We acknowledge uncertainty about these reports, as they have not yet gone through the serious injury designation process, however, they present a preliminary idea of the level of interaction between the proposed fishery and humpback whales. Ongoing efforts to better understand the proportion of different humpback whale DPSs in Puget Sound and identifying mortalities and fishery interactions to DPS will improve our ability to assess impacts from longer term fishery management actions in the future.

Despite a projected decrease in fishing effort within the action area in 2019, humpback whales have been returning to the Salish Sea in increasing numbers in recent years, meaning we may expect similar levels of interactions this year when compared to last year. The proposed action may therefore result in 1-2 interactions within the action area, which may range from not serious injury to mortality. These interactions would most likely impact the Hawaii DPS, which is not listed under the ESA. If these interactions were to impact the Central America or Mexico DPSs, they would represent between 0.15 and 0.3 interactions with individuals from the Central America DPS and between 0.42 and 0.84 from the Mexico DPS. These estimates represent very small proportions of the entire populations of each DPS and if only a portion of those interactions would be expected to result in serious injury or mortality, the risk to both populations are very low. For the Mexico DPS which has been showing signs of improvement in recent decades, as indicated by the recent listing as threatened as opposed to the formal global listing as endangered, this level of interaction would likely be undetectable. While the Central America DPS is smaller and trends are unknown, the very small number of anticipated interactions would also likely be undetectable at a population level.

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS's biological opinion that the proposed action is unlikely to reduce the likelihood of either survival or recovery of the Central America or Mexico DPSs of humpback whales. No critical habitat has been designated or proposed for this species; therefore, none was analyzed.

2.8 Conclusion

2.8.1 Puget Sound Chinook

After reviewing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed actions, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed actions are not likely to jeopardize the continued existence of the Puget Sound Chinook salmon ESU or adversely modify its designated critical habitat.

2.8.2 Puget Sound Steelhead

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

2.8.3 Puget Sound/Georgia Basin Rockfish

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

2.8.4 Southern Resident 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 actions, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed actions are not likely to jeopardize the continued existence of Southern Resident killer whales or adversely modify its designated critical habitat.

2.8.5 Central America and Mexico DPSs of Humpback whales

After reviewing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed actions, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed actions are not likely to jeopardize the continued existence of humpback whales.

2.9 Incidental Take Statement

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

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

2.9.1 Amount or Extent of Take

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

2.9.1.1 Puget Sound Chinook

NMFS anticipates incidental take of listed Puget Sound Chinook to occur in the proposed Puget Sound salmon and steelhead fisheries from May 1, 2019 through April 30, 2020 through contact with fishing gear. NMFS anticipates Puget Sound salmon fisheries occurring in 2019 will be limited to exploitation rates which, when combined with the exploitation rates in ocean fisheries that are not part of the fisheries of the proposed action, will not exceed the exploitation rates summarized in Table 21 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 proposed fisheries. Test, research, update and evaluation fisheries that inform fishery management decisions are included as part of the fishery-related mortality summarized in Table 21. Exploitation rates are used to define the extent of take for several reasons: (1) they are a direct measure of the take of the listed species that incorporates both the landed and release mortality resulting from implementation of the proposed actions; (2) they are a key parameters used to analyze the effects of the proposed actions; (3) fisheries are designed and managed based on exploitation rates rather than the mortality of individual fish; (4) they can be monitored and assessed; and, (5) they are responsive to changes in abundance over time and therefore a better measure of the effect on the listed species than just enumeration of individual fish.

For the relatively small fishery related research studies whose impacts are not included in the exploitation rates described above, the documentation provided with the proposed action enumerates the number of fish killed (PSC chum test fishery, Lake Washington predator removal and assessment, and Nooksack telemetry study). Based on this information, NMFS anticipates that no more than 8 adult and 60 immature Chinook incidental mortalities will occur in the research studies discussed in this opinion from May 1, 2019 through April 30, 2020.

