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 2020-2021 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 2020

NMFS Consultation Number: WCR-2020-00960

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	Yes	No
PS/GB yelloweye rockfish (*S. ruberrimus*)	Threatened	Yes	No	Yes	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	[1]No Designated Critical Habitat	[1]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

[1] Critical habitat was proposed for humpback whales along the West Coast of the United States in October 2019. The final rule has not gone into place.

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

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

Issued by: ______________________________

Barry A. Thom, Regional Administrator
West Coast Region
National Marine Fisheries Service

Date: **<u>May 8, 2020</u>** (***Date expires: April 30, 2021***)

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LIST OF ACRONYMS

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
CFD	CAPE FLATTERY DEEP
CFI	CAPE FLATTERY INDEX
CFM	CAPE FLATTERY MID SHELF
CFO	CAPE FLATTERY OFFSHELF
CFR	CODE OF FEDERAL REGULATIONS
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
DEIS	DRAFT ENVIRONMENTAL IMPACT STATEMENT
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
EAR	ECOLOGICAL ACOUSTICAL RECORDER
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
JF	JUAN DE FUCA
KCAL	KILOCALORIE
KG	KILOGRAM
KHZ	KILOHERTZ
KM	KILOMETERS
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
MSF	MARK SELECTIVE FISHERY
MSY	MAXIMUM SUSTAINABLE YIELD
MU	MAJOR UNIT
NF	NORTH FORK
NL	NOT LISTED
NMFS	NATIONAL MARINE FISHERIES SERVICE
NMI	NAUTICALMILE
NOAA	NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOF	NORTH OF FALCON
NOR	NATURAL-ORIGIN
NPFMC	NORTH PACIFIC FISHERIES MANAGEMENT COUNCIL
NPGO	NORTH PACIFIC GYRE OSCILLATION
NR	NON RETENTION
NRC	NATURAL RESOURCE CONSULTANTS
NRCS	NATURAL RESOURCES CONSERVATION SERVICE
NWFSC	NORTHWEST FISHERY SCIENCE CENTER
NWTRC	U.S. NAVY'S NORTHWEST TRAINING RANGE COMPLEX
OA	OCEAN ACIDIFICATION
OR	OREGON
PAH	POLYCYCLIC AROMATIC HYDROCARBON
PAL	PASSIVE AQUATIC LISTENER
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	puget sound steelhead recovery plan
POP	Persistent Organic Pollutant
ppb	Parts per Billion
PRA	Population Recovery Approach
PS	Puget Sound
PSA	puget sound anglers
PSC	pacific salmon commission
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
PWWA	pacific whale watchers association
QD	quinault deep
QET	Quasi-extinction Threshold
r	intrinsic rate of natural increase
R/S	recruits/spawner
RAAMF	Risk Assessment and Adaptive Management Framework
RCA	Rockfish Conservation Area
RCW	Revised Code of Washington
RERs	Rebuilding Exploitation Rates
RM	river mile
RMP	Resource Management Plan
ROV	Remotely Operated Vehicle

RPA	Reasonable and Prudent Alternative
SAR	Stock Assessment Report
SBC	Southern British Columbia
SEAK	Southeast Alaska
SF	South Fork
SJF	Strait of Juan de Fuca
SP/LP	Sand Point and La Push
SRKW	Southern Resident Killer Whale
SSPS	Shared Strategy for Puget Sound
SUS	Southern United States
SWFSC	Southwest Fishery Science Center
SWVCI	Southwest Vancouver Island
T	Threatened
TRT	Technical Recovery Team
TTS	Temporary Threshold Shifts
US	United States
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
Workgroup	Ad Hoc Southern Resident Killer Whale Workgroup
yr	year
µPa	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 2020-2021 Puget Sound Harvest Plan, as reflected in BIA's April 20, 2020 request (supplemented on April 24, 2020) for consultation to NMFS, inclusive of BIA's Biological Assessment and 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, 2020-April 30, 2021.

(3) Two actions associated with the management of the 2020 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.

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).

NMFS proposed critical habitat for humpback whales on October 9, 2019 (84 Federal Regulation (FR) 54354). The area proposed stretches across the majority of the west coast of the United States and includes 44,119 nautical miles $(nmi)^2$ for the Western North Pacific DPS, 12,966 nmi^2 for the Central American DPS, and 30,527nmi^2 for the Mexico DPS. The proposed nearshore critical habitat boundary in Washington is defined by the 50-m isobath, and the offshore boundary is defined by the 1,200-m isobath relative to MLLW. Critical habitat also includes waters within the U.S. portion of the Strait of Juan de Fuca to an eastern boundary line at Angeles Point at 123°33′ W. In November, 2019 the formal comment period deadline was extended until January 31, 2020 (84 FR 65346). Because the proposed humpback whale critical habitat has limited overlap with the action area and the action is not likely to result in meaningful bycatch of humpback whale prey, humpback whale critical habitat is not discussed further in this opinion.

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 2011b). 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, 2018 and 2019 fishery cycles (May 1, 2014 through April 30, 2020) 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; 2018c; 2019c). 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 has reviewed and provided comments and guidance on a new draft RMP submitted in December 2017 for consideration under Limit 6 of the ESA 4(d) Rule and has continued to work with the Puget Sound co-managers on further development of the plan. For 2020, NMFS will complete a one-year consultation under section 7 of the ESA on the effects of 2020-2021 Puget Sound salmon fisheries on ESA listed species.

On April 20, 2020, 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 2020-2021 Puget Sound Chinook Harvest Plan, as described in (Mercier 2020). The original request was supplemented on April 24, 2020 with an updated Environment Assessment. 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 2020-2021 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 and steelhead fisheries, and considers the total fishery-related impacts on Puget Sound Chinook salmon and steelhead from those 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 (Mercier 2020), the Environmental Assessment on the 2020 Puget Sound Chinook Harvest Plan (Mercier 2020), 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 the 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 2008f)	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 United States (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 2020-2021 Puget Sound Chinook Harvest Plan occurring from May 1, 2020 through April 30, 2021. This plan describes the framework within which the tribal and state jurisdictions jointly manage all recreational, commercial, ceremonial, subsistence and take-home salmon and steelhead fisheries, and considers the total fishery-related impacts on Puget Sound Chinook salmon and steelhead from those fisheries within the greater Puget Sound area. The 2020-2021 Chinook Harvest Plan is based on the 2010-2014 Puget Sound Chinook harvest RMP, with revisions to the conservation objectives, as has been necessary and appropriate. This 2020-2021 Chinook Harvest Plan details the current conservation and management objectives, including expected levels of impact to ESA-listed Chinook salmon and steelhead, over the one-year term of its implementation, and describes the suite of fisheries planned to meet these objectives. The Chinook Harvest Plan also contains management area-specific details on fishery time periods, gear restrictions, and catch allocation and bag limits, where applicable, anticipated to occur during the period (Mercier 2020). The Chinook Harvest Plan, as submitted by the BIA, 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 2020-2021 Season;
- the 2020-2021 List of Agreed Fisheries (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
- Pre-season plan for the Nisqually tribal selective net gear research fishery
- 2020 Green River Management actions,
- 2020 Puyallup River Management actions;
- a description of actions to be taken in the WDFW managed fishery season for 2020-2021 beneficial for Southern Resident Killer Whales;
- a summary assessment of the tribal salmon fishing impacts associated with the proposed 2020-21 Puget Sound Chinook Harvest Plan on Southern Resident killer whales
- the co-managers' anticipated impacts to Puget Sound steelhead,
- 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; HCSMP)

from May 1, 2020 through April 30, 2021. 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 Puget Sound Salmon and Steelhead Management Plan (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, 2020 through April 30, 2021 (see Mercier (2020) for fisheries proposed to occur during this period).

***NMFS**:*

The Fraser Panel of the Pacific Salmon Commission (PSC) controls sockeye and pink salmon 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 typically assumes control of commercial and subsistence 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 area fisheries are also managed together with the suite of other Puget Sound and PFMC fisheries to meet conservation and harvest management objectives for Chinook, coho, and chum salmon.

Two Federal actions will be taken by NMFS during the 2020 fishing season (May 1, 2020 – April 30, 2021) to allow the PSC's Fraser Panel to manage Fraser River sockeye and pink fisheries in U.S. Fraser Panel Waters. One action grants regulatory control of the U.S. Fraser Panel Area Waters to the Panel for in-season management (a reciprocal action in Canada takes place for their Panel waters). 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.

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. We considered whether or not the proposed Federal actions would cause any other activities and determined that it would. Puget Sound treaty Indian salmon fisheries and related enforcement, research, and monitoring projects associated with fisheries, other than those governed by the U.S. Fraser Panel, would occur as a consequence of the proposed action and are reasonably certain to occur. Because the state of Washington and the Puget Sound treaty tribes have submitted a proposal for joint management[2] of the 2020-2021 Puget Sound salmon fisheries, the non-treaty salmon fisheries and related enforcement, research, and monitoring projects associated with fisheries, other than those governed by the U.S. Fraser Panel, would also occur as a consequence of the proposed action and are reasonably certain to occur. We will be including the effects of these activities in the effects analysis of this opinion.

Many salmon stocks impacted in the Puget Sound salmon fisheries are also taken in other marine fisheries outside of the Puget Sound region. The conservation objectives developed for Puget Sound Chinook described in the 2020-2021 Puget Sound Harvest Plan are a mix of Southern United States (SUS), total (all marine and freshwater) exploitation rate (ER), and escapement abundance-based impact objectives. Therefore, the analysis of fishery impacts to Puget Sound Chinook stocks includes assumptions regarding their harvest in salmon fisheries along the Pacific west coast, including Southeast Alaskan (SEAK) and Canadian fisheries, ocean fisheries off the coasts of Washington and Oregon states, as well as fisheries in the marine, estuarine, and freshwater areas of Puget Sound (Puget Sound salmon fisheries), considered in this opinion, in determining whether conservation objectives are met. The Fraser Panel fisheries are included in the mix of Puget Sound salmon fisheries.

Puget Sound salmon fisheries for Chinook, coho, chum, and Fraser River sockeye and pink salmon are managed consistent with the provisions of the PST, an international agreement between the U.S. and Canada, which also governs fisheries in SEAK, those off the coast of British Columbia, the Washington and Oregon coasts, and the Columbia River. Canadian and SEAK salmon fisheries impact salmon stocks from the states of Washington, Oregon, and Idaho as well as salmon originating in SEAK and Canadian waters. As described above, fisheries off the coast of Washington and Oregon and in inland waters, such as the Puget Sound, harvest salmon originating in U.S. West Coast and Canadian river systems. The PST provides a framework for the management of salmon fisheries in these U.S. and Canada waters that fall within the PST's geographical scope. The overall purpose of the fishing regimens, is to accomplish the conservation, production, and harvest allocation objectives set forth in the PST (https://www.psc.org/publications/pacific-salmon-treaty/). The PST provides for the U.S. and Canada to each manage their own fisheries to achieve domestic conservation and allocation priorities, while remaining within the overall limits agreed to under the PST. In 2018, U.S. and Canadian representatives reached agreement to amend versions of five expiring Chapters of Annex IV (Turner and Reid 2018); both countries have since executed this agreement. Because the Puget Sound Chinook salmon are listed under the ESA and are subject to management under

[2] 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)).

the PST, objectives for Puget Sound salmon fisheries are designed to be consistent with these laws.

The new PST Agreement includes reductions in harvest impacts in all Chinook fisheries within its scope, including Puget Sound, and refines the management of coho salmon caught in these areas. The new Agreement includes reductions in the allowable annual catch of Chinook salmon in the SEAK and Canadian West Coast of Vancouver Island and Northern British Columbia fisheries by up to 7.5 and 12.5 percent, respectively, compared to the previous agreement. The level of reduction depends on the overall Chinook abundance in a particular year. This comes on top of the reductions of 15 and 30 percent for those same fisheries that occurred as a result of the prior 10-year agreement (2009 through 2018). Harvest rates on Chinook salmon stocks caught in southern British Columbia and U.S. salmon fisheries, including those in Puget Sound waters are reduced by up to 15% from the previous agreement (2009 through 2018). Beginning in January 2020 this will result in an increased proportion of abundances of Chinook salmon migrating to more southerly waters including those in the southern U.S. Although provisions of the updated agreement are complex, they were specifically designed to reduce fishery impacts in all fisheries to respond to conservation concerns for a number of U.S.—particularly Puget Sound Chinook—and Canadian stocks.

In 2019, NMFS consulted on impacts to ESA-listed species from several U.S. domestic actions associated with the new PST agreement (NMFS 2019f) including federal funding of a conservation program for critical Puget Sound salmon stocks and SRKW prey enhancement. The 2019 opinion (NMFS 2019f) included a programmatic consultation on the PST funding initiative, which is an important element of the environmental baseline in this opinion. In Fiscal Year 2020 Congress appropriated $35.1 million dollars for U.S. domestic activities associated with implementation of the new PST agreement, of which $5.6 million is being used for increased hatchery production to support prey abundance for SRKW and also includes $13.5 million in support of Puget Sound Critical Stock Conservation and Habitat Restoration and Protection Program. The beneficial effects of these activities (i.e., increases in the abundance of Chinook salmon available as prey to SRKW, hatchery conservation programs to support critical Puget Sound Chinook populations, and improved habitat conditions for those populations) are expected to begin in the next 3-5 years. Subsequent specific actions (i.e, hatchery production programs, habitat restoration actions) will undergo separate consultations, tiered from the programmatic consultation (NMFS 2019f), to assess effects for site-specific actions. The harvest management provisions of the new Agreement and the appropriations to initiate the conservation activities are in place now and will be taken into account in this biological opinion. The effects of the conservation activities will be important to the analysis of the impacts of Puget Sound salmon fisheries over the long term to Puget Sound Chinook salmon and SRKW. Additional detail on the activities associated with the PST funding initiative are described in the Environmental Baseline (Section 2.4).

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 as a whole for the conservation of a listed species" (50 CFR 402.2).

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.

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

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

- *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, Puget Sound rockfish, Southern Resident Killer Whales, humpback whales, and aquatic habitat at large, is climate change. The following section describes climate change and other ecosystem effects on these species.

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[3]. The marine survival of coastal steelhead, as well as Columbia River Chinook and coho, do not exhibit the same declining trend as the Salish Sea populations. Specifically, marine survival rates for steelhead in Washington State have declined in the last 25 years with the Puget Sound steelhead populations declining to a greater extent than other regions (i.e., Washington Coast and Lower Columbia River) and are at near historic lows (Moore et al. 2014). Climate changes have included increasing water temperatures, increasing

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

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). Preliminary work conducted as part of the Salish Sea Marine Survival Project reported that approximately 50 percent of the steelhead smolts that reach the Hood Canal Bridge did not survive in the 2017 and 2018 outmigration years. Of these steelhead that did not survive, approximately 80 percent were consumed by predators which display deep diving behavior, such as pinnipeds (Moore and Berejikian 2019). 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[4] 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. For species that depend on salmon for prey, such as SRKWs, the fluctuations in salmon survival that occur with these changes in climate conditions can have negative effects. 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). Macleod (2009) estimated, based on expected shifts in water temperature, 88% of cetaceans would be affected by climate change, with 47% likely to be negatively affected. 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. 2017). In addition to predation by marine mammals, Fresh (1997) reported that 33 fish species and 13 bird species are predators of juvenile and adult salmon, particularly during freshwater rearing and migration stages.

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

2.2.1.1 Status of Puget Sound Chinook

For Pacific salmon and steelhead, NMFS commonly uses four parameters to assess the viability of the populations that, together, constitute the species: spatial structure, diversity, abundance, and productivity (McElhany et al. 2000). These 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. On October 4, 2019 NMFS published 84 FR 53117, requesting updated information on all listed Puget Sound populations to inform the most recent five-year status review anticipated for completion in 2021.

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[5];

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.

[5] 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.

Spatial Structure and Diversity

The PSTRT determined that 22 historical populations currently contain Chinook salmon and grouped them into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity (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[6] (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 (70 FR 37160). NMFS proposed a rule to revise the Code of Federal Regulations to update the list of hatchery programs that are included as part of Pacific salmon and steelhead species listed under the Endangered species Act (81 FR 72759).

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)

[6] 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)
	Upper Sauk River (early)
	Lower Sauk River (moderately early)
	Suiattle River (very early)
	Cascade River (moderately early)
Central/South Puget Sound Basin	Cedar River
	North Lake Washington/ Sammamish River
	Green/Duwamish River
	Puyallup River
	White River
	Nisqually River

NOTE: NMFS has determined that the bolded populations, in particular, are essential to recovery of the Puget Sound ESU. In addition, at least one other population within the Whidbey Basin and Central/South Puget Sound Basin regions would need to be viable for recovery of the ESU. The PSTRT noted that the Nisqually watershed is in comparatively good condition, and thus the certainty that the population could be recovered is among the highest in the Central/South Region. NMFS concluded in its supplement to the Puget Sound Salmon Recovery Plan that protecting the existing habitat and working toward a viable population in the Nisqually watershed would help to buffer the entire region against further risk (NMFS 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 ensure 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; 2008f; 2008e; 2010a; 2011a; 2013b; 2014b; 2015c; 2016c; 2017b; 2018c; 2019c)

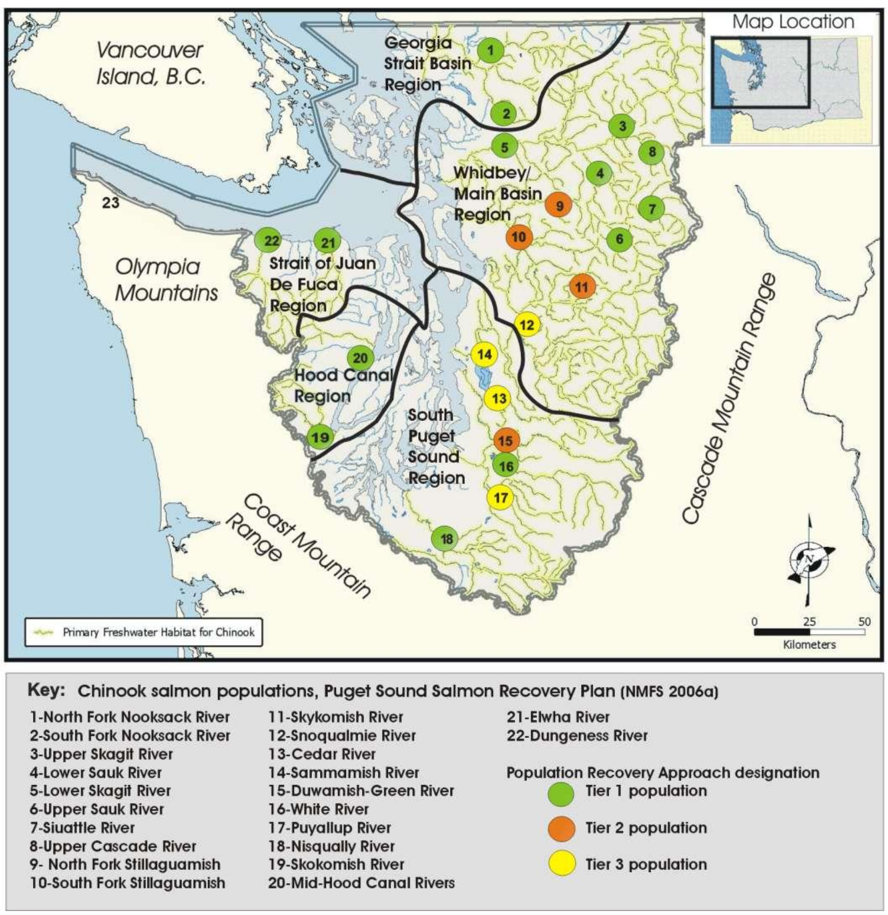

Figure 1. Puget Sound Chinook populations.

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[7] 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 2008c; 2008d; 2008b). 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 for most populations, four additional years of escapement data (2015-2018) (Table 4). Incorporation of this information indicates more positive trends in natural-origin Chinook salmon spawner population across the ESU.[8] 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 2015-2018, these recent average escapements represent an 11-126% increase in natural-origin escapement. These populations represent all five of the five recovery regions in Puget Sound.

Natural-origin escapements for seven populations are at or below their critical thresholds[9]. Both

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[7] Remove the two Elwha River dams and restoration of the natural habitat in the watershed began in 2011. Dam removal was completed in 2014.

[8] 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 NWFSC 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).

[9] After taking into account uncertainty, the critical threshold is defined as a point below which: (1) depensatory

populations in three of the five biogeographical regions are below or near their critical threshold: Georgia Strait, Hood Canal and Strait of Juan de Fuca (Table 3). When hatchery spawners are included, aggregate average escapement is over 1,000 for one of the two populations in each of these three regions; reducing the demographic risk to the populations in these regions. Ten populations are above their rebuilding thresholds[10]; seven of them in the Whidbey/Main Basin Region. This appears to reflect modest improvements in the status of most Puget Sound populations, relative to abundance estimates in these previous opinions (NMFS 2016c; 2017b; 2018c; 2019c) for the Puget Sound salmon fisheries were completed. There are exceptions to the general increases as well, with eight populations' average abundance being lower. In 2018 NMFS and the Northwest Fishery Science Center (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. Eight 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 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

processes are likely to reduce the population below replacement; (2) the population is at risk from inbreeding depression or fixation of deleterious mutations; or (3) productivity variation due to demographic stochasticity becomes a substantial source of risk (NMFS 2000b).

[10] The rebuilding threshold is defined as the escapement that will achieve Maximum Sustainable Yield (MSY) under current environmental and habitat conditions (NMFS 2000b), 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.

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). 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). Perhaps because Puget Sound Chinook salmon populations are not exhibiting a reduction in body size at age of maturation, the productivity estimates reported (Table 4) for many of the populations continue to demonstrate stable levels of recruitment.

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 2018 Run Year Geometric mean Escapement (Spawners)		NMFS Escapement Thresholds		Recovery Planning Abundance Target in Spawners (productivity)[2]	Average % hatchery fish in escapement 1999-2018 (min-max)[5]
		Natural [1] 1999-2018	Natural-Origin (Productivity[2])	Critical[3]	Rebuilding[4]		
Georgia Basin	Nooksack MU	1,787	281[9]	400	500		
	NF Nooksack	1,494	202[9] (0.4)	*200*[6]	-	3,800 (3.4)	85 (63-94)
	SF Nooksack	246	**57**[9] (1.8)	*200*[6]	-	2,000 (3.6)	51 (19-81)
Whidbey/Main Basin	Skagit Summer/Fall MU						
	Upper Skagit River	9,349	8,422 (2.8)	738	5,836	5,380 (3.8)	9 (0-36)
	Lower Sauk River	560	533 (3.2)	*200*[6]	371	1,400 (3.0)	4 (0-33)
	Lower Skagit River	2,089	1, 916 (2.8)	281	2,475	3,900 (3.0)	8 (0-23)
	Skagit Spring MU						
	Upper Sauk River	633	624 (3.2)	170	484	750 (3.0)	1 (0-4)
	Suiattle River	379	373 (2.0)	170	250	160 (2.8)	2 (0-7)
	Upper Cascade River	284	256 (1.4)	130	196	290 (3.0)	9 (0-50)
	Stillaguamish MU						
	NF Stillaguamish R.	1,052	499 (0.88)	300	550	4,000 (3.4)	50 (25-81)
	SF Stillaguamish R.	133	**69** (0.64)	*200*[6]	300	3,600 (3.3)	48 (9-100)
	Snohomish MU						
	Skykomish River	3,390	2,273 (1.5)	400	1,500	8,700 (3.4)	31 (10-62)
	Snoqualmie River	1,505	1, 216 (1.4)	400	900	5,500 (3.6)	19 (8-35)
Central/South Sound	Cedar River	927	661 (2.9)	*200*[6]	*282*[7]	2,000 (3.1)	28 (10-50)
	Sammamish River	1,132	**164** (0.5)	*200*[6]	*1,250*[6]	1,000 (3.0)	80 (36-89)
	Duwamish-Green R.	4,075	1,534 (1.5)	400	1,700	-	60 (27-79)
	White River[10]	1,817	643 (0.9)	*200*[6]	488[7]	-	57 (19-90)
	Puyallup River[11]	1,645	826 (1.3)	*200*[6]	797[7]	5,300 (2.3)	45 (19-79)
	Nisqually River	1,659	612 (1.4)	*200*[6]	1,200[8]	3,400 (3.0)	57 (17-87)
Hood Canal	Skokomish River	1,398	**282** (0.8)	452	1,160	-	71 (7-96)
	Mid-Hood Canal Rivers[12]	**187**		*200*[6]	*1,250*[6]	1,300 (3.0)	36[12] (2-87)
Strait of Juan de Fuca	Dungeness River	458	**178** (1.4)	*200*[6]	925[8]	1,200 (3.0)	59 (24-96)
	Elwha River[13]	1,653	**76**[9]	*200*[6]	*1,250*[6]	6,900 (4.6)	95 91-98)

[1] Includes naturally spawning hatchery fish (Nooksack Major Unit (MU)=1999-2016, North Fork (NF) population=1999-2016, and South Fork (SF) populations=1999-2017 geomean).
[2] Source productivity is Abundance and Productivity Tables from NWFSC database; measured as the mean of observed recruits/observed spawners through

brood year 2015. 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 2006b); 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 2000b; NMFS and NWFSC 2018).

[4] Rebuilding natural-origin escapement thresholds under current habitat and environmental conditions (McElhany et al. 2000; NMFS 2000b; NMFS and NWFSC 2018).

[5] Estimates of the fraction of hatchery fish in natural spawning escapements are from the Abundance and Productivity Tables from NWFSC database; measured as mean and range for 1999-2018.

[6] Based on generic VSP guidance (McElhany et al. 2000; NMFS 2000b).

[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 NF Nooksack available only for 1999-2016; SF Nooksack only for 1999-2017; Elwha for 2009-2017

[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 hatchery or natural-origin fish gaffed or seined from spawning grounds for supplementation program broodstock collectio

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	Total Natural Escapement Trend[1] (1990-2018)		Natural Origin Growth Rate[2] (1990-2015)	
		NMFS		Recruitment (Recruits)	Escapement (Spawners)
Georgia Basin	NF Nooksack (early)	1.11	increasing	1.04	1.02
	SF Nooksack (early)	1.30	stable	1.00	0.98
Whidbey/Main Basin	Upper Skagit River (moderately early)	1.03	increasing	0.99	1.02
	Lower Sauk River (moderately early)	1.01	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)	1.02	stable	1.02	1.01
	Upper Cascade River (moderately early)	1.01	stable	1.01	1.02
	NF Stillaguamish R. (early)	1.03	increasing	0.97	1.00
	SF Stillaguamish R[3] (moderately early)	0.94	**declining**	0.94	0.97
	Skykomish River (late)	1.00	stable	1.00	1.00
	Snoqualmie River (late)	1.00	stable	0.98	0.98
Central/South Sound	Cedar River (late)	1.04	increasing	1.01	1.04
	Sammamish River[4] (late)	1.01	stable	1.02	1.04
	Duwamish-Green R. (late)	0.98	stable	0.94	0.97
	White River[5] (early)	1.09	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)	1.05	stable	0.97	1.04
Strait of Juan de Fuca	Dungeness River (early)	1.07	increasing	1.03	1.06
	Elwha River[3] (late)	1.22	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. North Fork Nooksack available only for 1999-2016; SF Nooksack only for 1999-2017; Elwha for 2009-2017.

[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 = -18%, range = -52 to +41%), (October. 2018 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 rebuilding exploitation rates (RER) for many 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 five-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. On October 4, 2019 NMFS published 84 FR 53117, requesting updated information on all listed Puget Sound populations to inform the most recent five-year status review anticipated for completion in 2021. 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 available for consideration during the NWFSC (2015) status review.

As part of the early recovery planning process, NMFS convened a technical recovery team to identify historic populations and develop viability criteria for the recovery plan. The Puget Sound Steelhead Technical Recovery Team (PSSTRT) delineated populations 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).

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.

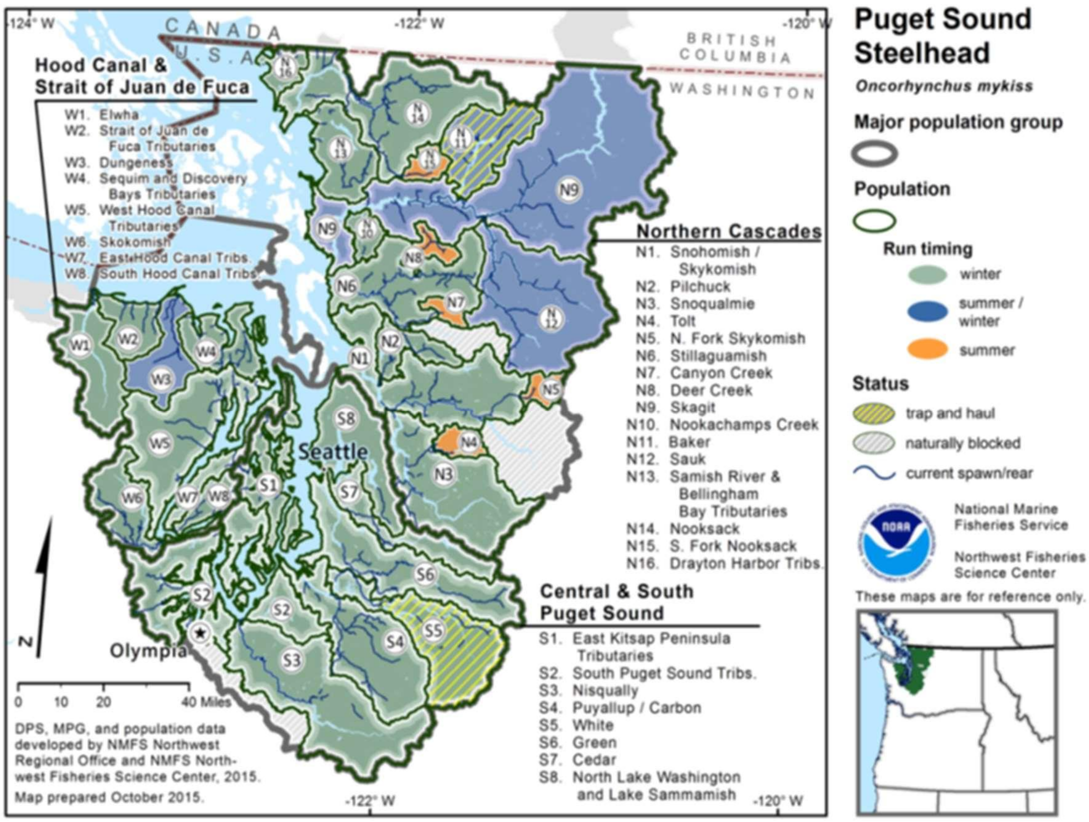

Figure 2. The Puget Sound Steelhead DPS showing MPGs and DIPs. The steelhead MPGs include the Northern Cascades, Central & Sound Puget Sound, and the Hood Canal & Strait of Juan de Fuca.

The NMFS adopted a recovery plan for Puget Sound Steelhead on December 20, 2019 (https://www.fisheries.noaa.gov/resource/document/esa-recovery-plan-puget-sound-steelhead-distinct-population-segment-oncorhynchus). The Puget Sound Steelhead Recovery Plan (Plan) (NMFS 2019h) provides guidance to recover the species to the point that it can be naturally self-sustaining over the long term. To achieve full recovery, steelhead populations in Puget Sound need to be robust enough to withstand natural environmental variation and some catastrophic events, and they should be resilient enough to support harvest and habitat loss due to human population growth. The Plan aims to improve steelhead viability by addressing the pressures that contribute to the current condition: habitat loss/ degradation, water withdrawals, declining water quality, fish passage barriers, dam operations, harvest, hatcheries, climate change effects, and reduced early marine survival. NMFS will use the recovery plan to organize and coordinate recovery of the species in partnership with state, local, tribal, and federal resource managers, and the many watershed restoration partners in the Puget Sound. 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 Plan (NMFS 2019h).

In the Plan, NMFS and the Puget Sound Steelhead Recovery Team (including the PSSTRT chair and members) modified the 2013 and 2015 PSSTRT viability criteria to produce the viability criteria for Puget Sound steelhead, as described below:

- All three MPGs (North Cascade, Central-South Puget Sound, and Hood Canal-Strait of Juan de Fuca) (Figure 2) must be viable. This criterion is based on a PSSTRT Viability Criterion (Hard et al. 2015). The three MPGs differ substantially in key biological and habitat characteristics that contribute in distinct ways to the overall viability, diversity, and spatial structure of the DPS.
- There must be sufficient data available for NMFS to determine that each MPG is viable.

The Plan (NMFS 2019h) also established MPG-level viability criteria. The following are specific criteria are required for MPG viability:

- At least 50 percent of steelhead populations in the MPG achieve viability.
- Natural production of steelhead from tributaries to Puget Sound that are not identified in any of the 32 identified populations provides sufficient ecological diversity and productivity to support DPS-wide recovery.
- In addition to the minimum number of viable DIPs (50%) required above, all DIPs in the MPG must achieve an average MPG-level viability that is equivalent to or greater than the geometric mean (averaged over all the DIPs in the MPG) viability score of at least 2.2 using the 1–3 scale for individual DIPs described under the DIP viability discussion in the PSSTRT Viability Criteria document (Hard et al. 2015). This criterion is intended to ensure that MPG viability is not measured (and achieved) solely by the strongest DIPs, but also by other populations that are sufficiently healthy to achieve MPG-wide resilience. The Plan allows for an alternative evaluation method to that in Hard et al. (2015) may be developed and used to assess MPG viability.

The Plan (NMFS 2019h) also identified specific DIPs in each of the three MPGs which must attain viability. These DIPs, by MPG, are described as follows:

For the **North Cascades MPG** eight of the sixteen DIPs in the North Cascades MPG must be viable. The eight (five winter-run and three summer-run) DIPs described below must be viable to meet this criterion:

- Of the eleven DIPs with winter or winter/summer runs, five must be viable:
- Nooksack River Winter-Run;
- Stillaguamish River Winter-Run;

- One from the Skagit River (either the Skagit River Summer-Run and Winter-Run or the Sauk River Summer-Run and Winter-Run);
- One from the Snohomish River watershed (Pilchuck, Snoqualmie, or Snohomish/Skykomish River Winter-Run); and
- One other winter or summer/winter run from the MPG at large.

The rationale for this is that there are four major watersheds in this MPG, and one viable population from each will help attain geographic spread and habitat diversity within core extant steelhead habitat (NMFS 2019h). Of the five summer-run DIPs in this MPG, three must be viable, representing each of the three major watersheds containing summer-run populations (Nooksack, Stillaguamish, Snohomish rivers). Therefore, the priority summer-run populations are as follows:

- South Fork Nooksack River Summer-Run;
- One DIP from the Stillaguamish River (Deer Creek Summer-Run or Canyon Creek Summer-Run); and
- One DIP from the Snohomish River (Tolt River Summer-Run or North Fork Skykomish River Summer-Run).

As described, these priority populations in the North Cascades MPG include specific, winter or winter/summer-run populations from the Nooksack, Stillaguamish, Skagit or Sauk, and Snohomish River basins and three summer-run populations from the Nooksack, Stillaguamish, and Snohomish basins. These populations are targeted to achieve viable status to support MPG viability. Having viable populations in these basins assures geographic spread, provides habitat diversity, reduces catastrophic risk, and increases life-history diversity (NMFS 2019h).

For the **Central and South Puget Sound MPG** four of the eight DIPs in the Central and South Puget Sound MPG must be viable. The four DIPs described below must be viable to meet this criterion:

- Green River Winter-Run;
- Nisqually River Winter-Run;
- Puyallup/Carbon rivers Winter-Run, or the White River Winter-Run; and
- At least one additional DIP from this MPG: Cedar River, North Lake Washington/Sammamish Tributaries, South Puget Sound Tributaries, or East Kitsap Peninsula Tributaries.

The rationale for this prioritization is that steelhead inhabiting the Green, Puyallup and Nisqually River watersheds currently represent the core extant steelhead populations and these watersheds contain important diversity of stream habitats in the MPG.

For the **Hood Canal and Strait of Juan de Fuca MPG** four of the eight DIPs in the Hood Canal and Strait of Juan de Fuca MPG must be viable. The four DIPs described below must be viable to meet this criterion:

- Elwha River Winter/Summer-Run (see rationale below);
- Skokomish River Winter-Run;
- One from the remaining Hood Canal populations: West Hood Canal Tributaries Winter-Run, East Hood Canal Tributaries Winter-Run, or South Hood Canal Tributaries Winter-Run; and
- One from the remaining Strait of Juan de Fuca populations: Dungeness Winter-Run, Strait of Juan de Fuca Tributaries Winter-Run, or Sequim/Discovery Bay Tributaries Winter-Run.

The rationale for this prioritization is that the Elwha and Skokomish rivers are the two largest single watersheds in the MPG and bracket the geographic extent of the MPG. Furthermore, both Elwha and Skokomish populations have recently exhibited summer-run life histories, although the Dungeness River population was the only summer/winter run in this MPG recognized by the PSTRT in Hard et al. (2015). Two additional populations — one population from the Strait of Juan de Fuca area and one population from the Hood Canal area — are needed for a viable MPG to maximize geographic spread and habitat diversity.

Lastly, the Plan (NMFS 2019h) also identified additional attributes, or characteristics which should be associated with a viable MPG.

- All major diversity and spatial structure conditions are represented, based on the following considerations:
- Populations are distributed geographically throughout each MPG to reduce risk of catastrophic extirpation; and
- Diverse habitat types are present within each MPG (one example is lower elevation/gradient watersheds characterized by a rain-dominated hydrograph and higher elevation/gradient watersheds characterized by a snow-influenced hydrograph).

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 Plan (NMFS 2019h).

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).

When NMFS initiated an ESA review for Puget Sound steelhead, a Biological Review Team (BRT) was formed to review the available information and assess the extinction risk of the DPS. The 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.[11] 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).

[11] 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).

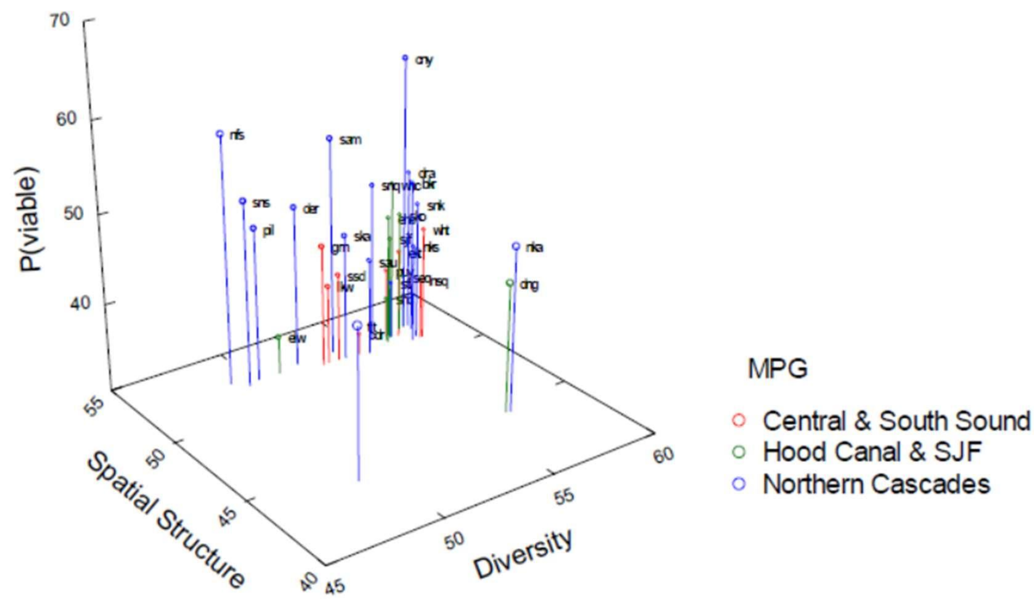

Figure 3. Scatter plot of the probabilities of viability for each of the 32 steelhead populations in the Puget Sound DPS as a function of VSP parameter estimates of influence of diversity and spatial structure on viability (Puget Sound Steelhead Technical Recovery Team 2011).

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). 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 5) (NWFSC 2015).

Table 5. 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 annual natural-origin spawner proportion estimates divided by the number of annual 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.[12] 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).

Abundance and Productivity

As stated previously, the 2007 BRT considered the major risk factors associated with abundance

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

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,[13] 6 of the 8 winter-run DIPs in the Central and South Puget Sound MPG,[14] and 8 of the 8 winter-run DIPs in the Hood Canal and Strait of Juan de Fuca MPG.[15] 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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[13] 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.

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

[15] 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.

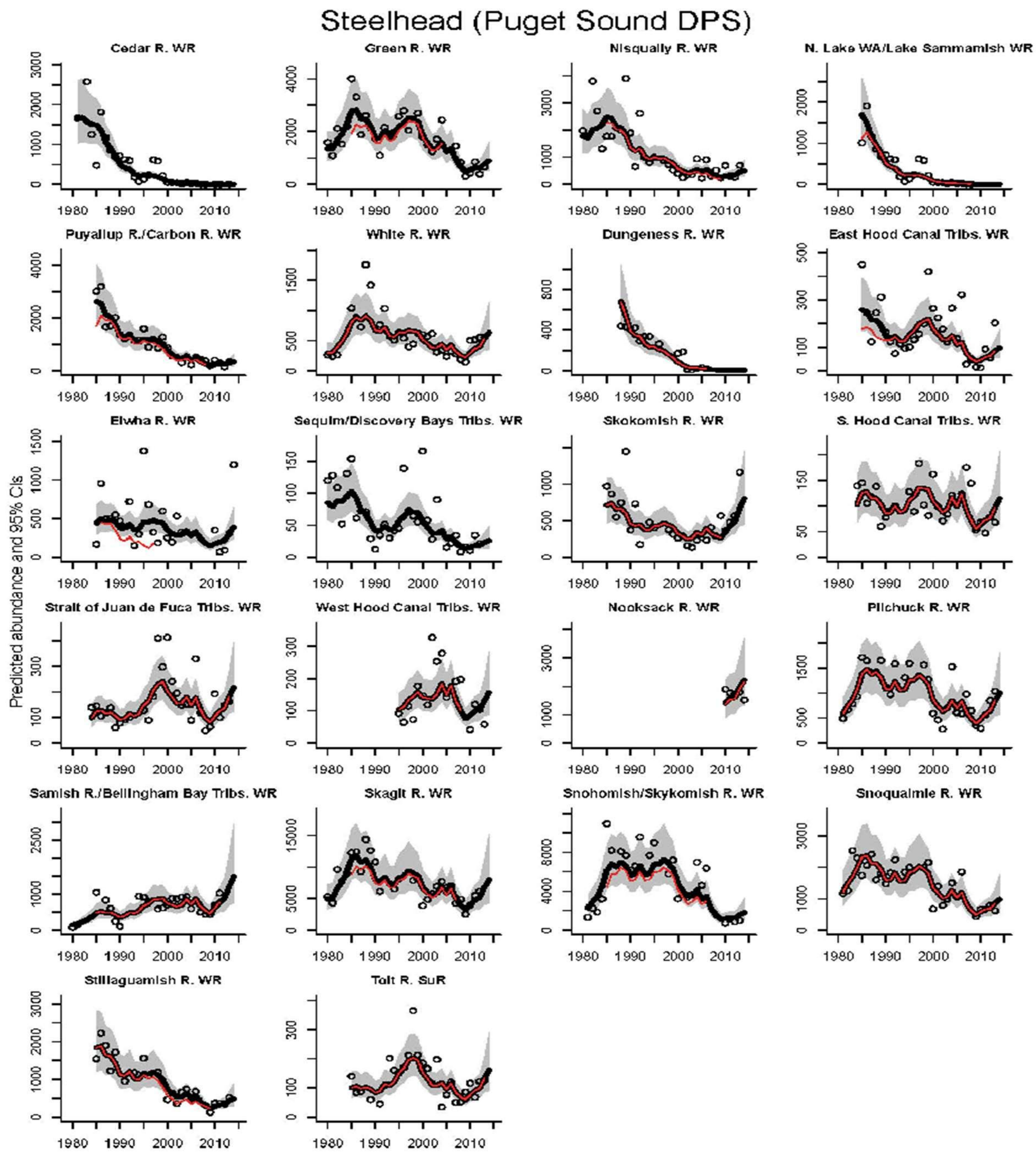

Figure 4. Trends in estimated total (black line) and natural (red line) population spawning abundance of Puget Sound steelhead. The circles represent annual raw spawning abundance data and the gray bands represent the 95% confidence intervals around the estimates (NWFSC 2015).

Since 2009, nine of the 22 populations indicate small to modest increases in abundance.[16] 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 6).

Table 6. 5-year geometric mean of raw natural spawner counts for Puget Sound steelhead (total spawner H and W counts). A value only in parentheses means that a total spawner count was available but no, or only one estimate (within the 5-year (yr) period) of natural-origin spawners was available. Values not in parentheses, where available, represent the 5-year geometric mean of natural-origin spawners for each period. 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/	Winter	Dungeness River	356 (356)	--	182 (186)	--	(141)	--

[16] 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
Strait of Juan de Fuca (SJF)		East Hood Canal Tribs.	110 (110)	176 (176)	202 (202)	62 (62)	60 (60)	-3 (-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)

The Recovery Plan (NMFS 2019h) provided updated current abundance by MPG and population, as a five-year average terminal run size (escapement + harvest) for return years 2012 – 2016 (Table 7 and Table 8).

Table 7. Current abundance and recovery goals for Puget Sound steelhead in the North Cascades MPG based on recruits/spawner (R/S) in years of high productivity and low productivity. Current abundance is the five-year average terminal run size (escapement + harvest) for return years 2012 – 2016, unless otherwise noted or not available (n/a). We suspect that our methods overestimated the historical steelhead abundance of populations composed of many small independent streams relative to those in larger rivers (NMFS 2019h).

North Cascades MPG Populations		Recovery Goals Abundance under Beverton-Holt	
Population	**Current Abundance**	**High productivity (R/S=2.3)**	**Low productivity (R/S=1.0)**
Drayton Harbor Tributaries	35[A]	1,100	3,700
Nooksack River	1,850	6,500	21,700
South Fork Nooksack River (summer-run)	n/a	400	1,300
Samish River + independent tributaries	1,090	1,800	6,100
Skagit River			
Sauk River	8,278[B]	15,000[D]	
Nookachamps Creek			
Baker River	n/a	1,100	3,800
Stillaguamish River	493[C]	7,000	23,400
Canyon Creek (summer-run)	n/a	100	400
Deer Creek (summer-run)	n/a	700	2,300
Snohomish/Skykomish River	1,066	6,100	20,600
Pilchuck River	878	2,500	8,200
Snoqualmie River	836	3,400	11,400
Tolt River (summer-run)	89	300	1,200
North Fork Skykomish River (summer-run)	n/a	200	500

[A] Restricted to Dakota Creek, return years 2014-2016.
[B] Combined abundance estimates for Skagit River, Sauk River, and Nookachamps Creek populations.
[C] Index of escapement for North Fork Stillaguamish River and tributaries upstream of Deer Creek, does not include entire watershed or population.
[D] Interim target for the Skagit River of an average total run abundance of 15,000 and with an intrinsic productivity at least equal to what was observed from 1978 through 2017.

Table 8. Current abundance and recovery goals for Puget Sound steelhead in the Central and South Sound and Hood Canal and Strait of Juan de Fuca MPGs based on R/S in years of high productivity and low productivity. Current abundance is the five-year average terminal run size (escapement + harvest) for return years 2012 – 2016, unless otherwise noted or not available (n/a). We suspect that our methods overestimated the historical steelhead abundance of populations composed of many small independent streams relative to those in larger rivers (NMFS 2019h).

Population	Current Abundance	Recovery Goals Abundance under Beverton-Holt	
		High productivity (R/S=2.3)	Low productivity (R/S=1.0)
Central and South Sound MPG Populations			
Cedar River	5	1,200	4,000
North Lake WA Tributaries	n/a	4,800	16,000
Green River	1,166	5,600	18,700
Puyallup/Carbon	740	4,500	15,100
White River	635	3,600	12,000
Nisqually River	951	6,100	20,500
East Kitsap tributaries	n/a	2,600	8,700
South Sound Tributaries	n/a	6,300	21,200
Strait of Juan de Fuca MPG Populations			
Elwha River	1168[A]	2,619[B]	
Dungeness River	626[C]	1,200	4,100
Strait Juan de Fuca Independent Tributaries	216[D]	1,000	3,300
Sequim and Discovery Bay Tributaries	27	500	1,700
Skokomish River	921	2,200	7,300
West Hood Canal tributaries	109	2,500	8,400
East Hood Canal tributaries	89	1,800	6,200
South Hood Canal tributaries	61	2,100	7,100

[A] Restricted to return years 2014-2017 and includes both natural-origin and hatchery-origin fish.
[B] Peters et al. (2014) identified 2,619 adult steelhead as the goal to reach the Viable Population Phase, the last four sequential recovery phases following removal of two dams on the Elwha River. In contrast to other recovery goals presented here, the Elwha River goal is not in the context of a stock-recruit productivity curve.
[C] Restricted to return years 2013-2015 and 2017.
[D] Estimate restricted to return years 2015 and 2016 within Morse Creek plus McDonald Creek, two of several streams in this population.

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 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.

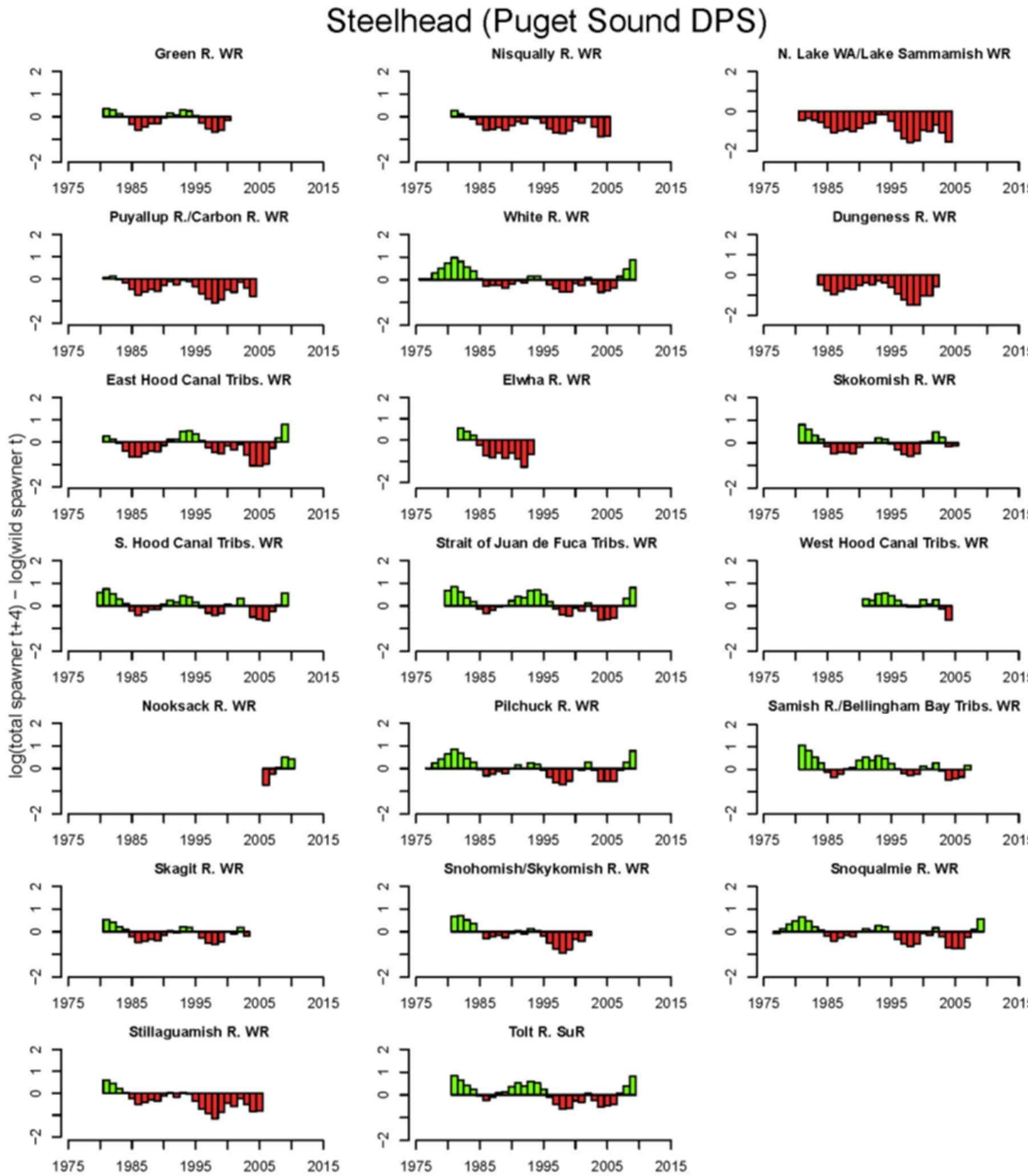

Figure 5. Trends in population productivity of Puget Sound steelhead (NWFSC 2015).