2.9.1.2 Puget Sound Steelhead

NMFS anticipates incidental take to occur in Puget Sound marine and freshwater commercial, recreational and ceremonial and subsistence, from May 1, 2019 through April 30, 2020 through contact with fishing gear.

NMFS anticipates that a maximum of 325 steelhead will be caught in marine area. This estimate includes an unknown proportion of ESA listed steelhead, unlisted hatchery steelhead, and hatchery and natural-origin fish from Canada.

NMFS also anticipates that the harvest rate on natural-origin steelhead in freshwater treaty and non-treaty fisheries will be no more than 4.2%, with an expected harvest rate of 1.5% or lower based on observations from more recent years (Table 15) (James 2018d; Shaw 2018; WDFW and PSIT 2018; Norton 2019)). This 4.2% was calculated as an average across the Puget Sound winter steelhead index populations (i.e., Snohomish, Green, Puyallup and Nisqually). This rate, as an average across the index winter steelhead populations; is not a population-specific freshwater harvest rate. NMFS does not have similar estimates of freshwater harvest for other Puget Sound steelhead populations. However, NMFS anticipates that the harvest rates for other populations will be within the range for the index populations discussed above based on the similarity of catch patterns and fishing regulations.

Harvest rates are used to define the extent of take for several reasons: (1) they are a direct measure of the take of the listed species that incorporates both the landed and release mortality resulting from implementation of the proposed actions; (2) they are a key parameter used to analyze the effects of the proposed actions; (3) fisheries are generally designed and managed based on harvest rates rather than the mortality of individual fish; (4) they can be monitored and assessed; and, (5) they are responsive to changes in abundance over time and therefore a better measure of the effect on the listed species than just enumeration of individual fish.

NMFS anticipates that no more than 19 adults steelhead incidental encounters and 7 mortalities will occur in the research test fisheries discussed in this opinion from May 1, 2019 through April 30, 2020.

2.9.1.3 Puget Sound/Georgia Basin Rockfish

NMFS anticipates that incidental take of ESA listed rockfish would occur by two separate pathways: (1) bycatch of listed-rockfish by anglers targeting salmon, and (2) the indirect effects of lost (derelict) nets. NMFS anticipates that up to 66 yelloweye rockfish, and 77 bocaccio would be killed as bycatch by commercial anglers during the 2019/2020 Puget Sound salmon fishing season that is the subject of this opinion. NMFS anticipates that some minimal take of ESA-listed rockfish would occur as a result of the indirect effects of lost nets in the Puget Sound/Georgia Basin. NMFS estimates that up to 20 gill nets from salmon fisheries may become lost, and of those up to five nets would not be retrieved. If those five nets are lost within rockfish habitat, they would degrade benthic areas potentially used by ESA-listed rockfish. Estimating the specific number of ESA-listed rockfish that may be killed from a new derelict net is difficult to quantify because of several factors, including the location of its loss, the habitat which it eventually catches on, and the occurrence of fish within or near that habitat, therefore we are using the number of nets lost and not retrieved (5) as a surrogate for the number of rockfish taken.

2.9.1.4 Southern Resident Killer Whales

The harvest of salmon that may occur under the proposed actions is likely to result in some level of harm constituting take to SRKW by reducing prey availability and increasing disturbance from vessels and noise, which may cause animals to forage for longer periods, travel to alternate locations, or abandon foraging efforts. All individuals of the SRKW DPS have the potential to be adversely affected in the action area (inland waters of their range). NMFS cannot quantify impacts to foraging behavior or any changes to health of individual killer whales in the population from a specific amount of removal of potential prey resulting from the Puget Sound fisheries because we do not have data needed to establish quantitative relationships between prey availability and these effects to SRKW. Therefore, NMFS is using the level of Chinook salmon catch in the Puget Sound fisheries as a surrogate for incidental take of SRKW. Chinook salmon catch in Puget Sound, which we can quantify and measure, relates directly to the extent of effects on prey availability from the proposed actions related to the Puget Sound fisheries, as we would expect catch to be proportional to the reduction in prey in a given year. As described above, NMFS anticipates Puget Sound salmon fisheries occurring in 2019 will be limited to exploitation rates which, when combined with the exploitation rates in ocean fisheries that are not part of the fisheries of the proposed action, will not exceed the exploitation rates summarized in Table 21 in the column titled Ocean + Puget Sound. The estimated effect for killer whales for a reduction in Chinook prey and impacts from vessels and noise would be highest in inland waters from July through September and represents a 5.4% reduction in the abundance of large (age 3-5) Chinook in the action area as estimated by FRAM. This 5.4% reduction in prey availability is what we expect to occur as a result of the proposed fisheries at the total exploitation rates within the levels described in Table 21. Because those exploitation rates are actually used to manage the fisheries, are the best measure of fishing effort including prey reduction and vessel activity, and are monitored, we believe they are the best surrogate for take of Southern Resident killer whales. Therefore, the extent of take for killer whales will be exceeded if the amount of take for Puget Sound Chinook is exceeded.

2.9.1.5 Central America and Mexico DPSs of Humpback Whales

In the biological opinion, NMFS determined that the incidental take of Central America and Mexico DPSs of humpback whales may occur as a result of interactions with Puget Sound sockeye gillnet fisheries under the proposed action. Humpback whale interactions with Puget Sound fisheries, considered as take in the biological opinion, include entanglement in a net or other components of fishing gear. In the Effects section, we estimated 1-2 interactions of humpback whales with the Puget Sound fisheries each year, ranging from not serious injury to mortality. These interactions would likely be with whales from the unlisted Hawaii DPS, as they likely have the highest abundance in Washington waters. There is uncertainty around which DPSs are found within the action area, and therefore we used a conservative approach when assessing the number of possible interactions with whales from these DPSs. These 1-2 interactions could represent between 0.15 and 0.3 interactions with individuals from the endangered Central America DPS and between 0.42 and 0.84 from the threatened Mexico DPS during the 2019-2020 fishing season.

While we are able to describe an amount of take that we expect to occur, monitoring of ESA-listed humpback whale interactions in the Puget Sound fisheries does not occur at a level that allows us to directly and effectively monitor those interactions. Fishery observers are not required for most of these fisheries. Furthermore, ESA-listed and non-listed humpbacks co-occur in the action area and are not readily distinguishable, and not likely identified in opportunistic reports. Because we cannot directly monitor take, we use a surrogate for the extent of take, which is capable of being monitored for purposes of determining when the surrogate has been exceeded. Entanglements of marine mammals in fishing gear must be reported in accordance with the MMPA. MMPA Section 118 established the MMAP in 1994. Under MMAP all fishers are required to report any incidental taking (injuries or mortalities) of marine mammals during fishing operations. Any animal that ingests fishing gear or is released with fishing gear entangled, trailing, or perforating any part of the body is considered injured, and must be reported. It was these reports from NMFS' entanglement database that were used to assess risk of entanglement. We will use these in-season mandatory reports, identified at the species level as a surrogate for the amount of take that occurs in the Puget Sound salmon fisheries under the proposed action. Therefore, the incidental take limit for Central America and Mexico DPSs of humpback whales is up to 2 humpback whales reported interacting in the Puget Sound fisheries resulting in entanglement during the 2019-2020 fishing season.

Section 7(b)(4)(C) of the ESA provides that if an endangered or threatened marine mammal is involved, the taking must first be authorized by Section 101(a)(5) of the MMPA. Accordingly, regarding Mexico and Central America DPSs of humpback whales, the terms of this incidental take statement and the exemption from Section 9 of the ESA become effective only upon the issuance of MMPA authorization to take the marine mammals identified here. Absent such authorization, the portions of this incidental take statement concerning these marine mammal species are inoperative.