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[17] 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).

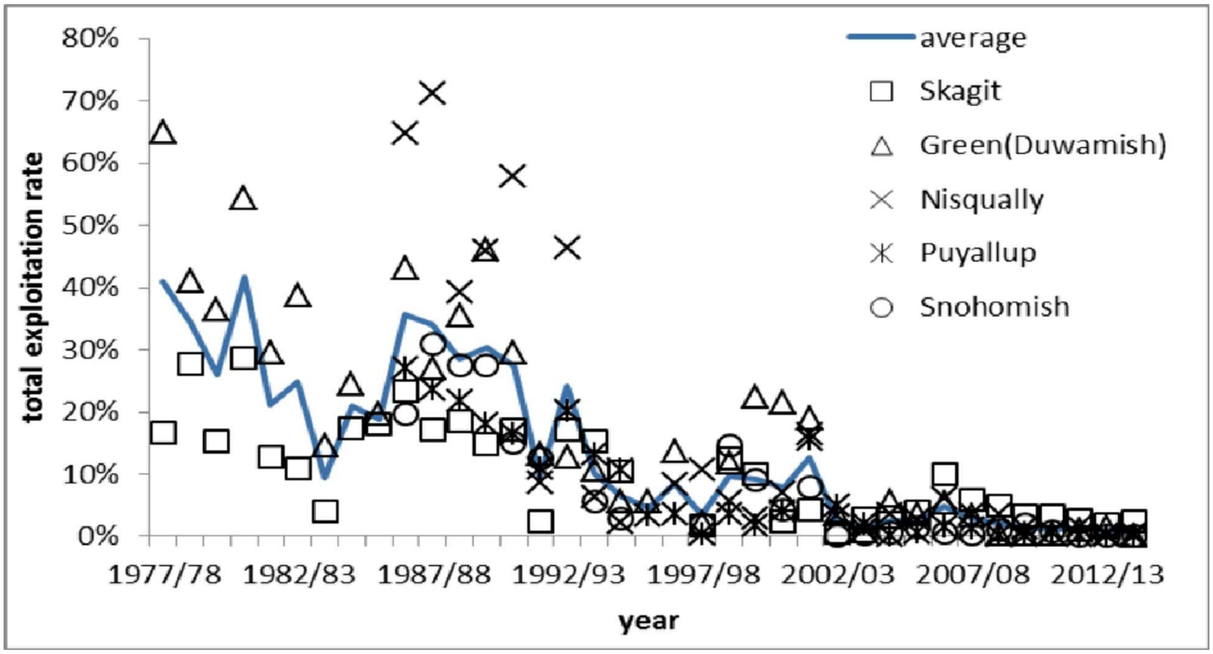

Figure 6. Total harvest rates on natural steelhead in Puget Sound Rivers (WDFW (2010) in NWFSC (2015).

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

[17] Green River and Nisqually River populations.

abundance for most Puget Sound steelhead populations (NWFSC 2015; NMFS 2019h).

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) and NMFS (2019h) 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 considered 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 2017f) 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 kilometers(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).

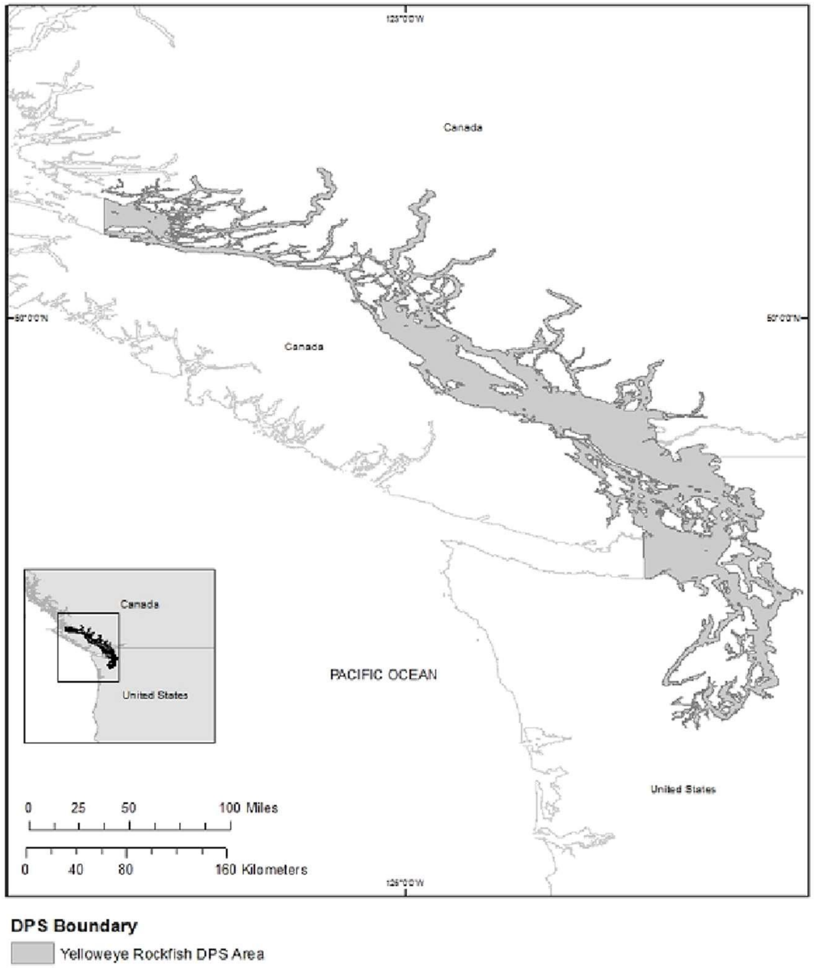

Figure 7. Yelloweye rockfish DPS area.

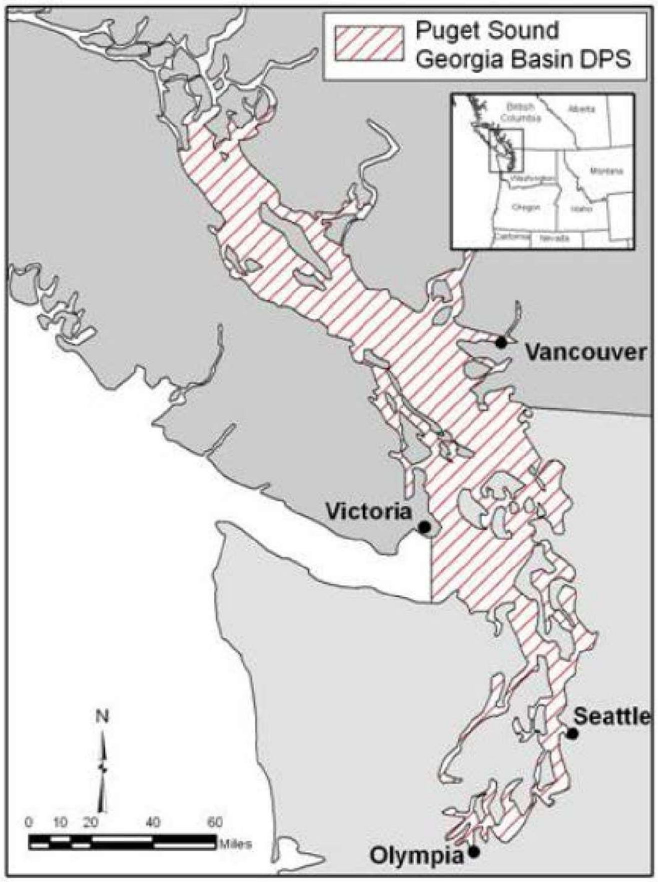

Figure 8. Bocaccio DPS area.

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[18].

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

[18] 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 from the population 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 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[19]. 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

[19] 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 2017f).

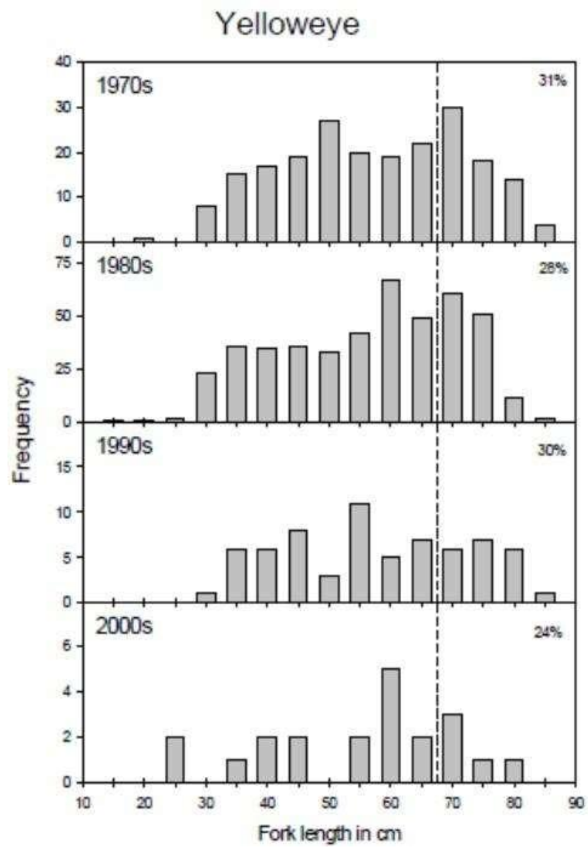

Figure 9. Yelloweye rockfish length frequency distributions (cm) binned within four decades.

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).

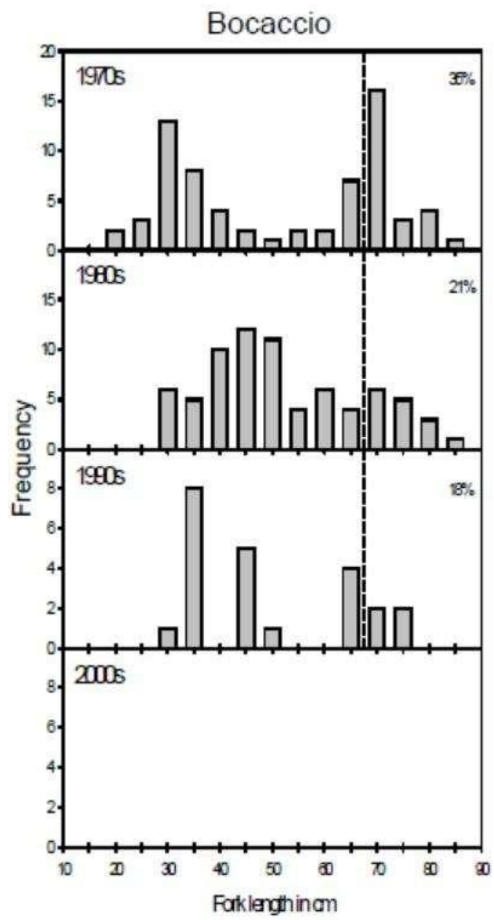

Figure 10. Bocaccio length frequency distributions (cm) within four decades. The vertical line depicts the size at which about 30 percent of the population comprised fish larger than the rest of the population in the 1970s, as a reference point for a later decade.

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).

Commercial and Recreational Bycatch

Listed rockfish are caught in some recreational and commercial fisheries in Puget Sound. Recreational fishermen targeting bottom fish in 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 9) 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 9. 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 2018e).

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 Resident killer whales (SRKWs) should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016j). NMFS considers SRKWs to be currently among eight of the most at-risk species as part of the Species in the Spotlight initiative[20] because of their endangered status, declining population trend, and they are high priority for recovery based on conflict with human activities and recovery programs in place to address threats. The population has relatively high mortality and low reproduction unlike other resident killer whale populations that have generally been increasing since the 1970s (Carretta et al. 2019a).

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 2008g). This section summarizes the status of SRKW throughout their range and summarizes information taken largely from the recovery plan (NMFS 2008g), most recent 5-year review (NMFS 2016j), the PFMC SRKW Ad Hoc Workgroup's report (PFMC 2020), as well as new data that became available more recently.

Abundance, Productivity, and Trends

Killer whales – including SRKWs - are a long-lived species and sexual maturity can occur at age 10 (review in NMFS (2008g)). Females produce a low number of surviving calves (n < 10, but generally fewer) over the course of their reproductive life span (Bain 1990; Olesiuk et al. 1990). Compared to Northern Resident killer whales (NRKWs), which are 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), and all age classes of SRKWs have reduced survival compared to other fish-eating populations of killer whales in the Northeast Pacific (Ward et al. 2013).

Since the early 1970s, annual summer censuses in the Salish Sea using photo-identification techniques have occurred (Bigg et al. 1990; Center for Whale Research annual photographic identification catalog, 2019). The population of SRKW was at its lowest known abundance in the early 1970s following live-captures for aquaria display (n = 68). The highest recorded abundance since the 1970s was in 1995 (98 animals), though the population declined from 1995-2001 (from 98 whales in 1995 to 81 whales in 2001). The population experienced growth between 2001 and 2006 and has been generally declining since then. However, in 2014 and 2015, the SRKW population increased from 78 to 81 as a result of multiple successful pregnancies (n = 9) that occurred in 2013 and 2014. At present, the Southern Resident population has declined to near historically low levels (Figure 11). As of May 2020, the population is 72 whales (one whale is missing and presumed dead since the 2019 summer census). The previously published historical estimated abundance of Southern Resident killer whales is 140 animals (NMFS 2008g). This estimate (~140) was generated as the number of whales killed or removed for public display in the 1960s and 1970s (summed over all years) added to the remaining population at the time the captures ended.

[20] https://www.fisheries.noaa.gov/resource/document/species-spotlight-priority-actions-2016-2020-southern-resident-killer-whale

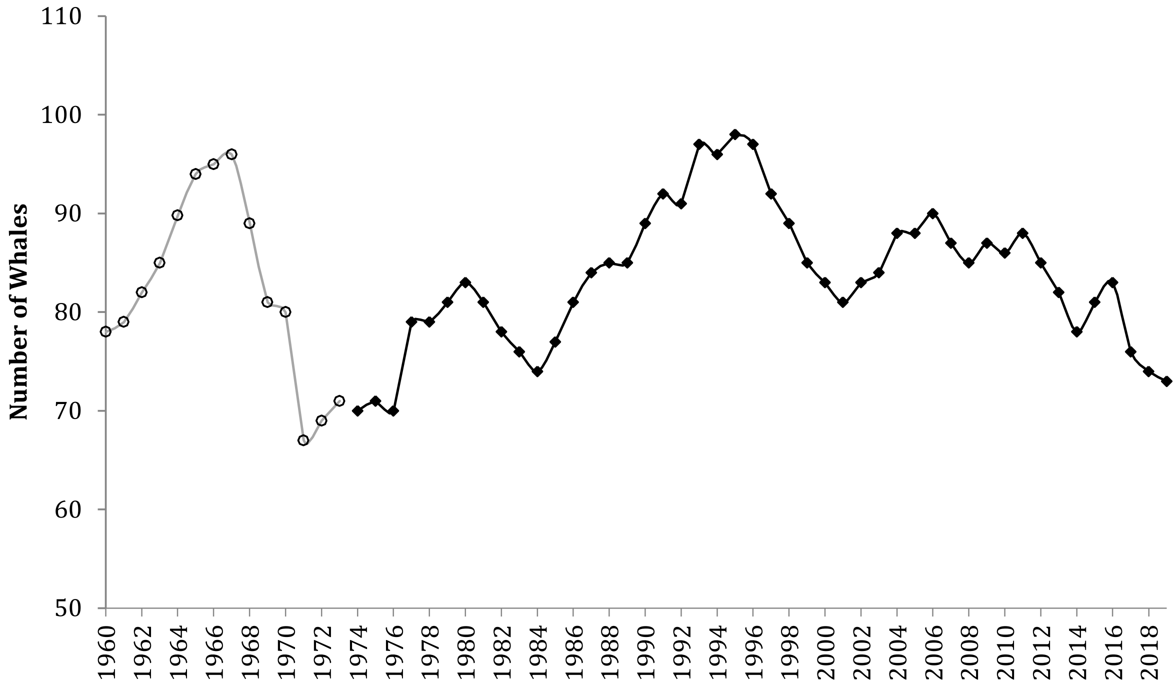

Figure 11. Population size and trend of Southern Resident killer whales, 1960-2019. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk et al. (1990). Data from 1974-2019 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) in this community and were provided by the Center for Whale Research (unpublished data) and NMFS (2008g). Data for these years represent the number of whales present at the end of each calendar year.

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). However, the consequence of this means inbreeding may be common amongst this small population, with a recent study by Ford et al. (2018) finding several offspring resulting from matings between parents and their own offspring. The fitness effects of this inbreeding remain unclear and are an effort of ongoing research (Ford et al. 2018).

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 and strandings data. Olesiuk et al. (2005) identified high neonate mortality that occurred outside of the summer season, and multiple new calves have been documented in winter months that have not survived the following summer season (CWR unpublished data). Stranding rates are higher in winter and spring for all killer whale forms in

Washington and Oregon (Norman et al. 2004).

The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the population viability analyses conducted for the 2004 Status Review for Southern Resident Killer Whales and the 2011 science panel review of the effects of salmon fisheries (Krahn et al. 2004a; Hilborn et al. 2012; Ward et al. 2013). According to the updated analysis, the model now suggests a downward trend in population size 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. The downward trend is in part due to the changing age and sex structure of the population. If the population experiences demographic rates (e.g. fecundity and mortality) that are more similar to 2016 than the recent 5-year average (2011-2016), the population will decline faster as shown in Figure 12 (NMFS (2016j).

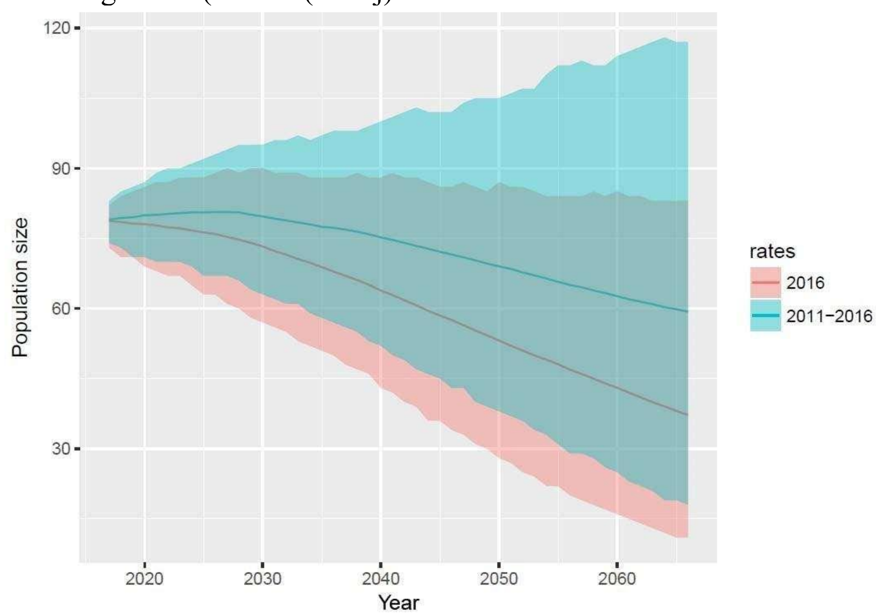

Figure 12. Southern Resident killer whale population size projections from 2016 to 2066 using 2 scenarios: (1) projections using demographic rates held at 2016 levels, and (2) projections using demographic rates from 2011 to 2016. The pink line represents the projection assuming future rates are similar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

Because of this population's small abundance, it is also susceptible to increased risks of demographic stochasticity – randomness in the pattern of births and deaths among individuals in a population. Several sources of demographic variance (e.g. differences between individuals or within individuals) can affect small populations and contribute to variance in a population's growth and increased extinction risk. Sources of demographic variance can include environmental stochasticity, or fluctuations in the environment that drive changes 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.

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, from 2010 through July 2019, only 15 of the 28 reproductive aged females successfully reproduced, resulting in 16 calves. There were an additional 10 documented non-viable calves, and likely more undocumented, born during this period (CWR unpubl. data). A recent study indicated pregnancy hormones (progesterone and testosterone) can be detected in SRKW feces and have indicated several miscarriages, particularly in late pregnancy (Wasser et al. 2017). The fecal hormone data have shown that up to 69 percent of the detected pregnancies do not produce a documented calf (Wasser et al. 2017). Recent aerial imagery corroborates this high rate of loss (Fearnbach and Durban unpubl. data). The congruence between the rate of loss estimates from fecal hormones and aerial photogrammetry suggests the majority of the loss is in the latter half of pregnancy when photogrammetry can detect anomalous shape after several months of gestation (Durban et al. 2016)

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 2008g; Hanson et al. 2013; Carretta et al. 2017b; Ford et al. 2017) (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 typically 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). During fall and early winter, SRWKs, and J pod in particular, expand their routine movements into Puget Sound, particularly J pod, likely to take advantage of chum, coho, and Chinook salmon runs (Osborne 1999; Hanson et al. 2010; Ford et al. 2016). Although seasonal movements are somewhat 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).

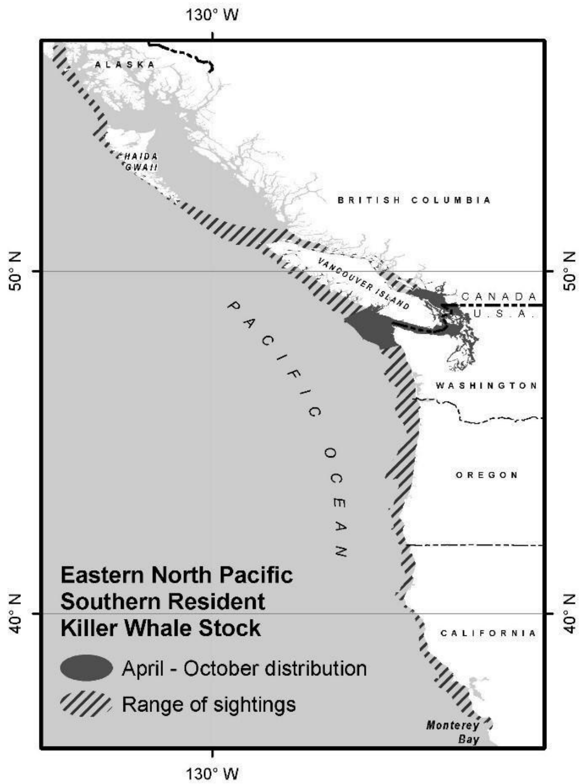

Figure 13. Geographic range of Southern Resident killer whales (reprinted from Carretta et al. (2017a)).

Land- and vessel-based opportunistic and survey-based visual sightings, satellite tracking, and passive acoustic research conducted have provided an updated estimate of the whales' coastal range that extends from the Monterey Bay area in California, north to Chatham Strait in southeast Alaska. Since 1975, confirmed and unconfirmed opportunistic SRKW sightings from the general public or researchers have been collected off British Columbia, Washington, Oregon, and California. Because of the limitations of not having controlled and dedicated sampling efforts, these confirmed opportunistic sightings have provided only general information on the whales' potential geographic range during this period of time (*i.e.,* there are no data to describe the whales' general geographic range prior to 1975). Together, these SRKW sightings have confirmed their presence as far north as Chatham Strait, southeast Alaska and as far south as Monterey Bay, California (NMFS 2019i).

As part of a collaborative effort between NWFSC, Cascadia Research Collective and the University of Alaska, satellite-linked tags were deployed on eight male SRKW (three tags on J pod members, two on K pod, and three on L pod) from 2012 to 2016 in Puget Sound or in the coastal waters of Washington and Oregon (Table 10). The tags transmitted multiple locations per day to assess winter movements and occurrences of SRKW (Hanson et al. 2017).

Over the course of the study, the satellite tagging resulted in a data range of duration days, from 3 days to 96 days depending on the tag, of monitoring with deployment durations from late December to mid-May (Table 10). The winter locations of the tagged whales included inland and coastal waters. The inland waters range occurs across the entire Salish Sea, from the northern end of the Strait of Georgia and Puget Sound, and coastal waters from central west coast of Vancouver Island, British Columbia to northern California (Hanson et al. 2017). J pod had high use areas (defined as 1 to 3 standard deviations) in the northern Strait of Georgia and the west entrance to the Strait of Juan de Fuca where they spent approximately 30 percent of their time there (Figure 14). K/L pods occurred almost exclusively on the continental shelf during December to mid-May, primarily on the Washington coast, with a continuous high use area between Grays Harbor and the Columbia River and off Westport and spending approximately 53 percent of their time there (Figure 15) (Hanson et al. 2017; Hanson et al. 2018). The tagging data provide general information on the home range and overlap of each pod from 2012 to 2016.

Satellite tagging can also provide details on preferred depths and distances from shore. Approximately 95 percent of the SRKW locations were within 34 km of the shore and 50 percent of these were within 10 km of the coast (Hanson et al. 2017). Only 5 percent of locations were greater than 34 km away from the coast, but no locations exceeded 75 km. Most locations were in waters less than 100m in depth.

Table 10. Satellite-linked tags deployed on Southern resident killer whales 2012-2016. (Hanson et al. 2018). This was part of a collaborative effort between NWFSC, Cascadia Research Collective, and the University of Alaska.