2.9.2 Effect of the Take

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

2.9.2.1 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

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

(1) In-season management actions taken during the course of the fisheries shall be consistent with the level of incidental take established preseason that were analyzed in the biological opinion (see Section 2.5.1.2 and 2.5.2.2) and defined in Section 2.9.1.1 and 2.9.1.2.

(2) Catch and the implementation of 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 describing the take of listed salmon and steelhead in the proposed fisheries and related research studies. Managers shall use results to improve management of Puget Sound Chinook and steelhead to ensure management objectives are met.
(5) Escapement monitoring for the salmon and steelhead populations that are affected by the proposed action shall be improved using available resources.

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

(6) 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.
(7) Harvest impacts on Southern Resident killer whales shall be monitored using the best available measures.
(8) NMFS, in consultation with the co-managers, will continue to assess the impacts of the fisheries on Southern Resident killer whales.

The following reasonable and prudent measures are included in this incidental take statement for Central America and Mexico DPSs of Humpback Whales:

(9) Monitor and report the extent of fishery interactions with ESA-listed marine mammals.

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

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

2.9.2.2 Terms and Conditions

The terms and conditions described below are non-discretionary, and NMFS, BIA, USFWS or any applicant must comply with them in order to implement the reasonable and prudent measures (50 CFR 402.14) described above. The NMFS, BIA, and USFWS or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in ITS (50 CFR 402.14). If the entity to whom a term and condition is directed does not comply with the following terms and conditions, the protective coverage for the proposed actions would likely lapse.

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

1a. Work with the Puget Sound treaty tribes and WDFW to ensure that in-season management actions taken during the course of the fisheries are consistent with the levels of anticipated take.

1b. Work with the Puget Sound treaty tribes and WDFW to complete 2019-2020 preseason annual steelhead fishing plans for all populations (where data are available) prior to implementation of the steelhead fishing season, but no later than December 15, 2019. Preseason fishing plans will include the annual fishing and research test fishing regimes and incidental harvest rates of steelhead in salmon and steelhead fisheries in compliance with the take estimates described in Section 2.9.1.2.

1c. In cooperation with the Puget Sound treaty tribes and WDFW as appropriate, ensure that commercial fishers report the loss of any net fishing gear within 24 hours of its loss to appropriate authorities.[48]

1d. The affected treaty tribes and WDFW, when conducting harvest research studies involving electrofishing, will follow NMFS' *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act* (NMFS 2000c).

1e. The co-managers and NMFS will meet by phone to discuss the initial results of the Green River inseason update. NMFS will be informed of any subsequent management actions taken by the state and tribal co-managers that deviate from the pre-season fishery structure in the 2019 List of Agreed to Fisheries.

1f. For the Green River population, the co-managers will take a combination of fishery and broodstock actions as described in the proposed action to achieve the spawning escapement goal of 1,200 natural-origin Chinook and seek additional opportunities to increase natural-origin Chinook on the spawning ground, e.g., further outplanting of natural-origin returns to the hatchery surplus to broodstock needs.

1g. For the Puyallup River population, the co-managers will take a combination of fishery and broodstock actions as described in the proposed action to achieve the spawning escapement goal of 750 natural-origin Chinook and seek additional opportunities to increase natural-origin Chinook on the spawning ground, e.g., further outplanting of natural-origin returns to the hatchery surplus to broodstock needs.

1h. For the Cedar River population, the co-managers will take fishery management actions to achieve the spawning escapement goal of 500 natural-origin Chinook on the spawning ground.

2. The Nisqually Chinook Stock Management Plan shall be finalized by July 1, 2019.

3. Work with the Puget Sound treaty tribes and WDFW to ensure that the catch and implementation of 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. The effectiveness of the management measures should be assessed in the postseason report.

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[48] 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.