Whale ID	Pod association	Date of tagging	Duration of signal contact (days)
J26	J	20 Feb. 2012	3
L87	J	26 Dec. 2013	31
J27	J	28 Dec. 2014	49
K25	K	29 Dec. 2012	96
L88	L	8 Mar. 2013	8
L84	L	17 Feb. 2015	93
K33	K	31 Dec. 2015	48
L95	L	23 Feb. 2016	3

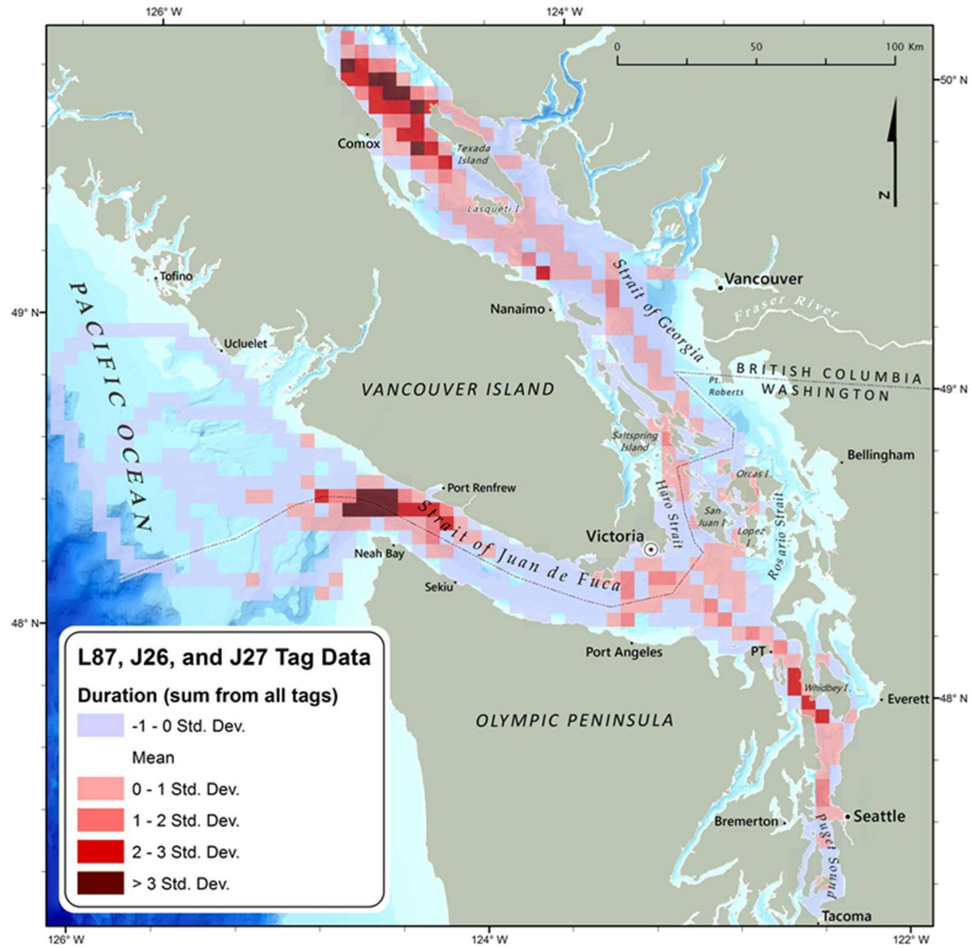

Figure 14. Duration of occurrence model output for J pod tag deployments (Hanson et al. 2017). "High use areas" are illustrated by the 0 to > 3 standard deviation pixels.

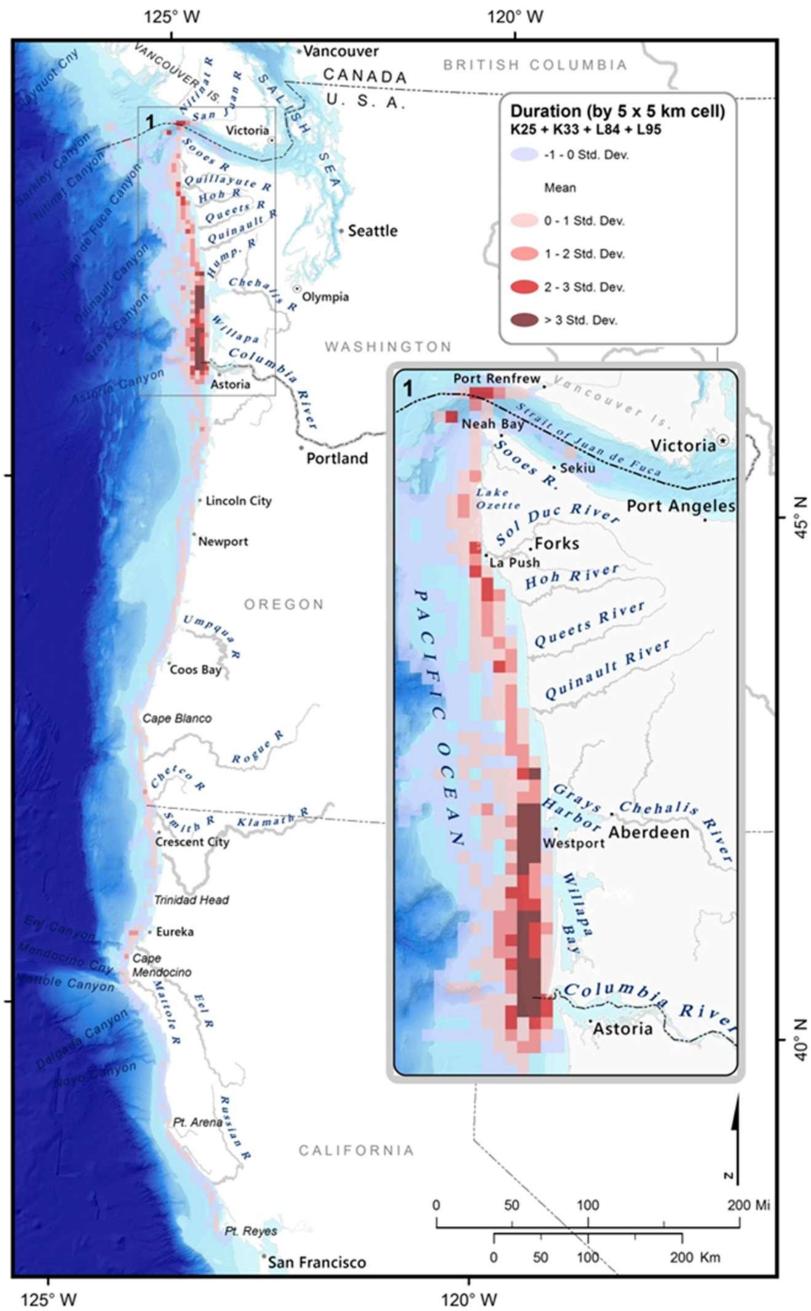

Figure 15. Duration of occurrence model for all unique K and L pod tag deployments (Hanson et al. 2017). “High use areas” are illustrated by the 0 to > 3 standard deviation pixels.

Passive acoustic recorders were deployed off the coasts of California, Oregon and Washington in most years since 2006 to assess their seasonal uses of these areas via the recording of stereotypic calls of the SRKW (Hanson et al. 2013; Emmons et al. 2019). Passive aquatic listeners (PALs) were originally deployed from 2006 – 2008. Since 2008, four to seventeen Ecological Acoustic Recorders (EARs) have been deployed. From 2006 – 2011, passive acoustic listeners and recorders were deployed in areas thought to be of frequent use by SRKWs based on previous sightings, where enhanced productivity was expected to be concentrated, and in areas with a reduced likelihood of fisheries interactions (Figure 16)(Hanson et al. 2013). The number of recorder sites off the Washington coast increased from 7 to 17 in the fall of 2014 and locations were selected based on "high use areas" identified in the duration of an occurrence model (Figure 17), and sites within the U.S. Navy's Northwest Training Range Complex (NWTRC) in order to determine if SRKWs used these areas in other seasons when satellite-linked tags were not deployed (Hanson et al. 2017; Emmons et al. 2019). "High use areas" for the SRKW in winter were determined to be primarily located in three areas 1) the Washington coast, particularly between Grays Harbor and the mouth of the Columbia River (primarily for K/L pods); 2) the west entrance to the Strait of Juan de Fuca (primarily for J pod); and 3) the northern Strait of Georgia (primarily for J pod). It is important to note that recorders deployed within the NWTRC were designed to assess spatial use off Washington coast and thus the effort was higher in this area (*i.e.* the number of recorders increased in this area) compared to off Oregon and California.

There were acoustic detections off Washington coast in all months of the year (Figure 18), with greater than 2.4 detections per month from January through June and a peak of 4.7 detections per month in both March and April, indicating that the SRKW may be present in Washington coastal waters at nearly any time of year, and in other coastal waters more often than previously believed (Hanson et al. 2017). Acoustic recorders were deployed off Newport, Fort Bragg, and Port Reyes between 2008 through 2013 and SRKW were detected 28 times (Emmons et al. 2019).

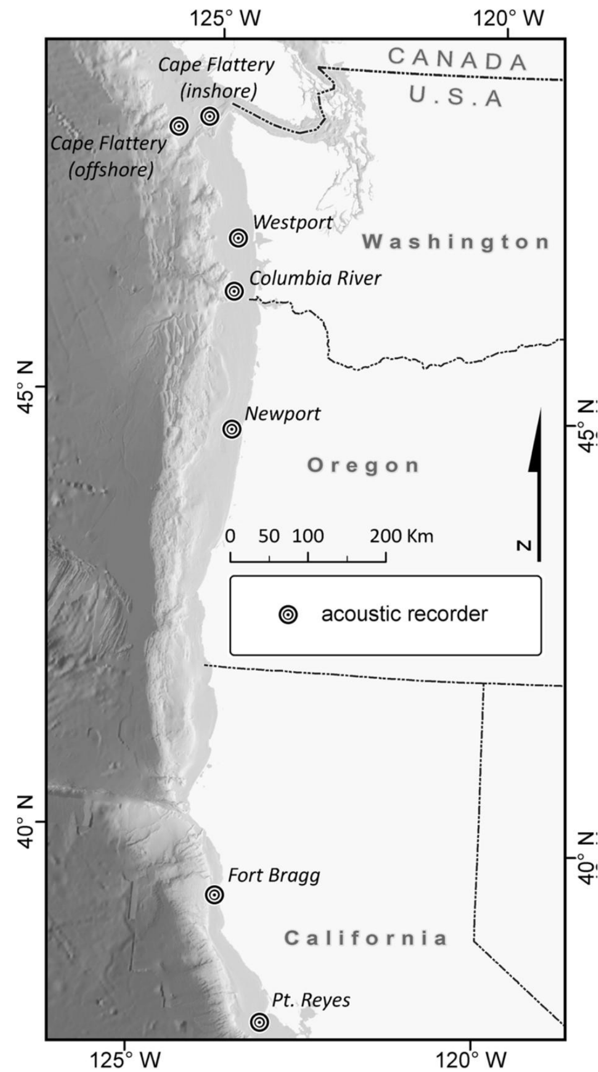

Figure 16. Deployment locations of acoustic recorders on the U.S. west coast from 2006 to 2011 (Hanson et al. 2013).

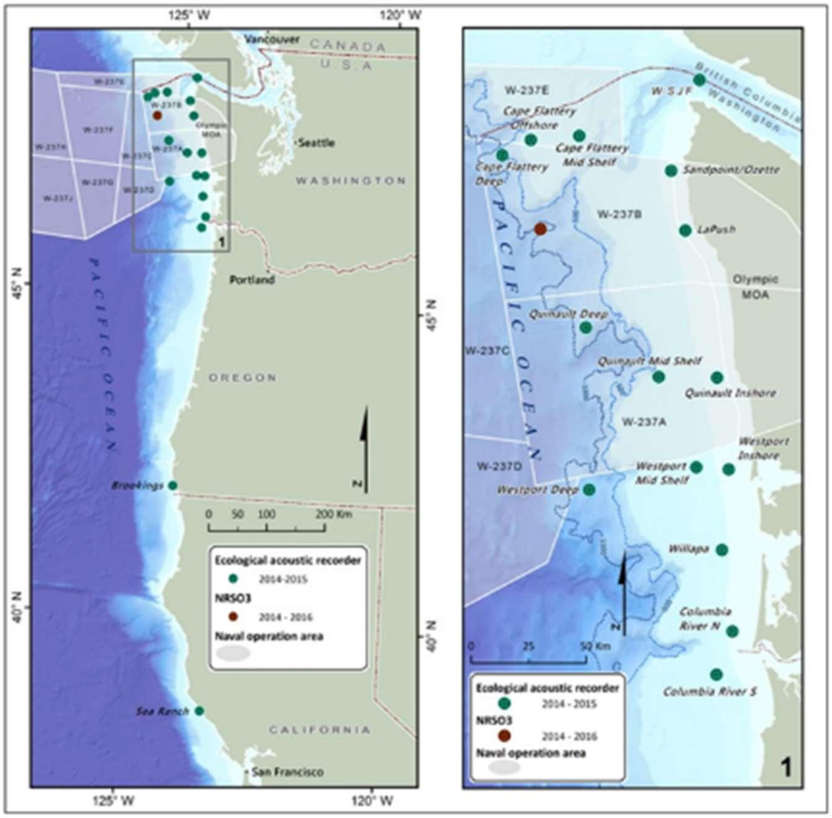

Figure 17. Locations of passive acoustic recorders deployed beginning in the fall of 2014 (Hanson et al. 2017).

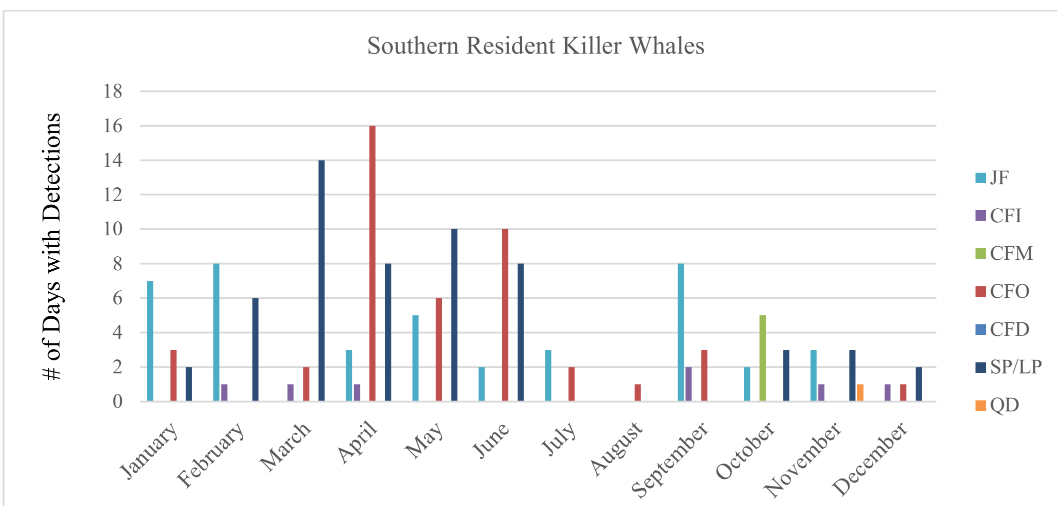

Figure 18. Counts of detections at each northern recorder site by month from 2014-2017 (Emmons et al. 2019). Areas include Juan de Fuca (JF); Cape Flattery Inshore (CFI); Cape Flattery Mid Shelf (CFM); Cape Flattery Offshelf (CFO); Cape Flattery Deep(CFD); Sand Point and La Push (SP/LP); and Quinault Deep (QD).

In a recent study, researchers collected data using an autonomous acoustic recorder deployed at Swiftsure Bank from August 2009 to July 2011 to assess how this area is used by Northern Resident and Southern Resident killer whales as shown in Figure 19 (Riera et al. 2019). SRKW were detected on 163 days with 175 encounters (see Figure 20 for number of days of acoustic detections each month). All three pods were detected at least once per month except for J pod in January and November and L pod in March. K and L pods were heard more often (87 percent of calls and 89 percent of calls, respectively), between May and September. J pod was heard most often during winter and spring (76 percent of calls during December and February through May; Riera et al. 2019). K pod had the longest encounters in June, with 87 percent of encounters longer than 2 hours occurring between June and September. L pod had the longest encounters in May, with 79 percent of encounters longer than two hours occurring during the summer (May through September). The longest J pod encounters were during winter, with 72 percent of encounters longer than 2 hours occurring between December and May (Riera et al. 2019).

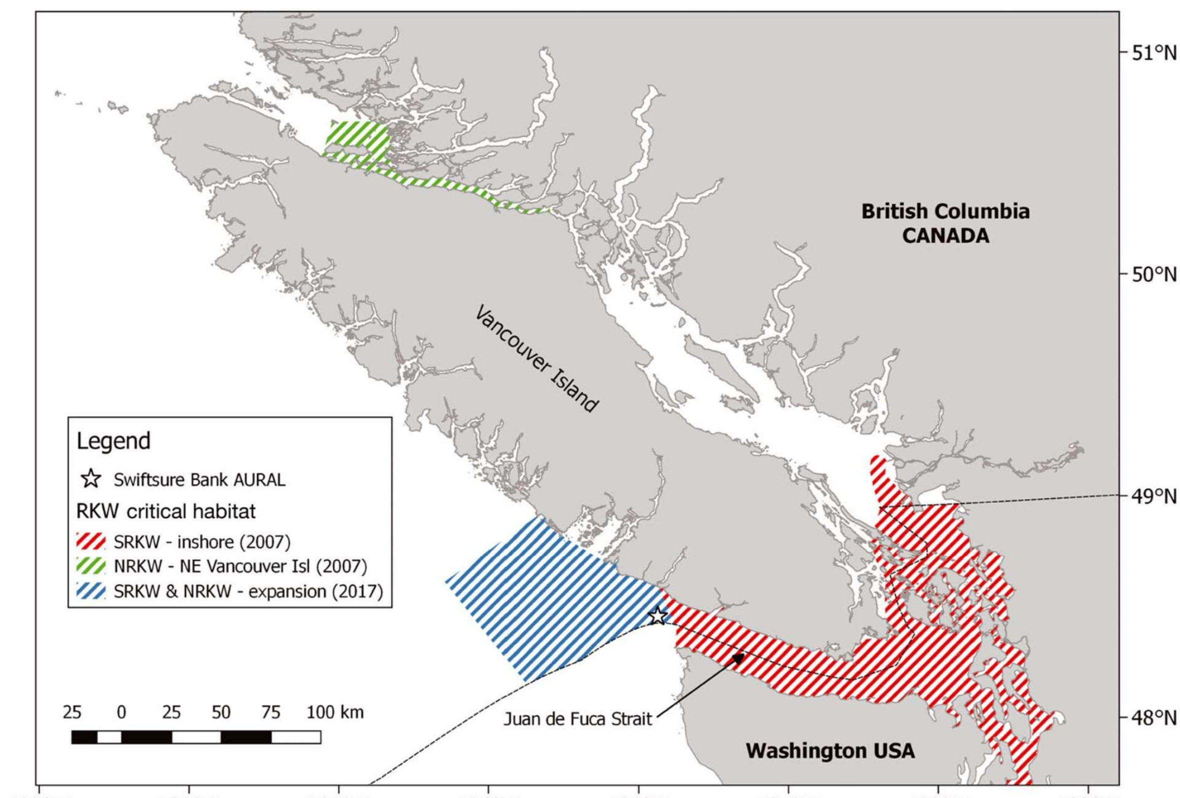

Figure 19. Swiftsure Bank study site off the coast of British Columbia, Canada in relation to the 2007 Northern Resident critical habitat (NE Vancouver Island) and 2007 Southern Resident killer whale critical habitat (inshore waters) and the 2017 Northern Resident and Southern Resident expansion of critical habitat (Riera et al. 2019).

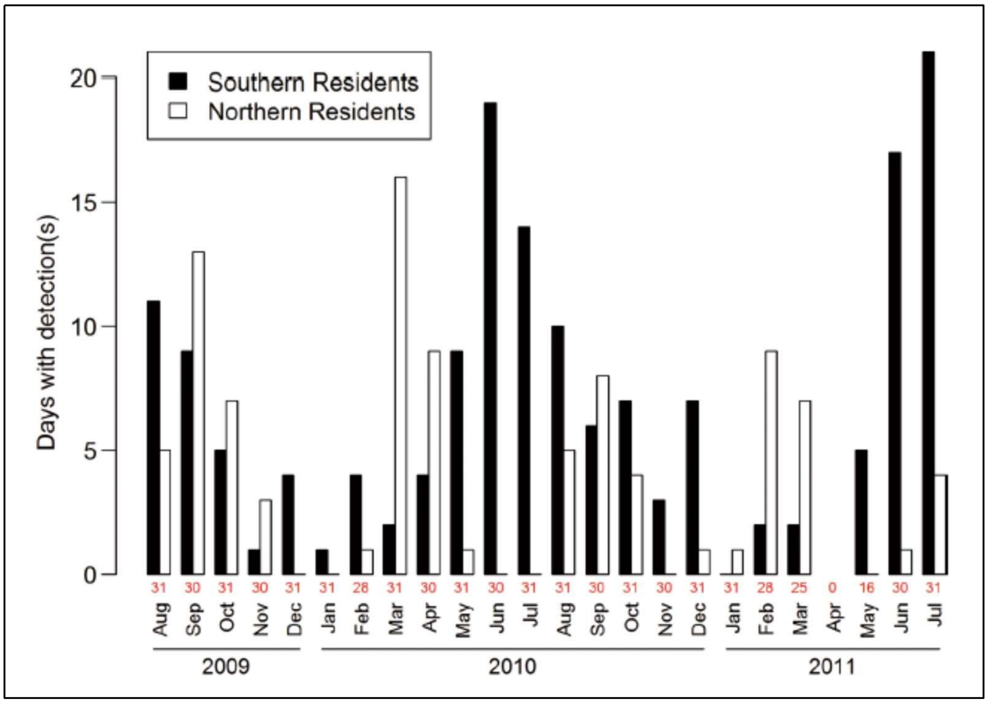

Figure 20. Number of days with acoustic detections of SRKWs at Swiftsure Bank from August 2009 – July 2011. Red numbers indicate days of effort (Riera et al. 2019).

Limiting Factors and Threats

Several factors identified in the final recovery plan for Southern Residents may be limiting recovery. The recovery plan identified three major threats including (1) quantity and quality of prey, (2) toxic chemicals that accumulate in top predators, and (3) impacts from sound and vessels. Oil spills and disease as well as the small population size are also risk factors. 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 (e.g. Lacy et al. 2017) and available data suggests that all of the threats are potential limiting factors (NMFS 2008g).

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, the majority of which has occurred in inland waters of Washington State and British Columbia, Canada during summer months and includes direct observation, scale and tissue sampling of prey remains, and fecal sampling. The diet data suggest that SRKWs are consuming mostly larger (i.e., generally age 3 and up) Chinook salmon. Chinook salmon is their primary prey despite the much lower abundance in comparison to other salmonids in some areas and during certain time periods. 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). The degree to which killer whales are able to or willing to switch to non-preferred prey sources (i.e., prey other than Chinook salmon) is also largely unknown, and likely variable depending on the time and location.

Over the last forty years, predation on Chinook salmon off the West Coast of North America by marine mammals has been estimated to have more than doubled (Chasco et al. 2017). In particular, southern Chinook salmon stocks ranging south from the Columbia River have been subject to the largest increases in predation, and Chasco et al. (2017) suggested 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 and this competition may be limiting the growth of the Southern Resident population.

May – September

Scale and tissue sampling from May to September in inland waters of Washington and British Columbia, Canada indicate that the SRKW's 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 from 2006 – 2010 indicate that when Southern Residents are in inland waters from May to September, they primarily consume Chinook stocks that originate from the Fraser River (80 – 90 percent of the diet in the Strait of Juan de Fuca and San Juan Islands; including Upper Fraser, Mid Fraser, Lower Fraser, North Thompson, South Thompson and Lower Thompson), and to a lesser extent consume stocks from Puget Sound (North and South Puget Sound), the Central British Columbia Coast and West and East Vancouver Island. This is not unexpected as all of these stocks are returning to streams proximal to these inland waters during this timeframe. Few diet samples have been collected in summer months outside of the Salish Sea.

DNA quantification methods are also 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 Southern Residents in the early to mid-summer months (May – August) using DNA sequencing from whale feces collected in inland waters of Washington and British Columbia. 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 inland waters of Washington and British Columbia in spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40% of the diet in September in inland waters, 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) in inland waters.

October – December

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). Diet data for the Strait of Georgia and coastal waters is limited.

January – April

Observations of SRKWs 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 and spring months. Although fewer predation events have been observed and fewer fecal samples collected in coastal waters, recent data indicate that salmon, and Chinook salmon in particular, remains an important dietary component when the SRKWs occur in outer coastal waters during these timeframes. Prior to 2013, only three prey samples for SRKW on the U.S. outer coast had been collected (Hanson et al. In Prep). From 2013 to 2016, satellite tags were used to locate and follow the whales to obtain predation and fecal samples. A total of 55 samples were collected from northern California to northern Washington (Figure 21). Results of the 55 available prey samples indicate that, as is the case in inland waters, Chinook are the primary species detected in diet samples on the outer coast, although steelhead, chum, lingcod, and halibut were also detected in samples. Despite J pod utilizing much of the Salish Sea – including the Strait of Georgia – in winter months (Hanson et al. 2018), few diet samples have been collected in this region in winter.

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 from California through Washington included 12 U.S. west coast stocks, and showed that over half the Chinook salmon consumed originated in the Columbia River (Hanson et al. in prep). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon collectively comprised over 90% of the 55 diet samples collected for SRKW's in coastal areas.

As noted, most of the Chinook prey samples opportunistically collected in coastal waters were determined to have originated from the Columbia River basin, including Lower Columbia Spring, Middle Columbia Tule, and Upper Columbia Summer/Fall. In general, we would expect to find these stocks given the diet sample locations (Figure 21) However, the Chinook stocks included fish from as far north as the Taku River (Alaska and British Columbia stocks) and as far south as the Central Valley California (Hanson et al. In Prep).