4. Work with the Puget Sound treaty tribes and WDFW to ensure that the fisheries that are the subject of this opinion are sampled for stock composition, including the collection of coded-wire tags and other biological information (age, sex, size) to allow for a thorough post-season analysis of fishery impacts on listed species and to improve preseason forecasts of abundance. This includes:
   i. ensuring that the fisheries included in this opinion are sampled for contribution of hatchery and natural-origin fish and the collection of biological information (age, sex, and size) to allow for a thorough post-season analysis of fishery impacts on listed Chinook and steelhead species.
   ii. 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.
   iii. using the information, as appropriate, together with estimates of total and natural-origin Chinook and wild steelhead encounters and mortalities (summer and winter-run) to report fishery impacts by population.

5a. Work with the affected tribes and WDFW to provide post season reports for the 2019-2020 fishery that include estimates of catch and encounters of listed Chinook in the fisheries that are the subject of this opinion, including the research studies, fishery impacts by population, and other relevant information described in Section 7.5 in the 2010 Puget Sound Chinook Harvest Management Plan (PSIT and WDFW 2010a). This includes catch and encounters in the research fisheries discussion in Section 2.5.2.2. The reports will also include escapement estimates for the populations affected by the proposed actions and the results of the work described in reasonable and prudent measure 3.

5b. Work with the affected treaty tribes and WDFW, to provide postseason reports for the 2019-2020 fishery season summarizing effects on all steelhead DIPs affected by the proposed fisheries as identified in this opinion, where data are available, no later than November 20, 2019 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 and WDFW salmon and steelhead fisheries described in this opinion;
   ii. a description of the method used to estimate postseason harvest and a description of any changes to the estimation methodologies used for assessing escapement and/or harvest rates.

6a. Work with the affected tribes and WDFW to implement or improve escapement monitoring for all Puget Sound Chinook and steelhead populations that are affected by the proposed actions to improve escapement estimation and to determine and/or augment exploitation rate and harvest rate estimates on natural-origin Chinook and steelhead stocks.

6b. For steelhead, coordinate the effort to implement or improve escapement monitoring of 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.

7a. 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.

7b. The co-managers shall monitor catch using measures and procedures that provide reliable accounting of the catch of Chinook.

7c. NMFS in cooperation with the affected co-managers, shall monitor the catch and implementation of non-fishery management actions included in the proposed action 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.

8. 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 Southern Resident killer whales 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.

9a. NMFS will engage in ongoing coordination and communication with Canada's Department of Fish and Oceans with the goal of ensuring that complementary actions are taken in Canadian fisheries that affect the abundance of Chinook prey available to Southern Resident killer whales

9b. NMFS will continue development of a Risk Assessment and Adaptive Management Framework including analytic methods for assessing fishery effects to SRKW through prey removal, and providing a method for managing these effects. An adaptive management framework should:

- be responsive to the status of SRKWs and Chinook salmon, and
- identify thresholds for Chinook salmon abundance and prey reductions from fisheries to inform fishery adjustments in order to increase prey availability.

10a. 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 Central America and Mexico DPSs of Humpback whales 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.

10b. NMFS, in cooperation with the affected co-managers, shall monitor the in-season Fraser sockeye run size to confirm it is within the scope of the pre-season estimates.

11. 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.

12. NMFS in cooperation with BIA, the USFWS, WDFW and the Puget Sound Treaty tribes, shall minimize take and monitor the number of yelloweye rockfish and bocaccio incidentally caught by fishermen targeting salmon, on an annual basis by:

a. Monitoring fisheries through fishermen interviews, fish tickets, and phone surveys, as applicable, at levels comparable to recent years.

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed actions on listed species or critical habitat or regarding the development of information (50 CFR 402.02). NMFS believes the following conservation recommendations are consistent with these obligations, and therefore should be implemented by the BIA, USFWS and NMFS in cooperation with the Puget Sound treaty tribes.

(1) As discussed in Section 2.5.1.2, preseason abundance expectations still present challenges for terminal area management for the Puyallup and Skokomish populations in maximizing harvest and achieving management objectives. Improvements in inseason management tools including inseason abundance updates would be useful 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 affected Puget Sound treaty tribes should explore and identify methods to update abundance inseason that would be useful for managing fisheries for these populations, particularly in terminal areas, to better achieve management objectives.

(2) The BIA, USFWS, and NMFS in collaboration with WDFW and the Puget Sound treaty tribes should continue to evaluate improvement in gear technologies and fishing

techniques in treaty tribal and U.S. Fraser Panel fisheries to reduce impacts on listed species without compromising data quality used to manage fisheries.

(3) The BIA, USFWS, and NMFS in collaboration with 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.

(4) 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).

(5) 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.

(6) The BIA, USFWS, and NMFS in collaboration with the WDFW, and the Puget Sound treaty tribes should work to require the use of descending devices to release incidentally encountered rockfish in salmon fisheries with barotrauma.

(7) The BIA, USFWS, and NMFS, in collaboration with the affected states and tribes, should consider a longer-term fishery management plan in the future that includes protective measures that take into account the status of the whales, their condition, and fluctuations in salmon abundance using an adaptive approach.

(8) NMFS should pursue research into the co-occurrence between humpback whales and fisheries within the action area, particularly as it relates to the composition and distribution of humpback whale prey

(9) NMFS should continue to support humpback whale photo-identification research in order to understand which DPSs are found within the action area

2.11 Reinitiation of Consultation

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

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) the amount or extent of incidental taking specified in the incidental take statement is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

2.12 "Not Likely to Adversely Affect" Determinations

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

Green Sturgeon

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

Eulachon

Eulachon (*Thaleichthys pacificus*) are endemic to the northeastern Pacific Ocean ranging from northern California to southwest and south-central Alaska and into the southeastern Bering Sea (Gustafson et al. 2010). Eulachon are anadromous, spawning in the lower reaches of rivers, followed by a movement to the ocean as small pelagic larvae. Although they spawn in fresh water rivers and streams, eulachon are mainly a marine fish, spending 95% of their lives in marine waters (Hay and McCarter 2000). Eulachon are a short-lived smelt (3-5 years), that averages 40g in weight and 10-30cm in length (Gustafson et al. 2010). Puget Sound lies between two of the larger eulachon spawning rivers (the Columbia and Fraser rivers) but lacks a large eulachon run of its own (Gustafson et al. 2010). Since 2011, eulachon have been found in small numbers throughout Puget Sound and in several watersheds including the Deschutes River, Dungeness River, Elwha River, Goldsborough Creek (Mason Co.), Nisqually River, and Salmon Creek (Jefferson Co.) (NMFS APPS database; https://apps.nmfs.noaa.gov/). Historically, major aboriginal subsistence fisheries for eulachon occurred from northern California into Alaska where the eulachon were eaten fresh, smoked, dried, and salted, and rendered as oil or grease (Gustafson et al. 2010). Since 1888, the states of Washington and Oregon have maintained commercial and recreational eulachon fisheries using small-mesh gillnets (i.e., ≤2 inches) and dipnets (Gustafson et al. 2010). Following the 2010 ESA-listing of the southern DPS of eulachon, the states of Washington and Oregon closed the commercial and recreational eulachon fisheries. In 2014, a reduced Level-I eulachon fishery in the Columbia River and select tributaries began which limits eulachon fisheries to 1% of its spawning stock biomass (Gustafson et al. 2016). Eulachon are also taken as bycatch in the pink shrimp and groundfish fisheries off of the Oregon, Washington, and California coasts (Al-Humaidhi et al. 2012). Salmon fisheries in the northern Puget Sound areas, however, use nets with larger mesh sizes (i.e., >4 inches) and hook and line gear designed to catch the much larger salmon species. The deployed gear targets pelagic feeding salmon near the surface and in mid-water areas. Thus, eulachon bycatch in salmon fisheries is extremely unlikely given these general differences in spatial distribution and gear characteristics. In fact, NMFS is unaware of any records of eulachon caught in either commercial or recreational Puget Sound salmon fisheries. Therefore, 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 2014b), coastal pelagic species (PFMC 2016), and Pacific coast salmon (PFMC 2014c) contained in the Fishery Management Plans developed by the PFMC and approved by the Secretary of Commerce. This section is NMFS' 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 2.3. 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 2014c).