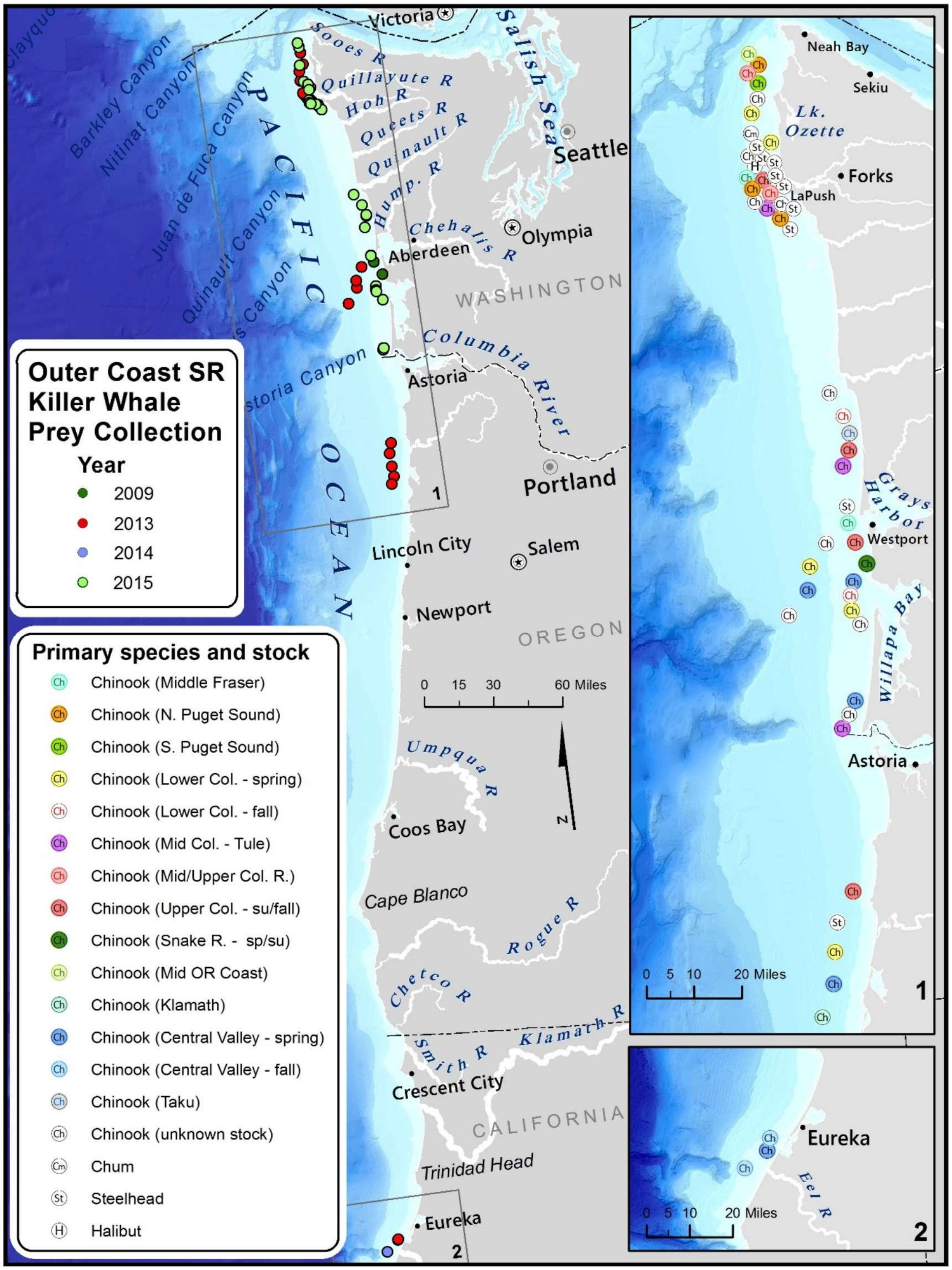

Figure 21. Location and species for scale/tissue samples collected from Southern Resident killer whale predation events in outer coastal waters (NMFS 2019i).

In an effort to prioritize recovery efforts such as habitat restoration and help inform efforts to use fish hatcheries to increase the whales' prey base, NMFS and WDFW developed a priority stock report identifying the Chinook salmon stocks along the West Coast (NOAA and WDFW 2018)[21]. The priority stock report was created by using observations of Chinook salmon stocks found in scat and prey scale/tissue samples, observations of the killer whale body condition through aerial photographs, and estimating the spatial and temporal overlap with Chinook salmon stocks ranging from 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 11 is a summary of those stock descriptions

[21]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 11. 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 South Puget Sound	Fall	Nooksack, Elwha, Dungeness, Skagit, Stillaguamish, Snohomish, Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal Systems
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 Fall and Spring	Sacramento, San Joaquin, Upper Klamath, and Trinity
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 (OR) Coast	Fall	Northern (Siuslaw, Nehalem, Siletz) and Central (Coos, Elk, Coquille, Umpqua)
15	West Vancouver Island	Fall	Robertson Creek, West Coast Vancouver Island (WCVI) Wild
16	Southern OR & Northern CA Coastal	Fall and Spring	Rogue, Chetco, Smith, Lower Klamath, Mad, Eel, Russian

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 2008g). The release of hatchery fish has not been identified as a threat to the survival or persistence of Southern Residents and there is no evidence to suggest the whales prefer wild salmon over hatchery salmon. Increased Chinook abundance, including hatchery fish, benefit this endangered population of whales by enhancing prey availability to SRKWs and hatchery fish often contribute significantly to the salmon stocks consumed (Hanson et al. 2010). Currently, hatchery fish play a mitigation role of helping sustain Chinook salmon numbers while other, longer term, recovery actions for natural fish are underway. 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.

Nutritional Limitation and Body Condition

When prey is scarce or in low density, SRKWs likely spend more time foraging than when prey is plentiful or in high density. 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 in 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 SWFSC (Southwest Fishery Science Center) have 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 of the previous year (at least in 2016 and 2017) (Trites and Rosen 2018). Other pods could not be reliably photographed in both seasonal periods.

Data collected from three SRKW strandings in recent years have also 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[22]. In fall 2016 another young adult male, J34, was found dead in the northern Georgia Strait (Carretta et al. 2019a). The necropsy indicated that the whale died of blunt force trauma to the head and the source of trauma is still under investigation.

Previous scientific review investigating nutritional stress as a cause of poor body condition for SRKWs concluded "Unless a large fraction of the population experienced poor condition in a particular year, and there was ancillary information suggesting a shortage of prey in that same year, malnutrition remains only one of several possible causes of poor condition" (Hilborn et al. 2012). Body condition in whales can be influenced by a number of factors, including prey availability, increased energy demands, disease, physiological or life history status, and may vary by season and across years. Body condition data collected to date has documented declines in condition for some animals in some pods and these occurrences have been scattered across demographic and social groups (Fearnbach et al. 2018).

It is possible that poor nutrition could contribute to mortality through a variety of mechanisms. To exhibit 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. Malnutrition and persistent or chronic stress can induce changes in immune function in mammals and may be associated with increased bacterial and viral infections (Neale et al. 2005; Mongillo et al. 2016; Maggini et al. 2018). 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).

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-

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

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, and reproduction. Relatively high levels of these pollutants have been measured in blubber biopsy samples from Southern Residents compared to other resident killer whales in the North Pacific (Ross et al. 2000; Krahn et al. 2007; Krahn et al. 2009; Lawson et al. 2020), 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).

Southern Resident 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 blubber and can later be released; when the pollutants are released, they are redistributed to other tissues when the whales metabolize the blubber, for example, responses to food shortages or reduced acquisition of food energy as possible stressor. 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

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 2008g). There is a growing body of evidence documenting effects from vessels on small cetaceans and other marine mammals (NMFS 2010d; 2016j; 2018f). 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 implementing these regulations, 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 December 2017, NMFS completed a technical memorandum evaluating the 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 some indicators suggested the regulations have benefited SRKWs by reducing impacts without causing economic harm to the commercial whale-watching industry or local communities, whereas some indicators suggested that vessel impacts continue and that some risks may have increased. 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.

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).

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.

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). Previous Polycyclic Aromatic Hydrocarbon (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. 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 (*Megaptera novaeangliae*) 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. 2018a; Muto et al. 2018b; Carretta et al. 2019b), report on estimated abundance and migratory destinations for North Pacific humpback whales (Wade et al. 2016; Wade 2017; Calambokidis and Barlow 2020), 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. Photo-identification matching is ongoing to assess which DPSs are present in inland waters and in what proportions. The majority of humpback whales observed in coastal waters of Washington and British Columbia are from the Hawaiian breeding population (approximately 63.5%), or Mexico (27.9%), and a few from Central American (8.7%) (Wade 2017)(Table 12).

In December, 2016, NMFS West Coast Region (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 2016h), however, more recent information is available in Wade (2017) and we are in the process of updating that guidance. Similar to the information in the 2016 memo and until additional information is available for Puget Sound, we will use the same proportions for coastal Washington/South British Columbia and inland waters of Washington. In summary, the updated proportional approach breaks down as follows:

Table 12. Proportional estimates of each DPS that will be applied in waters off of Washington/South British Columbia. E=Endangered, T=Threatened. NL = Not Listed (adapted from Wade (2017))

Feeding Areas	Central America DPS (E)	Mexico DPS (T)	Hawaii (NL)
Washington/SBC	8.7%	27.9%	63.5%

This biological opinion evaluates impacts on both the Central American and Mexico DPSs of humpback whales as both are assumed 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 reports (SARs) for humpback whales on the west coast of the United States (Carretta et al. 2019a; Muto et al. 2019) have not yet 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 California/Oregon/Washington (CA/OR/WA) stocks. These MMPA stocks include whales from multiple DPSs. In addition, there are two feeding groups along the US West Coast: the California/Oregon group that is mainly composed of the whales from the Mexico and Central America DPSs; and the northern Washington/southern British Columbia group that includes whales from the Hawaii DPS, the Mexican DPS, but also small numbers of whales from the Central American DPSs (Calambokidis et al. 2008; Barlow et al. 2011; Wade et al. 2016; Wade 2017).

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). North Pacific humpback whales are a distinct subspecies due to differences in mitochondrial DNA compared to the North Atlantic humpback whales and the Southern Hemisphere humpback whales (Baker et al. 2013). Exchange between the North Pacific breeding groups is rare (Calambokidis et al. 2001; Calambokidis et al. 2008). 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. (2016) estimated the abundance of the Mexico DPS to be 2,806 based on revised analysis of the available data. Although no specific estimate of the current growth rate of this 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. Wade (2017) estimated the abundance for the Central America DPS to be 783 individuals (Bettridge et al. 2015; Wade et al. 2016). The size of this population is relatively low compared to most other North Pacific breeding populations. The population trend for the Central America DPS is unknown (Bettridge et al. 2015). We note that the abundance estimates from Wade (2017) reflect data from surveys in 2004-2006 and there is more uncertainty in the population estimate of the Central America DPS compared to the estimates for the other two DPSs found within the project area (Carretta et al. 2019a). The unlisted Hawaii DPS was estimated to have a population size of 11,571 individuals (Wade 2017).

Although there are no estimates of humpback whale DPS abundances that reflect recent data, there is more recent information about humpback whale abundances along the U.S. West Coast that help shine light on how ESA-listed DPS abundances may have changed over the last 10-15 years, generally. In the most recent SARs for humpback whales that reflect data through 2014, (Carretta et al. 2019a), there are an estimated 2,374 humpback whales in the California and Oregon feeding group, and 526 in the Washington and southern British Columbia feeding group. Even more recently, Calambokidis and Barlow (2020) estimated the California and Oregon feeding group abundance of at least 3,000 humpback whales, and the Washington and southern British Columbia feeding group abundance of at least 900, using data through 2018.

Looking at these estimates produced by Calambokidis and Barlow (2020), the results suggest that the abundance of humpback whales in both feeding groups, and the U.S. West Coast collectively, has roughly doubled since the data used in the Wade (2017) analysis was collected. While it is unclear exactly how the abundance of each DPS has responded during this period, we could assume if there are at least 3,000 humpback whales off California and Oregon currently, and the previous analysis indicated Central America DPS constitutes 67% of the humpback whales present in the area (Wade 2017), then there should be approximately 2,000 Central American DPS humpback in just that one feeding group. Since this number of Central America DPS humpback whales is more than double the total estimate for the entire Central American DPS produced using data from 15 years ago, it is clear that current abundances and/or proportions must have changed, at least with respect to the Central America and Mexico DPSs given they are believed to constitute virtually all the whales off the coast of California and Oregon (NMFS 2016i; Wade 2017). In Washington and southern British Columbia, the picture is even more complicated because of the large presence of the Hawaii DPS, although increases in the Central America and/or Mexico DPS that appear to have inevitably occurred would likely help explain part of the doubling of humpbacks that have occurred in this feeding group as well.

In total we conclude it is likely that current abundance of each DPS is higher than it was 15 years ago, or that the relative proportions of humpback whale DPS in the feeding grounds have likely changed significantly, or (most likely) both to some degree. As a result, we treat the abundance estimates for each humpback whale DPS that visits U.S. West Coast feeding grounds presented in Wade (2017) as absolute minimum estimates in this biological opinion.

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.

Natural Threats

The most common predator of humpback whales is the killer whale, likely by transient killer whales (*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 from a grouping of long-term studies 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). Whales from the Mexico wintering ground and the California feeding area experience higher incidences of rake marks (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). Rare attacks by false killer whales have also been reported or suggested (Fleming and Jackson 2011).

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. The algal toxin 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). Entanglement can lead to decreased foraging ability, risk of infection, hemorrhaging, severe tissue damage, and draining of energy of whales (Moore and Hoop 2012); individuals may also die from starvation or drowning if the gear holds them in place (Lebon and Kelly 2019). 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. 2018) and entanglement reports have increased considerably since 2014.. For example, a minimum of 202 humpback whale confirmed entanglements have been reported since 2000, 143 of which have taken place since 2014 (NOAA 2019b; 2019a). An additional 31 unconfirmed humpback whale entanglements were reported since 2015. From 2012-2016 the serious injury/mortality estimates for the CA/OR/WA stock due to commercial fishery entanglements (15.7/yr), non-fishery entanglements (0.2/yr), recreational crab pot fisheries (0.15/yr), serious injuries assigned to unidentified whale entanglements (2.2/yr), plus observed ship strikes (2.1/yr), equals 20.4 animals, which exceeds the stock's Potential Biological Removal (PBR) of 16.7 animals (Carretta et al. 2019a). In 2018, at least 10 humpback whales were reported (10 confirmed reports, 2 unconfirmed reports) as entangled in fishing gear in inland Washington or coastal Oregon and Washington waters (NOAA 2019a). 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 but not limited to herring, capelin, sand lance, and mackerel (Clapham 2009). Pacific herring stocks in the southern Salish Sea, with the exception of the Hood Canal region, have been in decline for the last decade

(Sandell et al. 2019). No assessment of Northern anchovy or Pacific sand lance abundance in the Salish Sea has been conducted (Penttila 2007), although some studies show an increase in sand lance catch and abundance (Greene et al. 2015). The Pacific Fishery Management Council manages fisheries that target coastal pelagic species on the U.S. West Coast such as mackerel and sardine. The Pacific sardine fishery in Washington state has been closed since 2015 due to low sardine abundance (Wargo and Hinton 2016; PFMC 2019). When open, these fisheries have the potential to 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. A recent paper suggests strikes are the second greatest cause of death for humpback whales along the U.S. west coast (Rockwood et al. 2017). 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 et al. 1999) and other interactions with non-fishing vessels. Humpback whales spend the vast majority of their time within 30 meters of the sea surface (90 percent at night and 69 percent during daytime), increasing their risk of vessel strike (Calambokidis et al. 2019). 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. This type of overlap also occurs within the proposed action area. Ship speeds of greater than 10 knots are likely to be fatal (Nichol et al. 2017). Rockwood et al. (2017) modeled ship strikes along the west coast and determined there were an average of 1.4 humpback whale strikes per year from 2006 to 2016, with a minimum of 8.2 and a maximum of 28 deaths based on carcass buoyancy. Nichol et al. (2017) modeled the western portion of the Strait of Juan de Fuca to be a relatively high-risk area for humpback vessel strikes, along with areas near the shelf edge of Vancouver Island, and within the Strait itself. 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). 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, levels of PCBs, DDTs, and PBDEs were still high along the US. West Coast, with the highest concentrations in samples from Southern California and Washington. 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, similar to portions of 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.

Besseling et al. (2015) found evidence of microplastic in the gastrointestinal tract of a humpback whale carcass in the Netherlands. Because humpback whales are filter feeders, it is likely that other individuals are also accumulating microplastics from their diet although the impacts from ingesting microplastics are largely unknown.

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. Frankel and Clark (2000) found that the distance between surfacing by humpback whales increased with a greater received sound level in Hawaii, showing some behavioral reaction to experiencing louder noises by these whales.

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).

2.2.2 Status of Critical Habitat

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."

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

2.2.2.1 Puget Sound Chinook

Critical habitat for the Puget Sound Chinook ESU was designated on September 2, 2005 (70 FR 52630). It includes estuarine areas and specific river reaches associated with the following subbasins: Strait of Georgia, Nooksack, Upper Skagit, Sauk, Lower Skagit, Stillaguamish, Skykomish, Snoqualmie, Snohomish, Lake Washington, Duwamish, Puyallup, Nisqually, Deschutes, Skokomish, Hood Canal, Kitsap, and Dungeness/Elwha (70 FR 52630). The designation also includes some nearshore areas extending from extreme high water out to a depth

[23] 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).

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 2008c), the National Flood Insurance Program (NMFS 2008d), 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 66 watersheds within the range of this DPS. Nine watersheds received a low conservation value rating, 16 received a medium rating, and 41 received a high rating to the DPS (NMFS 2015a). 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.

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 2008c), the National Flood Plain Insurance Program (NMFS 2008d), 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 with Several federal agencies (e.g., Environmental Protection Agency (EPA), NOAA Fisheries, the Corps of Engineers, Natural Resources Conservation Service (NRCS), United States Geological Survey (USGS), Federal Emergency Management Agency (FEMA), and USFWS) collaborated on an enhanced approach to implement the Puget Sound Action Plan. On January 18, 2017, the National Puget Sound Task Force reviewed and accepted the Interim Draft of the Puget Sound Federal Task Force Action Plan FY 2017-2021, https://www.epa.gov/sites/production/files/2017-01/documents/puget-sound-federal-task-force-action-plan-interim-draft-2017-2021.pdf. The purpose of the Puget Sound Federal Task Force Action Plan is to contribute toward realizing a shared vision of a healthy and sustainable Puget Sound ecosystem by leveraging Federal programs across agencies and coordinating diverse programs on a specific suite of priorities. The U.S. EPA's Region 10 Administrator and NOAA Fisheries West Coast Region

Administrator co-chair the Task Force's Regional Leadership Team, and senior NOAA Fisheries staff represent the agency on the Regional Implementation Team. The Puget Sound Action Agenda, as well as salmon recovery and tribal habitat plans and priorities, are the foundations of the Federal Task Force 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 deepwater (< 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.

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. Based on the natural history of the Southern Residents and their habitat needs, NMFS identified the following physical or biological features essential to conservation: (1) Water quality to support growth and development; (2) Prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) Passage conditions to allow for migration, resting, and foraging.

In 2006, few data were available on SRKWs distribution and habitat use in coastal waters of the Pacific Ocean. Since the 2006 designation, additional effort has been made to better understand the geographic range and movements of SRKWs. For example, opportunistic visual sightings, satellite tracking, and passive acoustic research conducted since 2006 have provided an updated estimate of the whales' coastal range that extends from the Monterey Bay area in California, north to Chatham Strait in southeast Alaska (NMFS 2019i).

On September 19, 2019 NMFS proposed to revise the critical habitat designation for the SRKW DPS under the ESA by designating six new areas along the U.S. West Coast (84 FR 49214). Specific new areas proposed along the U.S. West Coast include 15,626.6 square miles (mi2) (40,472.7 square kilometers (km2)) of marine waters between the 6.1-meter (m) depth contour and the 200-m depth contour from the U.S. international border with Canada south to Point Sur, California (Figure 22). In the proposed rule (84 FR 49214), NMFS states that the "proposed areas are occupied and contain physical or biological features that are essential to the conservation of the species and that may require special management considerations or protection." The three physical or biological features essential to conservation in the 2006 designated critical habitat were also identified for the six new areas along the U.S. West Coast.

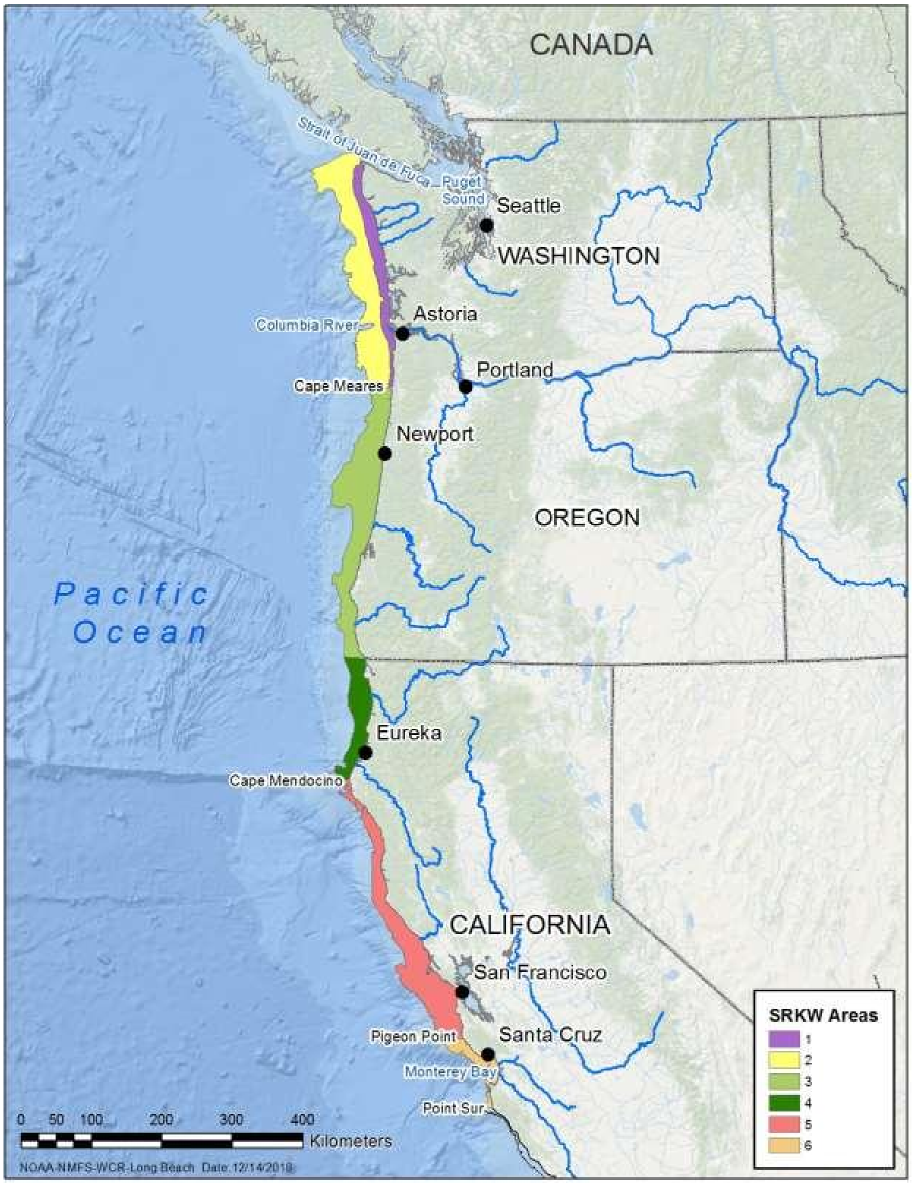

Figure 22. Specific areas containing essential habitat features (Figure 9 reproduced from (NMFS 2019i)).

Water Quality

Water quality supports SRKW's ability to forage, grow, and reproduce free from disease and impairment. Water quality is essential to the whales' conservation, given the whales' present contamination levels, small population numbers, increased extinction risk caused by any additional mortalities, and geographic range (and range of their primary prey) that includes highly populated and industrialized areas. Water quality is especially important in high-use areas where foraging behaviors occur and contaminants can enter the food chain. The absence of contaminants or other agents of a type and/or amount that would inhibit reproduction, impair immune function, result in mortalities, or otherwise impede the growth and recovery of the Southern Resident population is a habitat feature essential for the species' recovery. 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. Water quality varies in coastal waters from Washington to California. For example, as described in NMFS (2019i), high levels of DDTs have been found in SRKWs, especially in K and L pods, which spend more time in California in the winter where DDTs still persist in the marine ecosystem (Sericano et al. 2014).

Exposure to oil spills also poses additional direct threats as well as longer term population level impacts; therefore, the absence of these chemicals is of the utmost importance to Southern Resident conservation and survival. Oil spills can also have long-lasting impacts on other habitat features. Oil spill risk exists throughout the SRKW's coastal and inland range. From 2002- 2016, the highest-volume crude oil spill occurred in 2008 off the California coast, releasing 463,848 gallons (Stephens 2017). In 2015 and 2016, crude oil spilled into the marine environment off the California coast totaled 141,680 gallons and 44,755, respectively; no crude oil spills were reported off the coasts of Oregon or Washington in these years (Stephens 2015; 2017). Non-crude oil spills into the marine environment also occurred off California, Oregon, and Washington in 2015 and 2016 (Stephens 2015; 2017). 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

Most wild salmon stocks throughout the whales' geographic range 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 and in coastal waters of Washington, Oregon, and California. 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), so changes in Chinook salmon size may affect the quality of this feature of 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 (2010d), Ferrara et al. (2017)).

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 23) 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 Catch Reporting Areas 4B, 5, and 6C, and in the San Juan Islands region Catch Reporting Areas 6, 6A, 7, and 7A.

To assess the effects of the proposed actions on the Southern Resident killer whale DPS, we considered the geographic area of overlap in the marine distribution of Chinook salmon affected by the action, and the range of Southern Resident killer whales. 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.

This action area includes the areas where fishing under the proposed action will take place, and where the effects of that fishing on listed species considered in this opinion will occur.