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 2014b).

Essential fish habitat for CPS is defined based on the temperature range where they are found, and on the geographic area where they occur at any life stage. This range varies widely according to ocean temperatures. The east-west boundary of CPS EFH includes all marine and estuary waters from the coasts of California, Oregon, and Washington to the limits of the EEZ (the 200-mile limit) and above the thermocline where sea surface temperatures range between 10° and 26° centigrade. The southern boundary is the U.S./Mexico maritime boundary. The northern boundary is more changeable and is defined as the position of the 10° C isotherm, which varies seasonally and annually. In years with cold winter sea surface temperatures, the 10° C isotherm during February is around 43° N latitude offshore, and slightly further south along the coast. In August, this northern boundary moves up to Canada or Alaska. Assessment of potential adverse effects on these species EFH from the proposed actions is based, in part, on this information. A more detailed description and identification of EFH for coastal pelagic species is found in Amendment 8 to the Coastal Pelagic Species Fishery Management Plan (PFMC 2016).

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

Fishing Activities

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

Derelict Gear

When gear associated with commercial or recreational fishing breaks free, is abandoned, or becomes otherwise lost in the aquatic environment, it becomes derelict gear. In commercial fisheries, trawl nets, gillnets, long lines, purse seines, crab and lobster pots, and other material, are occasionally lost to the aquatic environment. The gear used in the proposed actions are gillnets, purse seines, beach seines and hook and line gear.

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 additional outreach and assessment efforts (i.e. Gibson (2013)), and recent lost net inventories (Beattie and Adicks 2012; Beattie 2013; James 2018a) it is likely that fewer nets will become derelict in the upcoming 2019/20 fishing season compared to several years and decades ago (previous estimates of derelict nets were 16 to 42 annually (NRC 2010)). In 2017, an estimated 11 nets became derelict (though not all of them may have been associated with a salmon fishery) and 10 were recovered (James 2018a). In 2016, an estimated 14 nets became derelict, nine of which were recovered (James 2017). In 2014, an estimated 13 nets became derelict, and 12 of them where recovered (James 2015), in 2013 an estimated 15 nets became derelict, 12 of which were recovered (Beattie 2013), and in 2012 eight nets were lost, and six were recovered (Beattie and Adicks 2012). A separate analysis from June 2012 to February 2016 a total of 77 newly lost nets were reported, and only 6 of these were reported by commercial fishermen (Drinkwin 2016). We do not yet have estimates of the number of nets lost in the 2018/2019 salmon fisheries. Based on this new information we estimate that a range of six to 20 gill nets may be lost in the 2019/2020 fishing season, but up to 75% of these nets would be removed within days of their loss and have little potential to damage EFH.

Harvest of Prey Species

Prey species can be considered a component of EFH (PFMC 2014c). For Pacific salmon, commercial and recreational fisheries for many types of prey species potentially decrease the amount of prey available to Pacific salmon. Herring, sardine, anchovy, squid, smelt, groundfish, shrimp, crab, burrowing shrimp, and other species of finfish and shellfish are potential salmon prey species that are directly fished, either commercially or recreationally. The proposed actions does not include harvest of prey species and will have no adverse effect on prey species.

Vessel Operation

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

Removal of Salmon Carcasses

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

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

3.2.2 Groundfish

As described in Section 2.5.3.4 of this opinion, NMFS believes that the proposed actions would have the following adverse effects on the EFH of groundfish.