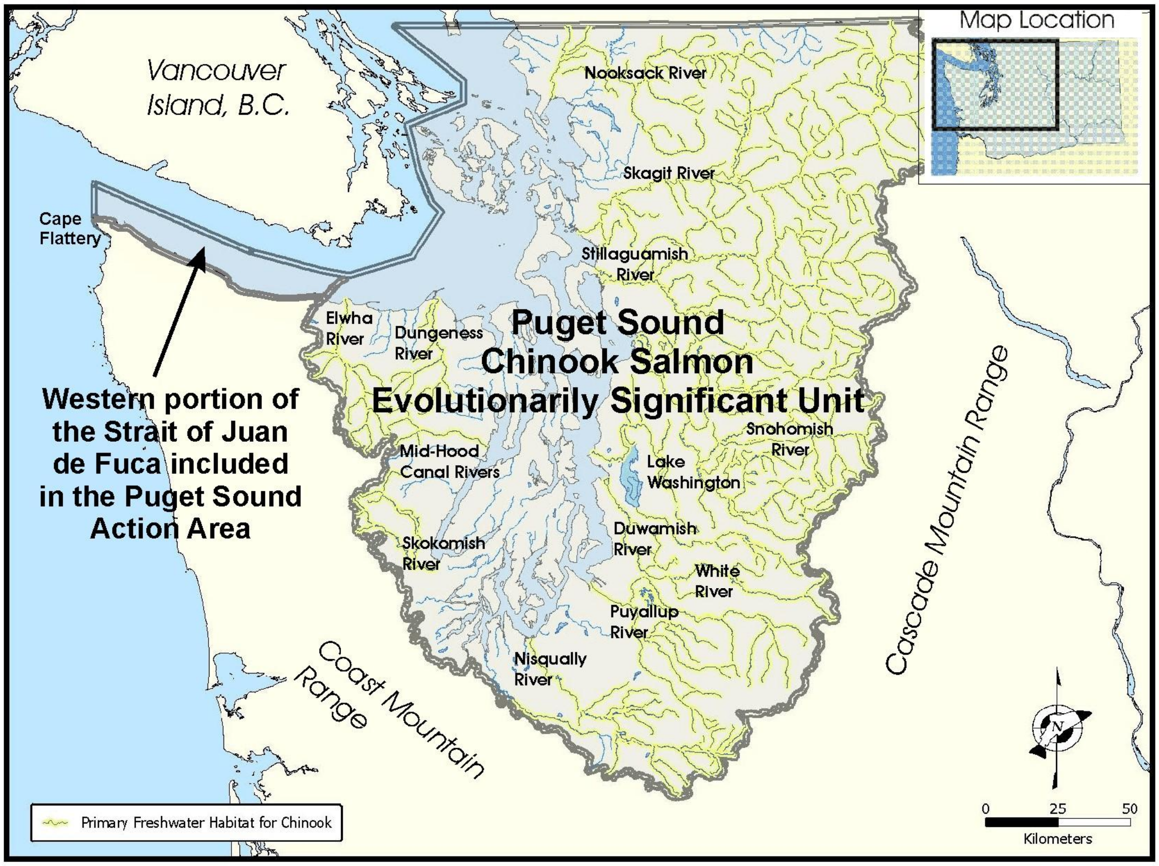

Figure 23. Puget Sound Action Area, which includes the Puget Sound Chinook ESU and the western portion of the Strait of Juan de Fuca in the United States.

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. On short time scales (seasonal, annual), high-frequency variation in environmental conditions leads to variation in salmon survival that gives rise to the typical noisy recruitment data. Longer, decadal-scale environmental factors such as PDO (Hare et al. 1999; Mantua and Hare 2002) and North Pacific Gyre Oscillation (NPGO) (Di Lorenzo et al. 2008) are of particular interest because they have been associated with longer-term variations in indices adult recruits per spawner (Dorner et al. 2018). 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 2017d) and the implementation of the Mitchell Act (NMFS 2017e). 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 implement harvest objectives that are more consistent with the underlying productivity of the natural populations; resulting in substantially reduced harvest impacts on most stocks, relative to pre-listing impacts. 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, 2018 and 2019 (Grayum and Unsworth 2015; Shaw 2015; 2016; Speaks 2017; Shaw 2018; Norton 2019b). 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 2011b). Recent year exploitation rates are summarized in Table 13 **(**FRAM validation runs, version 6.2, October 2018**)**.

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 13). 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 and are managed under the terms of the PST. 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. These fisheries are also managed under the terms of the PST. The effects of these Northern fisheries (Canada and SEAK) on Puget Sound Chinook were assessed in previous biological opinions (NMFS 2004a; 2008e; 2019f).

Table 13. Average 2009 to 2016 total and SUS ERs for Puget Sound Chinook management units (see Table 3 for correspondence to populations). This encompasses the provisions of the 2009-2018 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 (2015) 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[24]. An annual average of 55 (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 2018/2019 time period (WDFW and PSTIT

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

2016a; 2017a; WDFW and PSIT 2018; WDFW and PSTIT 2019; 2020). 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 2019, 38 steelhead were encountered in 3,629 observed sets (Addae 2020; WDFW and PSTIT 2020). With retention of steelhead prohibited, WDFW Enforcement may seize any retained steelhead landed. In 2013 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). GSI sampling occurred in 2018, and a single steelhead was released successfully post sampling. However, 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 100 (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 2018/2019 time period (WDFW and PSTIT 2020). The catch of steelhead in marine recreational fisheries has therefore declined by 51% in the years since listing. There is some mortality associated with the catch-and-release of unmarked steelhead in the marine recreational fishery. The mortality rate associated with catch-and-release is estimated at 10% (PSIT and WDFW 2010c), making the overall additional mortality from the marine recreational fisheries low.

In summary, at the time of listing, during the 2001/02 to 2006/07 seasons, an average of 325 steelhead were caught in marine treaty and non-treaty commercial, ceremonial and subsistence (C&S), and marine recreational fisheries (i.e., 126 treaty marine (all fisheries); 1 non-treaty marine commercial; 198 non-treaty marine recreational). Since listing, an average of 159 steelhead were caught in marine treaty and non-treaty commercial, ceremonial and subsistence, and recreational fisheries (i.e., 55 treaty marine; 4 non-treaty commercial; 100 non-treaty recreational) for the most recent time period (2007/2008 to 2018/2019) (Table 14). The steelhead caught in these marine area fisheries include ESA-listed natural-origin and hatchery 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 49% compared with the earlier, pre-listing period.

Table 14. Average marine area catch of steelhead from 2001/02 to 2006/07 and 2007/08 to 2018/19 time periods.

Time Period	Marine Catch			
	Treaty commercial & C&S	Non-Treaty Commercial	Non-Treaty Recreational	Total
2001/02 to 2006/07	126	1	198	325
2007/08 to 2018/19	55	4	100	159

In many Puget Sound freshwater areas, with the exception of the Skagit River, 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. Treaty fisheries typically retain both natural-origin and hatchery steelhead. The treaty freshwater fisheries for winter steelhead, with the exception of the Skagit River, target primarily hatchery steelhead by fishing during the early winter months when hatchery steelhead are returning to spawn and natural-origin steelhead are at low abundance. Fisheries targeting other salmon species may also capture natural-origin summer run steelhead incidentally. 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).

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 2018b). The annual, allowable impact rate to Skagit steelhead in the Skagit area fisheries is determined using a tiered system based on the terminal run size forecast for the Skagit River (Table 15). NMFS (2018b) concluded that the effects of the Skagit steelhead fishery to the viability and recovery of the Puget Sound steelhead DPS would be low and that the RMP met the requirements of the ESA 4(d) Rule.

Recreation steelhead fishing occurred under this plan April 14, 2018 until April 29, 2018—no tribal directed steelhead fishery occurred in 2018. The 2018 steelhead run forecast was for 5,247, which limited the overall annual impact on steelhead to 10%. During the short time the Skagit recreational catch-and-release fishery was open in 2018 an estimated total of 568 wild steelhead were caught and released, resulting in an estimated 57 mortalities (WDFW and PSTIT 2018). When combined with the estimated incidental mortalities from tribal and recreational fisheries targeting other species, the overall estimated steelhead mortalities during the 2017-18 Skagit steelhead management period were 116. The 2017-18 post season run size estimate was 6,199 steelhead (WDFW and PSTIT 2018), which was larger than the pre-season forecast. The 116 estimated mortalities resulted in an overall impact rate of 1.87 percent, far lower than either the 20 percent or 10 percent limits that the final run size or the forecasted run size, respectively, would have allowed.

The 2018/2019 Skagit fishery represented the first full season for the steelhead directed fishery. The preseason forecast was 6,567 adults, which would allow an up to 20 percent terminal impact rate (Table 15). The co-managers post-season reported total mortality was 326 wild steelhead for the July 1, 2018 through June 30, 2019 management period. The final post-season run size estimate was 4,636, which resulted in a total impact rate of 7.04 percent (WDFW 2019b). This final rate was below both the 20 and 10 percent limits of either the pre-season forecasted rate or the rate that resulted from the lower post-season run estimate, respectively (Table 15).

Based on the 2019-2020 Skagit basin pre-season steelhead forecast of 3,963 the co-managers will not implement any steelhead-directed fisheries in the Skagit basin for the remainder of the 2019/2020 season—ends June 30, 2020 (WDFW 2020a; 2020b), and all incidental impacts to Skagit steelhead in fisheries directed at other species will be managed under the 4% limit (Table 15).

Table 15. 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 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). Three of the 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). Given these circumstances, NMFS used available data for five Puget Sound winter and summer/winter steelhead populations with the most complete data to calculate a series of reference terminal harvest rates on Puget Sound natural-origin steelhead. NMFS calculated that the harvest rate on these natural-origin steelhead averaged 4.2% annually in Puget Sound terminal fisheries during the 2001/2002 to 2006/2007 time period just prior to listing (NMFS 2010b) (**Error! Reference source not found.**). Average harvest rates on the same natural-origin steelhead populations have demonstrated a reduction to 1.38% in Puget Sound fisheries during the 2007/2008 to 2018/2019 time period, a 66% decline (**Error! Reference source not found.**). These estimates include sources of non-landed mortality such as hooking mortality and net dropout.

Table 16. 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; 2020).

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
2018-19	--[c]	1.10	0.30	0.00	0.05
Avg HRs 2007-19	**--[c]**	**1.10**	**1.25**	**0.34**	**1.38**
Total Avg HR		**1.38%** total average harvest rate across populations from 2007-08 to 2018-19			

[a] Escapement methodology for the Nisqually River was adjusted in 2004; previous estimates are not comparable.
[b] Catch estimate not available in 2006-07 for Snohomish River.
[c] Skagit steelhead harvest rate limits are now managed under the Skagit Steelhead Harvest RMP.

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), and the 2019 Puget Sound Steelhead Recovery Plan concurred with this assessment (NMFS 2019h). As mentioned in the Status of the Listed Species sections for Puget Sound Chinook (Section 2.2.1.1) and Puget Sound steelhead (Section 2.2.1.2), final recovery plans have been adopted for both of these listed species. The NMFS adopted the recovery plan for Puget Sound Chinook on January 19, 2007 (72 FR 2493) and adopted the recovery plan for Puget Sound steelhead on December 20, 2019 (https://www.fisheries.noaa.gov/resource/document/esa-recovery-plan-puget-sound-steelhead-distinct-population-segment-oncorhynchus).

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 2018e). 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. The reforms 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) and/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).

Conservation hatchery programs, under the PST critical stock program, are currently operating in the Nooksack, Dungeness, and Stillaguamish rivers. A new program is being developed for Mid-Hood Canal. A programmatic consultation on the PST funding initiative was included in the consultation on SEAK fisheries (2019c) and the 2020 funding already appropriated provides a level of certainty these programs will continue. NMFS previously reviewed both the Dungeness and Stillaguamish programs through a section 7 consultation and approved them under the 4(d) rule for threatened Chinook salmon (NMFS 2016f; 2019b). Review of the Nooksack program and development of the Mid-Hood Canal program is currently ongoing. The latter two programs will be subject to further consultation once the site specific details are fully described. Modifications to the Dungeness and Stillaguamish programs could trigger reinitiation of those site specific consultations. The likely effects of these programs are described in general terms here.

Conservation programs are designed to preserve the genetic resources of salmon populations and protect against demographic risks while the factors limiting anadromous fish viability are addressed. In this way, hatchery conservation programs reduce the risk of extinction (NMFS 2005f; Ford et al. 2011a). However, hatchery programs that conserve vital genetic resources are not without risk to the natural salmonid populations. These programs can affect the genetic structure and evolutionary trajectory of the natural population that the hatchery program aims to conserve by reducing genetic diversity and fitness (HSRG 2014; NMFS 2014g). More details on how hatchery programs can affect ESA-listed salmon and steelhead can be found in Appendix C of NMFS (2018a), incorporated here by reference, and summarized below.

In addition, there are new initiatives to increase hatchery production to further enhance the SRKW's prey base. As described in the 2019 biological opinion on domestic actions associated with implementation of the new PST agreement (NMFS 2019f), additional hatchery production of Chinook funded through the PST funding initiative is expected to result in increased available prey throughout the SRKW's geographic range. The increases in the abundance of Chinook salmon available as prey to SRKW as a result from the funded hatchery production are expected to occur in the next 3 – 5 years as adult Chinook return to the action area. In Fiscal Year 2020 Congress appropriated $35.1 million dollars in the NMFS budget U.S. actions associated with for implementation of the new PST agreement, which included $5.6 million that is being used for increased hatchery production to support prey abundance for SRKW. While there is 2020 funding, and actions are being implemented during the year covered by this opinion, the potential for additional years of funding will be considered as part of future consultations on the PFMC salmon FMP and other fishery management plans as they are developed or amended as necessary. As site-specific actions under the PST funding initiative are identified the effects will be analyzed through subsequent section 7 consultations, unless the activities and effects have already been analyzed through an existing consultation.

In the programmatic assessment of the PST funding initiative NMFS (2019f), we described our expectations for increased prey abundance for SRKWs through increases in the abundance of age 3-5 Chinook salmon in the times and areas most important to SRKWs. The expectations included increased abundance in inside areas (Puget Sound) in the summer and outside areas (Coast) during the winter (Dygert et al. 2018) resulting in a minimum increase of adult fish abundance by 4-5 percent in both inside areas in the summer and coastal areas in the winter. We estimated accomplishing this would require the release of 20 million smolts from hatcheries located in Puget Sound, the Columbia River, and coastal Washington areas.

In 2020, NMFS developed the following criteria to determine which hatchery production proposals might be funded by NMFS to increase the SRKW prey base:

- Increased hatchery production should be for Chinook stocks that are a high priority for SRKW (NOAA and WDFW 2018)
- Increased production should represent an array of Chinook stocks from different geographic areas and run timings (i.e., a portfolio)
- Increased production cannot jeopardize the survival and recovery of any ESA-listed species, including salmon and steelhead
- Because of funding and timing constraints, increased production proposals should not require major capital upgrades to hatchery facilities
- All proposals should have co-manager agreement, as applicable
- All increased production must be reviewed under the ESA and NEPA, as applicable, before NMFS funding can be used.

NMFS will work with hatchery operators and funders to ensure that all increased hatchery production to support SRKW has been reviewed under ESA (and NEPA as applicable) to ensure that it does not jeopardize the survival and recovery of any ESA-listed species. This will include a review of the effects to the species and its designated critical habitat. NMFS has been working collaboratively with the state and tribal co-managers, and other interested parties, to meet the goals related to increasing prey abundance, minimize the risk to listed salmon species, and provide coincident benefits for additional harvest. While the appropriations described above have been secured, thereby providing certainty that the program will operate, NMFS is working with the hatchery operators to determine the details of the increased production (e.g., what hatcheries will be used, what Chinook stocks will be reared, etc.). NMFS will ensure all applicable ESA consultations and NEPA analyses are completed for the increased hatchery production.

Additional increased production is being funded by WDFW and is contributing toward the goal of producing an additional 20 million juvenile Chinook salmon annually. Some of this increased production has completed ESA consultations and is included in

Table ***17***. The rest of the increased production is being reviewed by NMFS and is discussed in Section 2.6, Cumulative Effects.

Table 17. Puget Sound Hatchery programs that have been addressed in previously completed ESA Section 7 consultations.

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
Five Elwha River Hatchery Programs	Elwha Channel Hatchery summer/fall Chinook	December 2014	(NMFS 2014c)
	Lower Elwha Fish Hatchery steelhead		
	Lower Elwha Fish Hatchery coho		
	Lower Elwha Fish Hatchery chum		
	Lower Elwha Fish Hatchery odd and even year pink salmon		
Three Dungeness River Hatchery Programs	Dungeness River Hatchery spring Chinook	May 31, 2016	(NMFS 2016f)
	Dungeness River Hatchery coho		
	Dungeness River Hatchery pink		
Ten Hood Canal Hatchery Programs	Hoodsport Fall Chinook	September 30, 2016	(NMFS 2016d)
	Hoodsport fall chum		
	Hoodsport pink		
	Enetai Hatchery fall chum		
	Quilcene National Fish Hatchery coho		
	Quilcene Bay net pens coho		
	Port Gamble Hatchery fall chum		
	Hamma Hamma Chinook		
	Hood Canal steelhead supplementation		
	Port Gamble Bay net pens coho		

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
Three Early Winter Steelhead Programs in Dungeness, Nooksack, and Stillaguamish River Basins	Dungeness early winter steelhead	April 13, 2016	(NMFS 2016e)
	Kendall Creek winter steelhead		
	Whitehorse Ponds (Stillaguamish) early winter steelhead		
Ten Hatchery Programs in the Green/Duwamish Basin	Soos Creek Hatchery fall Chinook	April 15, 2019	(NMFS 2019d)
	Keta Creek coho (w/ Elliot Bay net pens)		
	Soos Creek Hatchery coho		
	Keta Creek Hatchery coho		
	Soos Creek Hatchery coho		
	Keta Creek Hatchery chum		
	Marine Technology Center coho		
	Fish Restoration Facility (FRF) coho		
	FRF fall Chinook		
	FRF steelhead		
	Green River native late winter steelhead		
	Soos Creek Hatchery summer steelhead		
Four Hatchery Programs in the Stillaguamish River Basin	Stillaguamish summer Chinook	June 20, 2019	(NMFS 2019b)
	Stillaguamish fall Chinook		
	Stillaguamish coho		
	Stillaguamish fall chum		

Biological Opinion	Programs Authorized in Opinion	Signature Date	Citation
Six Hatchery Programs in the Snohomish River Basin	Bernie Kai-Kai Gobin Salmon Hatchery “Tulalip Hatchery” subyearling summer Chinook	September 27, 2017	(NMFS 2017d)
	Wallace River Hatchery summer Chinook		
	Tulalip Bay Hatchery coho		
	Wallace River Hatchery coho		
	Everett Bay net pen coho		
	Tulalip Bay Hatchery chum		

There are currently 13 hatchery programs in Puget Sound that propagate steelhead. Currently there are five steelhead supplementation programs operating for natural-origin winter run steelhead conservation purposes in Puget Sound. Fish produced through the five conservation 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, an additional conservation program 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 2016g)) 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 2016e; 2016g). In evaluating and approving the Early Winter Steelhead (EWS) programs for effects on listed fish (NMFS 2016e; 2016g), 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 2016g).

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 annual hatchery releases averaged about 2,500,000 annually (NMFS 2014a). Recent-year (post 2014) reductions from this average total have 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 (2016g)). When compared to total historic release levels analyzed for the EWS and ESS in the Puget Sound Hatcheries draft environmental impact statement (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

[25] The Elwha dams have been removed, which has significantly changed the Elwha River's hydrology and now

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 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 2008c), Washington State Department of Transportation Preservation, Improvement, and Maintenance Activities (NMFS 2013a), the National Flood Insurance Program (NMFS 2008d), 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

allows for steelhead and salmon access to miles of historical habitat upstream.

are incorporated here by reference.

In addition to increased hatchery production, the programmatic consultation on the funding initiative for U.S. domestic actions associated with the new PST Agreement (NMFS 2019f) assessed improved habitat conditions for specified populations of Puget Sound Chinook salmon. By improving conditions for these populations, we anticipate Puget Sound Chinook abundance would increase, also benefiting SRKW. The FY20 appropriated funds for implementation of U.S. domestic actions associated with the new PST Agreement includes $10.4 million in support of Puget Sound Critical Stock Habitat Restoration and Protection. The following outlines the criteria for prioritizing $10.4 million in FY20 implementation funds in support of Puget Sound Critical Stock Habitat Restoration and Protection as informed by the programmatic criteria from NMFS 2017. These criteria will emphasize habitat projects in the watersheds for four ESA-listed Puget Sound Chinook salmon populations that are in critical status. Similar to the hatchery element of the PST funding initiative NMFS has developed phased selection criteria to select projects in FY 2020 – FY 2022. They are (in rank order):

1) Project supports one or more limiting life stage of at least one of the four Puget Sound critical stocks,
2) Project supports one or more limiting life stage of a high priority population for Puget Sound Chinook recovery,
3) Project supports Puget Sound Chinook salmon population that are priority prey for SRKWs (NOAA and WDFW 2018),
4) Project supports the recovery of multiple ESA-listed species (i.e., Chinook and steelhead) in a given watershed, and
5) Project removes a passage barrier for one or more of the four Puget Sound critical stocks or high priority populations for Puget Sound Chinook recovery

In 2017, NMFS conducted a programmatic consultation resulting in a biological opinion (NMFS 2017c) on the effects of the Seattle District Corps of Engineers permitting of fish passage and restoration actions in the state of Washington. We anticipate that most if not all of the projects funded through the Puget Sound Critical Stock Habitat Restoration and Protection initiative would require some form of Corps approval and will fall within the scope of the 2017 programmatic consultation, but in cases where they would not they would be subject to individual site-specific consultations. The projects under consideration for the initiative would include riverine, lacustrine, wetland, estuarine and marine restoration activities designed to maintain, enhance, and restore aquatic functions as well as projects specifically designed to recover listed fishes. In order to be covered under the programmatic consultation, projects must meet design criteria that would be expected to limit the adverse impacts of the constructing the projects to ESA listed fish, thus we expect projects funded under this initiative to use those design criteria. Design constraints for the types of projects expected to be funded are found in Washington state technical guidelines (described in NMFS 2017c), and are informed by other programmatic consultations that are used to provide consistency across programs. Actions covered by the NMFS (2017c) programmatic consultation are fish passage and habitat restoration projects that include several restoration action categories (e.g. levee removal, salmonid spawning gravel restoration, and fish passage restoration or improvement).

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-native 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

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

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).

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 effects of the proposed fisheries (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 2008g). 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 2008g). This section summarizes these primary threats in the action area and focuses primarily on actions that affect prey availability. The three limiting factors may interact synergistically and subsequent sections describe activities in the Environmental Baseline resulting from the other primary threats.

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 abundance, productivity, spatial structure, and diversity of Chinook salmon are affected by a number of natural and human actions and these actions also affect prey availability for SRKWs. As discussed in the Status section, the abundance of Chinook salmon in recent years is significantly less than historic abundance due to a number of human activities. The most notable human activities that cause adverse effects on ESA-listed and non ESA-listed salmon 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. 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 outside of NMFS' jurisdiction for Section 7(a)(2) consultation, but nonetheless significantly impact available prey. We then qualitatively assess the remaining prey available to Southern Resident killer whales in light of this environmental baseline.

Harvest Actions

Directed salmon fisheries that intercept fish that would otherwise reach the action area as adults occur all along the Pacific Coast, from Alaska to California. In past harvest consultations including Puget Sound salmon fisheries—(NMFS 2010c; 2014b; 2015c; 2016c; 2017b; 2018c; 2019c), Pacific Coast Salmon Plan fisheries (NMFS 2008a; 2020a), the *U.S. v. Oregon* Management Agreements (NMFS 2008f; 2018a), the PST 2009 Agreement (NMFS 2008e) and southeast Alaska salmon fisheries (NMFS 2019f) —we characterized the short-term and long-term effects harvest has on the SRKWs from prey reduction. 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.

The new PST Agreement includes reductions in harvest impacts in all Chinook fisheries within its scope and refines the management of coho salmon caught in these areas. The new PST Agreement includes reductions in the allowable annual catch of Chinook salmon in the SEAK and Canadian West Coast of Vancouver Island and Northern British Columbia fisheries by up to 7.5 and 12.5 percent, respectively, compared to the previous agreement. The level of reduction depends on the Chinook abundance in a particular year. This comes on top of the reductions of

15 and 30 percent for those same fisheries that occurred as a result of the prior 10 year agreement (2009 through 2018). Harvest rates on Chinook salmon stocks caught in southern British Columbia and southern U.S. salmon fisheries, including those under the jurisdiction of the PFMC are reduced by up to 15 percent from the previous agreement (2009 through 2018). These reductions will result in larger proportions of annual salmon abundance returning to the more southerly U.S. Pacific Coast Region portion of the EEZ than under prior PST Agreements. Therefore, under the new PST agreement, reductions in prey from fisheries managed under the new agreement are expected to be lower than under the previous agreement.

In its 2019 opinions on domestic actions related to the new PST Agreement (NMFS 2019f), NMFS assumed that the State of Alaska would manage its SEAK salmon fisheries consistent with the provisions of the new 2019 PST Agreement. Using methodology similar to previous biological opinions completed up to that time (e.g. NMFS 2019c), NMFS estimated that the percent reductions of Chinook salmon in inland waters of WA from the SEAK fisheries in the three FRAM time steps (October – April, May – June, July – September) were expected to range from 0.1% to 2.5% with the greatest reductions occurring in July – September under the 2019 PST Agreement. Percent reductions in coastal waters of WA and OR from the SEAK fisheries were expected to range from 0.2% to 12.9%[27] and similarly the greatest reductions would occur in July – September. Under the 2009 PST Agreement, percent reductions of Chinook salmon in inland waters ranged from 0.2% to 2.9% and 0.2% to 15.1% in coastal waters as a result of the SEAK fisheries (NMFS 2019f). Therefore, the majority of the impacts that the SEAK salmon fisheries have on prey availability in the action area would occur in the coastal waters of WA and OR.

In 2009, NMFS consulted on the effects of the Pacific Coast Salmon Fishery Management Plan (FMP) (NMFS 2009b) and concluded that the PFMC salmon fisheries did not jeopardize the survival and recovery of SRKW. On April 12, 2019, NMFS reinitiated consultation to consider the effects of the fisheries on SRKWs given the change in the whales' status and substantial amount of new information available on the whales' diet and distribution. The PFMC formed the Ad Hoc SRKW workgroup (Workgroup) to reassess the effects of PFMC-area ocean salmon fisheries on SRKW, and depending on the results, develop a long-term approach that may include proposed conservation measure(s) or management tool(s) that limit PFMC salmon fishery impacts on Chinook salmon prey available for SRKW. The Workgroup took into account the SEAK fisheries.

In March 2020, the Workgroup completed their risk assessment and a final draft is available (PFMC 2020). A final version along with recommendations for the PFMC is expected at the June 2020 PFMC meeting. In the recent SRKW Ad Hoc report (PFMC 2020), the Workgroup estimated the reductions in Chinook salmon in the Salish Sea (i.e. Action Area) (as well as other coastal areas along southwest Vancouver Island, Washington, Oregon, and California) from the

[27] The methodology to estimate this percent reduction differs from current methods that were derived during the PFMC SRKW Ad Hoc workgroup. Because of this, we are limited in our ability to compare impacts from different fisheries. NMFS and the co-managers are currently developing a similar methodology as that described in PFMC 2020. We provide general percent reductions from salmon fisheries in the meantime but this warrants caution in comparing impacts.

PFMC salmon fisheries. Using new methodology compared to previous fishery consultations, they found that the PFMC salmon fisheries reduced prey availability in the Salish Sea by up to 3.0 percent (see PFMC (2020), Appendix E Table 3). NMFS has completed a biological opinion, incorporating analyses from the Workgroup's risk assessment, and determined that the 2020 PFMC ocean salmon fisheries are not likely to jeopardize the continued existence of endangered SRKWs or adversely modify their designated or proposed critical habitat (NMFS 2020a). In 2020, the percent reduction in the Salish Sea attributable to the PFMC salmon fisheries is expected to be 1.8% (within the range of the most recent decade)(NMFS 2020a).

In the most recent biological opinion on salmon fisheries in Puget Sound (NMFS 2019f), NMFS reviewed past years of data on Chinook salmon abundance and percent reductions from fisheries and 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 from the retrospective time period (1992-2016). NMFS estimated that the percent reductions of Chinook salmon from the Puget Sound fisheries in 1992 – 2016 in inland waters of WA in the three FRAM time steps (October – April, May – June, July – September) were expected to range from 0.4% to 17.7%[28] with the greatest reductions occurring in July – September. Percent reductions in coastal waters from Puget Sound fisheries were expected to range from 0.0% to 2.7% and similarly the greatest reductions would occur in July – September (NMFS 2019a). NMFS estimated percent reductions from the Puget Sound fisheries in 2019 was 5.4% and the pre-season estimates for abundance of age 3-5 Chinook in inland waters were slightly higher in 2019 than in 2018. The 2019 estimate was also higher than the recent 10-year average (2007-2016). Furthermore, there was an expected additional 28% increase in adult hatchery-origin Puget Sound Chinook escaping pre-terminal fisheries (or fisheries in marine areas, whereas terminal fisheries occur near river mouths) over the most recent 10-year average (Warren 2019). Additional conservation measures were also implemented in 2019 to reduce impacts on SRKWs given the whales' declining status including area closures in an area known to be important to Southern Resident killer whales, continuing implementation of a package of outreach and education programs, and continuing the promotion of adhering to voluntary "No-Go" Whale Protection Zone along the western side of San Juan Island (Warren 2019).

These analyses suggested that in the short term, prey reductions from ocean and past Puget Sound fisheries were small relative to remaining prey available to the whales. In the long term, harvest actions that affect prey availability in the action area (including fisheries that occur outside the action area, e.g. PFMC salmon fisheries and SEAK salmon fisheries) were not likely to appreciably reduce the survival or recovery of listed Chinook salmon and SRKW, and were therefore not likely to jeopardize the continued existence of listed Chinook salmon or SRKW.

Hatchery Actions

Hatchery production of salmonids has occurred for over 100 years. Currently, there are over 300 hatchery programs in Oregon, Washington, Idaho, and California that produce juvenile salmon that may migrate through the action area. Currently, hatchery operators release over 350 million juvenile salmon and steelhead annually. Many of these fish contribute to both ocean fisheries and the SRKW prey base.

NMFS has completed section 7 consultation on over 200 hatchery programs in over 45 biological opinions (refer to Appendix B NMFS (2020a)). A detailed description of the effects of these hatchery programs can be found within the site-specific biological opinions referenced in NMFS (2020a) Appendix B, Table B.1. These effects are further described in Appendix C of NMFS (2018a), which is incorporated here by reference. For efficiency, discussion of these effects is not repeated here.

Currently, hatchery production is a significant component of the salmon prey base within the range of SRKW (Barnett-Johnson et al. 2007; NMFS 2008h). Scarcity of prey has been identified as a threat to SRKW's survival, and we expect these hatchery programs to continue benefiting SRKW by contributing to their prey base.

Hatchery programs to support critical Chinook populations and increase SRKW prey base

As discussed in the Environmental Baseline for Puget Sound Chinook and steelhead, the PST-related funding initiative includes funds for conservation hatchery programs to support critical Chinook populations. Increasing the abundance of these populations through these hatchery programs may also increase SRKW prey base.

As also discussed in the sections above describing the Environmental Baseline for Puget Sound Chinook and steelhead, the PST-relative funding initiative is also intended to increase hatchery production to further enhance the SRKW's prey base. The increases in the abundance of Chinook salmon available as prey to SRKW as a result of the PST-related funding for hatchery production are expected to occur in the next 3 – 5 years as adult Chinook return to the action area. Further details about implementation of hatchery production with this funding are discussed above in Section 2.4.1.

Additional increased production is being funded by WDFW and is contributing toward the goal of producing an additional 20 million juvenile Chinook salmon annually. Some of this increased production has completed ESA consultations and is included in NMFS 2020, Appendix B Table B.1. The rest of the increased production is being reviewed by NMFS and is discussed in Section 2.6, Cumulative Effects.

Habitat Actions

Habitat-altering activities such as agriculture, forestry, marine construction, levy maintenance, shoreline armoring, dredging, hydropower operations and new development can reduce prey available to SRKWs in the action area. 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. In fact, Chinook salmon currently available to the whales are still below their pre-ESA listing levels, largely due to these past activities that pre-date the salmon listings. 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 2014d). 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 SRKW (NMFS 2008g). For these consultations, RPAs were identified in order to avoid jeopardy and not adversely modify or destroy designated critical habitat (NMFS 2008d; 2014d). We recently consulted on the Howard Hanson Dam, Operations, and Maintenance (NMFS 2019e). 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 2008g; 2014d; 2019e).

In addition to increased hatchery production, as described above in the Chinook section of the Environmental Baseline, the programmatic consultation on the funding initiative for U.S. domestic actions associated with the new PST Agreement (NMFS 2019f) assessed improved habitat conditions for specified populations of Puget Sound Chinook salmon. By improving conditions for these populations, we anticipate Puget Sound Chinook abundance would increase, also benefiting SRKW.

Assessing Baseline Prey Availability

We assessed Chinook salmon abundance before fisheries in the action area by referring to the approach described in the PFMC SRKW Ad Hoc Workgroup Report (PFMC 2020). Here, we briefly describe the method the Workgroup developed to estimate the starting abundance of Chinook available (age 3 and older) available for fishery management years 1992-2016 within the action area during October – April (for more information see PFMC (2020)).

Coastwide adult abundance estimates for most Chinook salmon stocks were generated using Chinook FRAM (PFMC 2008a) post-season runs (Round 6.2 of base period calibration; 10.29.2018). Abundance estimates for FRAM stocks (see Appendix B; Table 1 for a list of the FRAM stocks) are calculated using stock-specific terminal run size estimates by age and mark status provided by regional technical staff. Stock-specific terminal run sizes are then expanded by maturation rates, fishing mortality, and natural mortality estimates to derive a starting abundance. For additional details related to calculations of FRAM starting abundances, please refer to PFMC (2020).

Rangewide ocean abundances were distributed among spatial boxes (e.g., waters off California and Oregon as well as North of Falcon (NOF), southwest Vancouver Island (SWVCI) and the Salish Sea; see PFMC for the full descriptions of the areas) based on estimates of the proportion of each stock found in each area each season. For fall run stocks, proportional abundance in each management area was based on the results of Shelton et al. (2019). The "Shelton et al. model" is a state-space model that infers time- and area-specific ocean abundances of tagged fish from representative coded-wire tagged release groups using information on release size, time- and area-specific fishery catch and effort, and age structure of returning spawners. For spring run stocks, which lacked distribution estimates from the Shelton et al. model, the Workgroup followed the logic described in https://www.fisheries.noaa.gov/webdam/download/93036440. Because the stocks in the two models (FRAM and the Shelton et al. model) were not identically defined, the Workgroup matched up individual FRAM stocks to units of analysis in the Shelton et al. model as described in PFMC (2020). Estimated Chinook salmon abundance aggregated in the Salish Sea for each time step during the retrospective time period are provided in Table 18[29] (for abundance estimates in other spatial areas, refer to PFMC (2020)). These starting abundances are prior to natural mortality estimates or fishery mortality estimates for each time step. The starting abundances are used because the Workgroup agreed this was the most appropriate initial abundance estimate for the purpose of estimating reductions in area-specific abundance attributable to fishery removals. To determine the effects of the Puget Sound fisheries, fishery mortalities from the season are removed (see Effects section).

Table 18. Beginning Chinook salmon abundances for the Salish Sea during 1992-2016 during the October and April, May and June, and July and September FRAM time steps (refer to (PFMC (2020); Appendix E for starting abundances Oct-April).

Year	Abundance (Oct-April)	Abundance (May-Jun)	Abundance (Jul-Sep)
1992	617,146	535,783	505,800
1993	597,178	515,721	477,264
1994	432,374	390,727	371,700
1995	496,808	431,419	400,169
1996	510,183	454,765	426,702
1997	685,086	612,776	584,946
1998	501,831	460,256	445,331
1999	638,485	564,518	521,462
2000	433,840	375,259	346,099
2001	708,027	636,098	578,747
2002	690,372	640,252	562,255
2003	677,307	636,422	574,603
2004	665,469	618,905	575,037

[29] We used the Sacramento stock as represented in FRAM (rather than what was provided by the ad-hoc Workgroup) and did not include the non-FRAM stocks (Klamath, Rogue, Upper Columbia spring) because all of these stocks (including Sacramento) contribute < 1% of the abundance in the Salish region.

Year	Abundance (Oct-April)	Abundance (May-Jun)	Abundance (Jul-Sep)
2005	600,685	532,797	480,778
2006	676,746	607,999	572,822
2007	545,882	470,830	417,375
2008	599,543	537,786	494,055
2009	440,728	407,143	370,611
2010	823,502	754,536	694,273
2011	607,477	564,967	512,640
2012	521,484	471,394	408,768
2013	741,088	713,521	635,138
2014	634,183	605,792	533,163
2015	639,524	626,184	561,865
2016	568,888	517,333	462,557

To put these starting abundance estimates in Table 18 in context, we are able to estimate the prey energy requirements for all members of the population each day, and estimate the prey energy requirements for the entire year, for specific seasons, and/or for geographic areas (inland waters and coastal waters) as described in previous biological opinions (e.g. NMFS 2019c). The daily prey energy requirements (DPERs) for individual females and males range from 41,376 to 269,458 kcal/day and 41,376 to 217,775 kcal/day, respectively (Noren 2011). The DPERs can be converted to the number of fish required each year if the caloric densities of the fish (kcal/fish) consumed are known. However, caloric density of fish can vary because of multiple factors including differences in species, age and/or size, percent lipid content, geographic region and season. 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 by assuming the caloric density of Chinook was 16,386 kcal/fish (i.e., the average value for adults from Fraser River). Williams et al. (2011) and Chasco et al. (2017) 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. These estimates provide a general indication of how many Chinook salmon need to be available and consumed to meet the biological needs of the whales. These estimates can vary based on several underlying assumptions including the size of the whale population and the caloric density of the salmon.

Given there is also no available information on the whales' foraging efficiency, it is difficult to evaluate how much Chinook salmon or what density of salmon needs to be available to the whales in order for their survival and successful reproduction. The whales and prey are both highly mobile and have large ranges with variable overlap seasonally. It is likely that the whales will need more fish available throughout their habitat than what is required metabolically to meet their energetic needs.

In previous biological opinions (e.g. NMFS 2019c), we compared the food energy of prey available to the whales to the estimated metabolic needs of the whales. 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. 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. Relatively low foraging ratios were estimated in the summer months (July – September) in inland waters of WA. For example, 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 (assuming a population size of 75 individuals and using maximum daily prey energy estimates) 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 (see NMFS 2019 for further details). In coastal waters off Washington, Oregon, and California, forage ratios ranged from 10.84 to 33.41 in October – April, from 29.24 to 88.15 in May – June, and from 42.67 to 154.79 in July – September. Chasco et al. (2017) 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 comparing forage ratios across geographic areas. They found forage ratios across the entire west coast have declined during the last 40 years and were consistently higher in coastal waters of British Columbia and southeast Alaska than estimated ratios in Washington waters.

The abundance estimates in Table 18 are the number of adult Chinook salmon available to the whales at the beginning of each time step, prior to natural mortality and fishery mortality in that time step. Therefore these are considered maximum estimates of prey available. Similar to other fishery models, the model the Workgroup used assumed constant adult mortality throughout the year; however, natural mortality of salmonids likely varies across years, due in part to the relative abundance of Chinook salmon and their multiple predators. Hilborn et al. (2012) noted that natural mortality rates of Chinook salmon are likely substantially higher than the previous stock assessments. Salmonids are prey for pelagic fishes, birds, and marine mammals (including SRKWs).

To better understand natural mortality, Chasco et al. (2017) estimated Chinook salmon consumption in Washington inland waters by four marine mammal predators from 1970 to 2015. They estimated that marine mammal predation of Chinook salmon off the West Coast of North America has more than doubled over the last 40 years. For example, 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 SRKWs consume, and approximately six times more than commercial and recreational catches. They also 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 SRKWs 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. (2017) 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 SRKW population.

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). These populations are primarily distributed within the urbanized waters of the Salish Sea and along the west coast of Vancouver Island (DFO 1999; Weitkamp 2010). However, populations of Chinook salmon that originated from the developed Fraser River that had a more northern distribution in the coastal waters of British Columbia and Alaska (DFO 1999) had much lower concentrations of certain contaminants (Mongillo et al. 2016). Additionally, (O'Neill and West 2009) discovered elevated concentrations of polychlorinated biphenyls (PCBs) in Puget Sound Chinook salmon compared to those outside Puget Sound. Similarly, J pod--the SRKW pod most frequently seen in Puget Sound--has also been found to have higher levels of PCBs, consistent with these higher PCB concentrations in Puget Sound Chinook salmon (O'Neill et al. 2006; Krahn et al. 2007). Intermediate levels of PCBs were measured in California and Oregon populations, but Chinook originating from California have been measured to have higher concentrations of DDTs (O'Neill et al. 2006; Mongillo et al. 2016).

Since the late 1970s, size and age structure in Chinook salmon has substantially changed across the Northeast Pacific Ocean (Ohlberger et al. 2018). Since the late 1970s, 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). Reasons for this shift may be largely due to direct effects from size-selective removal by marine mammals and fisheries, followed by evolutionary changes toward these smaller sizes and early maturation (Ohlberger et al. 2019).

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 (Houghton 2014; Ferrara et al. 2017). 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 2013 to 2017 an average of 12 to 17 boats;(Seely 2016)). The average number of vessels with the whales decreased in 2018 and 2019 due to decreased viewing effort on SRKWs by commercial whale watching vessels, with an average of 10 and 9 vessels with the whales at any given time, respectively (Shedd 2020). However, fishing vessels are also found in close proximity to the whales and were responsible for 13% of the incidents inconsistent with the Be Whale Wise Guidelines and federal regulations in 2019 (Shedd 2020). 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).

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 federal actions relating to permitted projects 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 2016j). In 2018, DFO disentangled a transient killer whale entangled in commercial prawn gear near Salt Spring Island, British Columbia (NMFS strandings data, unpubl.). 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, which subsequently fell out with no signs of injury or infection (Center for Whale Research unpublished data).

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[30]. No entanglements, injuries or mortalities of SRKW 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). 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). As described above, SRKWs can be occasionally exposed to concerning PAH levels

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

(Lachmuth et al. 2011). Lundin et al. (2018) measured relatively higher levels of PAHs in whale fecal samples prior to the 2011 vessel regulations that increased the distance vessels could approach the whales compared to subsequent years after the vessel regulations were in place.

2.4.4 Mexico and Central America DPSs of Humpback Whales

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. Humpback whales in the action area are part of the northern Washington and southern British Columbia feeding group and may belong to the Mexico, Hawaii, or Central America DPSs.

Humpback whales historically were abundant throughout the Salish Sea, with an estimated population of 20,000 for the Northern Pacific pre-exploitation (Ivashchenko et al. 2016). During the 1800s and early 1900s they were extensively hunted and effectively removed from the Salish waters (Webb 1988). 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[31]. 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 202 confirmed humpback whale entanglements in fishing gear on the U.S. West Coast from 2000 to 2019, at least 29 of which were reported in Washington (NOAA 2019a; 2019b; Saez et al. 2020). When the origins of entanglements can be identified, which is the case for approximately 50 percent of entanglements, they have largely been from pot/trap fisheries. NOAA has released entanglement reports for 2017, 2018, and half of 2019 that describe the extent and location of entanglements on the West Coast (
Table ***19***). In 2018, there were 34 confirmed entangled humpbacks whales. Of these, 3 confirmed entanglements were reported within Washington's inland waters, predominately in the Strait of

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

Juan de Fuca with gillnet gear entanglements. An additional unconfirmed humpback whale entanglement was reported in the Strait of Juan de Fuca (NOAA 2019a). At least 5 humpback whales were confirmed to be entangled gear from the Washington state Dungeness crab fishery from 2017 to present (Fisheries 2018; NOAA 2019a; 2019b). The reporting location of an entanglement is not always the same as the entanglement origin so it is possible that more humpback whales have been entangled in gear from Washington State, including from the inland waters.

Table 19. Humpback Whale Entanglements on the West Coast for 2017- August 2019.

Year	Total Entanglements	Number of Reports in WA	Number of WA Inland Waters Reports	WA Dungeness Crab Entanglements
2017	16	3	1	2
2018	34	12	3	2
2019 (January to August)	10	3	0	2

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. Additionally, there is a herring fishery in Puget Sound, with some areas open year round, some areas closed January 16 through April 15, and certain areas closed year round[32].

Harvest

Commercial whaling in the 19th and 20th centuries removed tens of thousands of whales from the North Pacific Ocean. Humpback whale products were produced from their oil, meat, and bones. 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.

Natural and Anthropogenic Noise

[32] WDFW. (2020). Commercial Puget Sound herring fishery. Retrieved from: https://wdfw.wa.gov/fishing/commercial/puget-sound-herring.

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.

Based on studies of humpback whale vocalizations, these whales are estimated to have a hearing sensitivity from tens of Hz to approximately 10kHz, but maybe extend up to 24kHz (Au et al. 2006; Southall et al. 2007; Canada 2013). Recent studies have shown that humpback whales continue to produce songs during their migrations and occasionally within their feeding grounds (Vu et al. 2012). A study in the waters around Ogasawara Island found that humpback whales temporarily stopped singing instead of modifying the frequency of their songs in the presence of large, noisy vessels (Tsujii et al. 2018). These studies indicate that vessel noise within the action area may impact humpback whale communication, which could include coordination during feeding.

In-water construction activities are permitted by the 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 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. In 2018 and 2019, NMFS consulted on multiple bulkhead replacements and pier repair and maintenance plans that were found to not likely adversely affect ESA-listed humpback whales due to short construction length, marine mammal monitoring protocols for in-water work, and the low likelihood of humpback whales to be present during the construction period.[33] 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, potential exposure to noise from pile driving was expected to result in behavioral modifications including avoidance and interruption of feeding and migration (NMFS 2018d). 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 2014e).

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. In 2019 NMFS consulted on the United States Coast Guard's action to codify regulations for the Traffic Separation Schemes in the Puget Sound area. NMFS found this action was not likely to adversely affect ESA-listed humpback whales because it did not change the amount of vessel traffic in the Puget Sound Area (NMFS 2019g). While there are no federal regulations regarding vessel distances from humpback whales in Washington waters, there are Be Whale Wise guidelines that recommend a 100-yard approach[34] distance for large whales. These guidelines cover coastal and inland waters of Washington. Commercial whale watching activities focused on humpbacks are likely increasing with more whale sightings, however, the Pacific Whale Watch industry also has guidelines to minimize impacts from their commercial whale watching activities.

Ship strikes and other interactions with vessels occur regularly with humpback whales along the West Coast, with a small number in inland waters. Between 2007 and 2019, there were 27 reported ship strikes on humpback whales along the West Coast, four of which were within Washington waters (NMFS stranding data Two humpback whales were struck by vessels off of Clallam County, one in 2008 and one in 2016 (NMFS stranding data 2020). A humpback whale carcass was found near Neah Bay in 2018 and a necropsy confirmed that the whale was struck by

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[33] Accessed from https://pcts.nmfs.noaa.gov/pcts-web/homepage.pcts

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

a vessel (NMFS stranding data 2020). In May 2019 a juvenile humpback whale was struck by a Washington State ferry in Elliot bay and the strike was presumed to be fatal (NMFS Stranding Data 2019).

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.

2.4.5 Scientific Research

The listed salmon, steelhead, rockfish, Southern Resident killer whales, and humpback 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 20). 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 20 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 20. Average annual take allotments for research on listed species in 2014-2019 (Dennis 2020).

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	--
		Listed hatchery clipped adipose	32	8
PS/GB Bocaccio	Adult	Natural	38	21
PS/GB Yelloweye Rockfish	Adult	Natural	40	22

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, suction cup tagging, 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. In general, the primary objective of this research is population monitoring and assessment, gathering data for behavioral and ecological studies, 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, which incorporate coded-wire tag based models, are converted to FRAM-based (Fishery Regulation and Assessment Model) equivalents (NMFS and NWFSC 2018)(Table 21) 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 21).

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[35] 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.[36] The rates that are estimated to result from the proposed fisheries are compared to the relevant FRAM-equivalent RERs. Generally speaking, where estimated impacts of the proposed fisheries are less than or equal to the FRAM-equivalent 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 21. Rebuilding Exploitation Rates by Puget Sound Chinook population. Newly revised RERs (2018) are bolded. Surrogate FRAM-based RERs are italicized.

[35] After taking into account uncertainty, the critical threshold is defined as a point below which: (1) depensatory processes are likely to reduce the population below replacement; (2) the population is at risk from inbreeding depression or fixation of deleterious mutations; or (3) productivity variation due to demographic stochasticity becomes a substantial source of risk (NMFS 2000b). The rebuilding threshold is defined as the escapement that will represents MSY under current environmental and habitat conditions (NMFS 2000b). Thresholds were based on population-specific data where available.

[36] 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
Strait of Georgia	Nooksack Early	N.F. Nooksack S.F. Nooksack	5%	5%
Whidbey/Main Basin	Skagit Spring	Upper Sauk River Suiattle River Upper Cascade	**38%** **55%** **53%**	**24%** **32%** **35%**
	Skagit Summer/Fall	Upper Skagit River Lower Skagit River Lower Sauk River	**50%** **35%** **52%**	**46%** **36%** **49%**
	Stillaguamish	N.F. Stillaguamish River S.F. Stillaguamish River	**38%** 28%	**22%** 17%
	Snohomish	Skykomish River Snoqualmie	**37%** **44%**	**19%** **20%**
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 Elwha[d]		*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[37] 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.[38]

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 (e.g., two years to finalize sport fishery catch), two years of exploitation rates are assessed every other year. The most recent information is available through 2016 based on work completed in 2018 (Table 22).

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

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

[38] NMFS has used RERs as part of its assessment of proposed harvest actions on the Puget Sound Chinook ESU in biological opinions and application of take limits under the ESA 4(d) Rule since 1999 (NMFS 1999; 2005b; 2008e; 2010a; 2014f; 2015c; 2016c; 2017b; 2018c; 2019c).

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.

Table 22. 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 20). Specific circumstances for these areas are discussed in more detail in the Effects on the Species section for each of the relevant regions.

The NMFS 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 2000b; 2004b; 2011b).

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, 2020 through April 30, 2021 are summarized in Table 23. 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 U.S. salmon fisheries outside Puget Sound (NMFS 2004a; 2008e; 2019f). 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 and in Canada (Mercier 2020). Thus, Table 23 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 23 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 23 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 21.

NMFS' critical and rebuilding escapement thresholds represent natural-origin spawners (Table 23). However, long-term time series of data on the contribution of natural-origin fish to escapement are limited for all Puget Sound populations; particularly those historically dominated by hatchery production. The co-managers are refining abundance forecasts and modeling tools like the FRAM as better information becomes available. Several historically hatchery-dominated populations are transitioning to natural-origin management and, for others, hatchery production will continue to contribute significantly to escapement depending on their role in ESU recovery.

Consequently, the preseason expectations of natural-origin escapements compared to the escapement thresholds in Table 23 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.

Table 23. FRAM adult equivalent exploitation rates expected in 2020 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 population's RER within a management unit (top half of table) or fall below a population's 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	24.4%	7.7%	**33.1%**	5%
Whidbey/ Main Basin	Skagit spring	12.7%	8.1%	20.8%	24-35%
	Skagit summer/fall	25.0%	23.0%	**48.0%**	36-49%
	Stillaguamish	12.0%	6.4%	**18.4%**	17-22%
	Snohomish	15.1%	5.9%	**21.1**%	19-20%
Central/South Sound	Lake Washington	17.2%	17.1%	**34.2%**	*5-24%*
	Duwamish-Green R	17.2%	34.7%	**51.9%**	17%
	White River	9.3%	14.1%	23.3%	*24%*
	Puyallup River	17.2%	29.3%	**46.4%**	*17-35%*
	Nisqually River	13.6%	35.2%	**48.8%**[1]	*35%*
Hood Canal	Mid-Hood Canal R.	17.1%	5.9%	**22.9%**	*5%*
	Skokomish River	17.0%	31.3%	**48.3%**	35%
Strait of Juan de Fuca	Dungeness River	13.8%	2.4%	**16.2%**	*5%*
	Elwha River	13.4%	2.3%	**15.7%**	*5%*

Escapement		Natural (HOR+NOR)	NOR	Critical	Rebuilding
Georgia Basin	Nooksack Management Unit		371	400	500
	NF Nooksack (early)		**139**	*200*	-
	SF Nooksack (early)		231	*200*	-
Whidbey/ Main Basin	Upper Skagit River (moderately early)	7,397	7.050	738	5,740
	Lower Sauk River (moderately early)	445	445	*200*	371
	Lower Skagit River (late)	1,717	1,717	281	2,131
	Upper Sauk River (early)	871	871	130	470
	Suiattle River (very early)	469	469	170	223
	Upper Cascade River (moderately early)	168	168	130	148
	Stillaguamish R MU (NF + SF)[2]	888	349	400	502
	NF Stillaguamish R. (early)		**297**	300	550
	SF Stillaguamish R. (moderately early)		**52**	*200*	300
	Skykomish River (late)		1,766	400	1,491
	Snoqualmie River (late)		1,233	400	816
Central/South Sound	Cedar River (late)	855	571	*200*	282
	Sammamish River (late)	812	**114**	*200*	*1,250*
	Duwamish-Green R. (late)	4,001	1,043[3]	400	1,700
	White River (early)	2,125	502	*200*	488
	Puyallup River (late)	2,633	1,157	*200*	797
	Nisqually River (late)	687[3]	599	*200*	1,200
Hood Canal	Mid-Hood Canal Rivers (late)	39	**39**	*200*	*1,250*
	Skokomish River (late)	2,749	**335**	452	1,160
Strait of Juan de Fuca	Dungeness River	760	**85**	*200*	925
	Elwha River	3,319	**153**	*200*	*1,250*

Source: Chin3120_BiOpTab.xlsm (J. Carey, NOAA, pers. comm., April, 2020). 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] Exploitation rate over 47% is dependent on NMFS' approval of the Nisqually Indian Tribe's final 2020 selective fishery plan.