Habitat Alteration

Lost commercial fishing nets would adversely affect groundfish EFH. As described in section 2.5.3.4, most nets hang on bottom structure that is also used by rockfish and other groundfish. This structure consists of high-relief rocky substrates or boulders located on sand, mud or gravel bottoms (Good et al. 2010). Derelict nets alter habitat suitability by trapping fine sediments out of the water column. This makes a layer of soft sediment over rocky areas, changing habitat quality and suitability for benthic organisms (Good et al. 2010). Nets can also cover habitats used by groundfish for shelter and pursuit of food, rendering the habitat unavailable. Using the most common derelict net size reported by Good et al. (2010), if up to 20 nets were initially lost and five were not retrieved they would degrade approximately damage up to 35,000 square feet (0.8 acre) of habitat (assuming an average of 7,000 square feet per net) of benthic habitat.

Reduction in Groundfish Prey and Entanglement

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

3.2.3 Coastal Pelagic

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

3.3 Essential Fish Habitat Conservation Recommendations

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

NMFS is not providing any EFH conservation recommendations for salmon EFH because the proposed actions includes adequate measures to mitigate for the potential adverse effects from salmon fishing. We provide the following conservation recommendations to minimize the adverse effects to groundfish EFH; consistent with the terms and conditions described for rockfish in Section 2.9.2.2 of the opinion:

Derelict Gear Reporting

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

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in section 3.2 above, approximately 0.8 acre of designated EFH for Pacific coast groundfish species.

3.4 Statutory Response Requirement

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

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

3.5 Supplemental Consultation

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

4. DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

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

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended users of this consultation are the applicants and funding/action agencies listed on the first page. Other interested users could include the agencies, applicants, and the American public. Individual copies of this opinion were provided to the BIA, NMFS, USFWS and the applicants. The document will be available through the NOAA Institutional Repository (https://repository.library.noaa.gov/), after approximately two weeks. The format and naming adheres to conventional standards for style.

4.2 Integrity

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

4.3 Objectivity

Information Product Category: Natural Resource Plan

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

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

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

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

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Appendix A

Viable Risk Assessment Procedure

Viability Risk Assessment Procedure

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

The Viable Risk Assessment Procedure:

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

The result of applying the VRAP to an individual population is an RER which is the highest allowable ("ceiling") exploitation rate that satisfies specified risk criteria related to survival and recovery. Calculation of RERs depend on the selection of two abundance-related reference points (referred to as critical and rebuilding escapement thresholds (CET and RET[49]4)), and two risk criteria that define the probability that a population will fall below the CET and exceed the RET. Considerations for selecting the risk criteria and thresholds are discussed briefly here and in more detail in NMFS 2000.

The selection of risk criteria for analytical purposes is essentially a policy decision. For jeopardy determinations, the standard is to not "…reduce appreciably the likelihood of survival and recovery …" (50 CFR 402.2). In this context, NMFS used guidance from earlier biological opinions to guide the selection of risk criteria for VRAP. NMFS' 1995 biological opinion on the operation of the Columbia River hydropower system (NMFS 1995) considered the biological requirements for Snake River spring/summer Chinook to be met if there was a high likelihood, relative to the historic likelihood, that a majority of populations were above lower threshold levels[50]5 and a moderate to high likelihood that a majority of populations would achieve their

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[49]4 Also referred to in previous opinions as the Upper Escapement Threshold.

[50]5 The Biological Requirements Work Group defined these as levels below which uncertainties about processes or

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

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

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

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

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

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

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

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

> where S is the number of fish spawning in a single return year, R is the number of adult equivalent recruits,[516] and **e** is a vector of environmental, density-independent indicators of annual survival.

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

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

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

The simple forms of these models can be augmented by the inclusion of environmental variables correlated with brood year survival. The VRAP is therefore flexible in that it facilitates comparison of results depending on assumptions between production functions and any of a wide range of possible environmental co-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.[52]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% 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

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[52]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.

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.