[2] 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.

[3] Additional adult Chinook salmon will be transported from hatchery traps to augment spawner abundances—NORs in the Green River, HORs and NORs in the Nisqually.

Test, research, update, and evaluation fisheries that inform fishery management decisions are included as part of the fishery-related mortality reflected in Table 23 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 202 for the North Fork Nooksack and 57 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=202, 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[39]. 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). Preliminary results for the 2019 return indicate substantial spawners from the supplementation program contributing to the spawning population. This was particularly beneficial since the 4yo NOR returns were the product of a very low spawning abundance in 2015 (<10 NOR spawners and few supplementation program returns). 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. 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 0.4 for the North Fork and 1.8 for the South Fork (Table 3). These results indicate a relative lack of response in terms of North Fork natural-origin production given the much higher total natural escapements and a small positive response from the supplementation program in the South Fork, as described in the above paragraphs. 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 1.4. 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; 2008c; PSIT and WDFW 2010a). Exploitation rates during 2009-2016 averaged 30 percent (total) and seven percent (SUS) (Table 13). The 2009-2016 average SUS rate is equal to the exploitation rate management objective for southern U.S. fisheries (SUS) in place during that

[39] 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.

time as defined by the applicable Puget Sound harvest plan[40] (Table 22). Seventy-eight percent of the harvest occurred in Alaska and Canadian fisheries (Table 13).

The anticipated total exploitation rate resulting from the PFMC, PST fisheries and proposed actions is 33.1 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., 7.7 percent (Table 23). With the proposed action, the North Fork population is anticipated to be below its critical thresholds (Table 23), which is cause for concern, although total natural escapement, including the supplementation program spawners, for the North Fork population is anticipated to remain higher than its critical threshold in 2020 given recent year hatchery-origin contribution rates (see Table 3 for comparison of natural spawning escapement and natural-origin spawning escapement). The South Fork population is expected to exceed its critical threshold for 2020. Exploitation rates on the Nooksack population have been reduced 18 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 (2018) 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 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 to allow for harvest of surplus North Fork hatchery fish. While selective gear is one option for the 2020 planned fisheries (Mercier 2020), the overall impact limit in this fishery remains the same, likely incentivizing the continued use of selective gear by some of the tribal fishers. That is, since selective gear has a lower mortality rate, more hatchery fish may be caught per natural-origin fish thus extending the fishery and the increasing the potential harvest under the allowable impact limit. Any proposed extension of the in-river C&S fishery in 2020 beyond June 15 would rely on in-season monitoring and an assessment of impacts to the populations and would need NMFS concurrence (Mercier 2020). In 2020, 88 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 2020, we estimate that at most an additional 15 and 25 natural-origin spawners would return to the North and South

[40] The Nooksack management unit was managed for an objective of 7% exploitation rate in southern U.S. fisheries until 2017 when the new FRAM was implemented. A comparison of exploitation rate estimates under the old and new FRAM indicated the previous objective of 7% was equivalent to a rate of 11% under the new base period. In light of the new information, co-managers revised their objective to 10.5%.

Fork Nooksack early Chinook escapements, respectively and would not change the status of the populations for 2020.

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 2020 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 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. 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 2020 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 for recovery of the Nooksack early Chinook salmon populations —the North Fork program for some time and the South Fork program in the more recent years—are providing substantially increased numbers of returning adults to bolster the spawning populations in each population. These increased numbers of total spawners have the benefit of stabilizing and reducing demographic risks to these populations. Therefore, any substantive constraints to fisheries occurring in 2020 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 1999-2018 is above the rebuilding thresholds for seven populations (Upper Skagit moderately-early, Lower Sauk moderately-early, Upper Sauk early, Suiattle very early, Upper Cascade moderately-early, Skykomish late, and Snoqualmie late), below the critical threshold for the South Fork Stillaguamish moderately-early, and in between for the NF Stillaguamish and Lower Skagit populations (Table 3). Observed productivity from 1999-2015 broods is 1.1 or more for all but the North Fork and South Fork Stillaguamish populations (Table 3) while longer term trends (1990-2015) indicate declining growth in recruitment for the six of the 10 populations (Upper Skagit, Lower Sauk, Lower Skagit, NF and SF 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 stable or increasing for seven 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 13). Between 50 and 64 percent of this harvest occurred in Alaska and Canadian fisheries. Under the proposed action, total exploitation rates for five populations (Suiattle, Lower Sauk, Upper Sauk, Upper Cascade, NF Stillaguamish) are expected to be below their RERs in 2020 (Table 21 and Table 23). Exploitation rates on five populations (Upper Skagit, Lower Skagit, Skykomish, and Snoqualmie, and SF Stillaguamish) are expected to exceed their RERs in 2020. NMFS considers the proposed actions to present a low risk to the five populations for which exploitation rates would not exceed their RERs. Exploitation rates in 2020 for five populations (Upper Skagit, Lower Skagit, Skykomish, Snoqualmie, and SF Stillaguamish) are anticipated to exceed their RERs by a small (1.1 percentage point) to substantial (12 percentage points) amount. The exploitation rates in 2020 Puget Sound fisheries are expected to be relatively low across the four Whidbey/Main Basin management units (6%-23%) (Table 23). All populations in the region except the North and South Fork Stillaguamish are expected to exceed their critical thresholds. Seven of the 10 populations will also exceed their rebuilding thresholds (Table 23) in 2020. For the North and South Fork Stillaguamish, if the proposed actions were not to occur in 2020, we estimate that an additional 3 natural-origin spawners would return to the South Fork and an additional 14 natural-origin spawners would return to the North Fork, which would not provide sufficient additional natural-origin spawners to significantly change the status or trends of the population from what would occur without the fisheries. Additionally, the two supplementation hatchery programs in the Stillaguamish watershed are expected to escape an additional 540 adult fish to augment the North Fork and South Fork spawning populations, reducing any short-term risk for these populations.

In summary, the effects of the proposed actions in 2020 are consistent with the recovery plan guidance, as they will result in at least two to four populations representing the range of life histories displayed in the region being 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 critical and rebuilding abundance criteria given current habitat conditions, representing a diversity of healthy populations in the region as a whole. Exceedance of the RERs for five of the 10 populations in the region indicates some short-term risk from the proposed fisheries. However, 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 2020 for the Upper Skagit, Lower and Upper Sauk, Suiattle, Upper Cascade, Skykomish, and Snoqualmie populations 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 2020. The number of additional spawners that would be gained from further fishery reductions is very 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 population, Chinook populations in this region exhibit a fall type life history and were historically managed primarily to achieve hatchery production objectives. The White River 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 under the Puget Sound Harvest Plan: 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 (high viability) 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 systems 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 and improve their status as impacts of the limiting factors are reduced over time. 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 2020, 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, Puyallup 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, 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 recruitment (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) and its life history type is common within the region.

Natural-origin spawning escapements in 2020 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, White River, and Puyallup (Table 23). The additional contribution of hatchery spawners to natural escapement for most of these populations (Table 23) 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 13), above the RERs for all five management units (Table 21). The Puyallup and White management units exceeded their 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 13).

In 2014, the co-managers examined the available information to identify the factors contributing to the exceedance of Puyallup exploitation rate objective. The estimated exceedances of the annual Puyallup total ER objective (50%) were relatively low, ranging from 1-5%. Based on their review, managers took additional management actions in 2015 and again in 2016 to provide greater assurance that the fisheries would meet the overall exploitation rate limits.[41] In 2018, the co-managers conducted another performance assessment (James 2018b).

As described in the 2018 performance assessment, 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

[41] 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.

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. Mark-selective fishing rules have been implemented recently in the sport fishery resulting in low exploitation rates. Major sections of the river have been closed during openings for the tribal net fisheries for pink, coho, or Chinook salmon to reduce impacts on Chinook. Exploitation rates in the most recent two years of the time series (2015 and 2016) have been well below the 50% objective indicating the actions by the comanagers were effective.

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 (underestimation of actual rates in these fisheries) 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).

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 2020, 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 2020 are projected to result in 1,157 natural-origin fish escaping to the spawning grounds with an additional 1,476 hatchery origin recruits straying to the spawning grounds for a total natural escapement of 2,633. These outcomes will result in natural-origin escapement above the rebuilding threshold. The exceedance of the RER in the 2020 fisheries should not significantly affect the long-term persistence of the Puyallup Chinook salmon.

Exploitation rates in 2020 for four of the five management units are expected to exceed their RERs or RER surrogates for the populations in those management units (Lake Washington representing the Sammamish and Cedar populations, Puyallup, and Nisqually) (Table 23), by substantial amounts. The White River population total exploitation rate in 2020 is expected to be just under its RER. 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 are no indigenous populations remaining in these watersheds because they are extirpated. The observed increasing and stable trends in escapement and growth rate for the Cedar and Sammamish, respectively, should mitigate increased risk possible as a result of exceeding the RER in 2020. In addition, escapement for the Cedar is expected to exceed its rebuilding threshold in 2020 (Table 23). If the Puget Sound salmon fisheries closed in 2020, we estimate that an additional 24 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 = 0.5, Table 3). The low productivity of the watersheds given the much higher level of overall escapement (Table 3 and Table 23) 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 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 for this population in the proposed Puget Sound salmon fisheries is 34.7 percent for a total exploitation rate of 51.9 percent for the 2020 fishing season (Table 23). 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 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 2020 is above the rebuilding threshold (Table 23) and above the level of natural-origin escapement observed in most years since 2010. Escapements in 2016, 2017, and 2018 were much higher than other recent years because of higher than expected returns coupled with more constrained fisheries in those years because of forecasted low abundance. Anticipated total returns in 2020 for the Green River are consistent with the returns from those stronger brood years. The proposed 2020 fisheries were shaped to take advantage of the higher overall abundance, while still reducing the Puget Sound exploitation by 3% and the total exploitation by 2.1% compared with the preseason expectations in 2019.

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, all 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. The resulting increased escapement and shift in spawning distribution, relative to the years preceding 2014, 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.

Under the proposed actions, the comanagers will continue to 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 (Mercier 2020) in 2020. The 1,200-escapement target is the average natural-origin escapement over the recent 10 years 2009-2018 including the the much higher escapements observed in 2016 (2,566), 2017 (2,011) and 2018 (2,231). 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, surplus to the hatchery program needs, will be transferred to the upper Green River spawning grounds to achieve the spawning escapement goal of at least 1,200 natural-origin Chinook. Therefore, management of the fisheries in 2020 will ensure that the gains in recent years to escapement are preserved, with additional opportunities to strengthen the trend[42].

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 35.2 percent for a total exploitation rate of 48.8 percent. This total exploitation rate is inclusive of an additional 1.8% in-river exploitation to evaluate mark-selective removal gears added to the current 47% objective[43] (Table 23). 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.

As mentioned above the Nisqually Indian Tribe's Natural Resources staff propose to conduct a selective fishery gear study in the lower Nisqually River tribal net fishery in 2020. This will be the second year of this 5-year work, the first year (2019) being a trial year for various gear effectiveness at catching fish. This year's work will begin testing the short-term mortality of fish captured in the gear, to begin to estimate what the release mortality of the gear might be. Once the 2020 plan is finalized and NMFS approves, the test fishery may access additional fish in the river up to the equivalent of 1.8% total exploitation rate. This work is focused on development of effective and usable gear in the tribal net fishery, part of a transition strategy to be able to harvest the surplus hatchery-origin fish while limiting the impacts of the in-river fishery, when combine with all other fisheries to a 47% total exploitation rate on the Nisqually population.

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

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[42] Noting the higher returns in 2016, 2017 and 2018 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.
[43] Pending NMFS review and approval of final fishing plan prior to beginning the 2020 test fishery.

longer-term transitional strategy must be coordinated with corresponding habitat and hatchery actions and take into account the current status of the population. The transition will occur over years and perhaps decades as the habitat improves to support better production and the current population becomes locally adapted and less reliant on hatchery production to sustain it. Over the last 15 years, the co-managers have taken significant steps to transition from hatchery goal management to an exploitation rate ceiling approach for the Nisqually population based on impacts to unmarked Chinook.

The co-managers completed a transitional strategy in December 2017 (Nisqually Chinook Work Group 2017) (Mercier 2020). The plan now guides harvest and hatchery actions moving forward, including fisheries in 2020, 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 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 2020 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 2020 is above its critical threshold. Therefore, the additional risks associated with exceeding the RER in the 2020 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 77 percent of the harvest of unmarked Nisqually Chinook in 2020 Puget Sound salmon fisheries.

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 2020. Therefore, implementation of the proposed 2020 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 2020 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 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.

While the overall historical structure of the Hood Canal Chinook salmon populations is unknown, the TRT determined that any early run-timing life history components were extirpated (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). Moreover, recent discontinuation of a supplementation program in the Hamma Hamma River and the resulting decrease in recent year natural-origin returns may indicate the low capacity for production in the absence of supplementation and/or the source stock or river system supplemented may be incompatable. Genetic analysis indicates no difference between fish originating from the George Adams and Hoodsport hatcheries and those currently 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. Beginning in 2005, the co-managers increased mark rates of hatchery fish produced in the Hood Canal Region 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. 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).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 (200K release goal) being collected in 2018 and the expectation of full program in 2020. 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 2020 (Unsworth and Grayum 2016; Speaks 2017; Shaw 2018; Norton 2019a; Mercier 2020). 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 1999-2018, for both the Skokomish and Mid-Hood Canal populations, are below their critical thresholds and productivity is below 1.0 (Table 3). When hatchery-origin spawners are taken into account, average escapement for the Skokomish exceeds its rebuilding threshold. Growth rates for recruitment are declining for both populations and the growth rate for escapement is 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 and the most recent years' low post-supplementation returns are not yet factored into the trends. 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 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 was generally responsible for the increased escapement observed in the Hamma Hamma River. From 2010 to 2018, on average 87% of the Chinook salmon spawning in the Hamma Hamma River were of hatchery origin (WDFW and PSTIT 2009; 2011; 2012; 2013; 2014; 2015; 2016b; 2017b; WDFW and PSIT 2019). 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 13), both well above their RERs (Table 21). 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 13). Alaska and Canadian fisheries accounted for 52 and 20 percent of the harvest of the Mid Hood Canal and Skokomish rivers populations (Table 13).

Under the proposed actions, escapement for both populations is expected to be below the critical thresholds (Table 23). Total exploitation rates for both populations are expected to exceed their RER or RER surrogate (Table 23). For the Mid-Hood Canal population, the exploitation rate in 2020 Puget Sound salmon fisheries under the proposed actions is expected to be low (5.9%; Table 23). If Puget Sound salmon fisheries were closed in 2020, we estimate that less than two additional natural-origin spawners would return to the Mid-Hood Canal population. Approximately 183 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 2020 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 2020 under the proposed actions from Puget Sound salmon fisheries is 31.3 percent with a total exploitation rate in 2020 of 48.3 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, in that timeframe, compared with achieving the RER of 35 percent and a very small change (1 percentage point) in the probability of the population falling below the critical level (NMFS 2011a).

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 22). The ceiling was exceeded by 3 percent to 13 percentage points (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 2020 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, 2018 and 2019 (Bowhay and Warren 2016; Speaks 2017; Shaw 2018) and may continue to be closed in 2020 (Mercier 2020).

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 indicating that additional caution was still warranted. The 2018 performance review indicated errors in FRAM model inputs for Canadian fisheries that were corrected for, adjusting the previous underestimate of fishing mortality by 0.8 percent (James 2018b). With the correction, two of the last four years' estimates of exploitation rates from the most recent FRAM validation runs were equal to the objective and two were higher (Table 22) (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 2020. The conservation objective for Skokomish, developed in the 2010 Puget Sound Chinook RMP (WDFW and PSTIT 2011), was for a 50 percent total exploitation rate ceiling. The proposed 2020 Puget Sound fisheries are forecasted to achieve a 48.3% 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), 2019 (Norton 2019a), and for 2020 (Mercier 2020). 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.

In summary, given the information and context presented above, the fishing regime represented by the proposed actions should adequately protect the two populations in the Region in 2020. Therefore, implementation of the proposed 2020 fisheries will meet the recovery plan guidance by not impeding the viability of at least two 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 (Skokomish and Mid-Hood Canal). The Mid-Hood Canal population may experience increased demographic risk in the given the extremely low forecast for 2020. However, as with the Skokomish River, 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 2020 Puget Sound fisheries would not measurably affect the risks to survival or recovery for the Mid-Hood Canal population.

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 low—1.4 recruits per spawner for Dungeness an 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 in the 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 13, both above their RERs (Table 21). Under the proposed actions, natural-origin escapement is expected to be below the critical threshold for both the Dungeness and the Elwha salmon populations (Table 23). However, when hatchery spawners are taken into account, escapements are much higher, with both populations' total spawners well exceeding their critical threshold and the Elwha exceeding its rebuilding threshold.(Table 3 and Table 23). Total exploitation rates for both populations are expected to exceed their RER surrogates by a substantial margin. This partially reflects an adjustment to the age structure used in the forecast starting in 2020, an improvement agreed-to by the co-managers, which results in an increase to the estimated impact rates overall and of northern fisheries in particular. Over 70 percent of the harvest occurs outside the jurisdiction of the co-managers (Table 13) while exploitation rates in 2020 Puget Sound salmon fisheries are expected to be less than 2.5% (Table 23). If Puget Sound salmon fisheries closed in 2020, we estimate that one additional and no additional natural-origin spawners would return to the Dungeness and Elwha escapements, respectively. Therefore, further constraints on 2020 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 includes hook-and-line, drift and set gillnets, beach seines, and to a limited extent, purse seines. These types of fishing gear in general actively avoid contact with the substrate because of the resultant interference with fishing and potential loss of gear.

Derelict fishing gear can affect habitat in a number of ways including barring passage, harming eelgrass beds or other estuarine benthic habitats, or occupying space that would otherwise be available to salmon. 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 2020/21 fishing season compared to several years and decades ago (previous estimates of derelict nets were 16 to 42 annually (NRC

2010)). In 2018, an estimated eight nets became derelict, and six of them were recovered (James 2019). 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). The Northwest Straits Foundation—from June 2012 to February 2016—reported a total of 77 newly lost nets were reported, and only 6 of these were reported by commercial fishermen (Drinkwin 2016). Based on this information we estimate that a range of six to 20 gill nets may be lost in the 2020/21 fishing season, but up to 75% of these nets would be recovered within days of their loss. The few unrecovered nets are unlikely to affect critical habitat for Puget Sound Chinook 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. These impacts would be localized and transitory in nature. 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). 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 of the various measures described above 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. There will likely be some small adverse effect to critical habitat from derelict fishing gear.

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 incidental harvest rates averaged 4.2% from 2001-2007, across the index populations in Puget Sound (**Table 16**). A key consideration in recent biological opinions addressing the effect of harvest to natural origin steelhead was therefore whether harvest 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 total steelhead in mixed stock marine area fisheries (Table 14); from the time of listing to catches in more recent years and concluded that average catch had declined by 49%, Table 14. 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 16**). In April of 2018 NMFS approved an individual harvest plan for one of the index populations, the Skagit River under the ESA (NMFS 2018b; discussed in Section 2.4.1). As a result, the index populations used for calculating specific and average 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). This was also supported in the 2019 Puget Sound Steelhead Recovery Plan (NMFS 2019h). 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 four 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 (Figure 20 illustrates the marine and terminal areas where fisheries occur) 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?

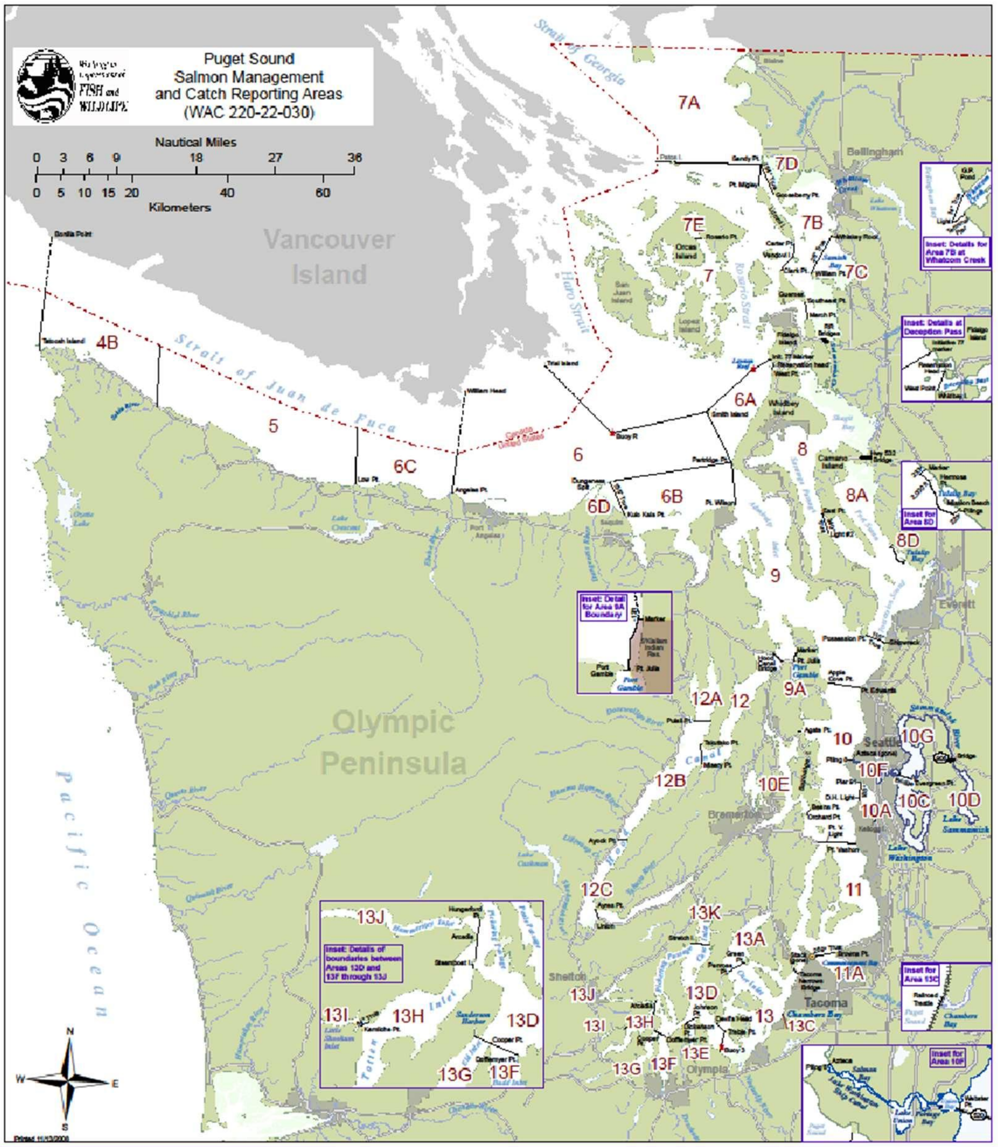

Figure 24. Puget Sound Commercial Salmon Management and Catch Reporting Areas (https://wdfw.wa.gov/sites/default/files/2019-03/wac_220-022-030.pdf).

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 extant 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 extant 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 from 2001/2002 through 2006/2007 as described in Section 2.4.1; Table 14 (NMFS 2011b; 2014b; 2015c; 2016c; 2017b; 2018c). 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 2020-2021 season (Mercier 2020). 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. The catch of steelhead in marine area fisheries in recent years (averaging 159 from 2007/08 – 2018/19) has been well below the 325 reported at the time of listing and better represents what the expected catch is likely to be under the proposed action. As described in Section 2.4.1 and summarized in Table 14, the catch in the more recent period (07/08-18/19) represents a 49% decline from the period prior to listing.

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 (Mercier 2020). 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 16**, 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. 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 may 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 2020/21 fishing season compared to several years and decades ago (previous estimates of derelict nets were 16 to 42 annually (NRC 2010)). In 2018, an estimated 8 nets became derelict, and six of them were recovered (James 2019). 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 2020/21 fishing season, but 75% or more of these nets would be recovered within days of their loss. The few unrecovered nets is unlikely to affect critical habitat for Puget Sound Chinook 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. These impacts would be localized and transitory in nature. 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. Because of the various measures described above are part of the proposed actions, 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/DPS 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 used depth and mortality information to estimate the proportion of listed rockfish killed as a result of the state regulation limiting gear deeper than 120 feet deep (consultation number F/NWR/2012/1984/ and WCR-2017-8426). This allowed us to use similar methods as the PFMC (2008b) 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 24).

Table 24. 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 2020/21 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 24 to estimate mortality rates for caught and released yelloweye rockfish 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 recreational 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[44] 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 2019a). In 2019, WDFW estimated that anglers targeting salmon caught zero bocaccio and zero yelloweye rockfish (WDFW 2020c).

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 2020/21 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), 295,000 fishing trips targeted salmon in 2017 (WDFW 2018), 177,925 trips in 2018 (WDFW 2019a), and 328,428 trips in 2019 (WDFW 2020c).

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

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

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, resulting in a conservative abundance scenario and potential overestimate when evaluating 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 fish (WDFW 2011) (Table 25). 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 25. 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	0.001	0.05

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 26). 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 26. 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	0.02	1.7

In addition to fishery mortality, rockfish are killed by derelict fishing gear (Good et al. 2010), though we are unable to quantify the number of yelloweye rockfish and bocaccio killed by pre-existing derelict gear or new gear that would occur as part of commercial fisheries addressed in the proposed actions. As elaborated in Section 2.4.3.4, due to changes in state law, additional outreach and assessment efforts (i.e. Gibson 2013), and recent lost net inventories (Beattie and Adicks 2012; Beattie 2013; James 2017) it is likely that fewer nets (likely six to 20 annually) will become derelict in the upcoming 2020/21 fishing season compared to several years and decades ago. Because of the low number of anticipated derelict gill nets, it is likely that few (if any) yelloweye rockfish and bocaccio mortalities will occur from new derelict gill nets, and that any additional mortality would not induce additional risk to any population.

2.5.3.1 Effects on Populations

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 (Walters and Parma 1996; PFMC 2000), 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).

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.

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 deepwater 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 25).

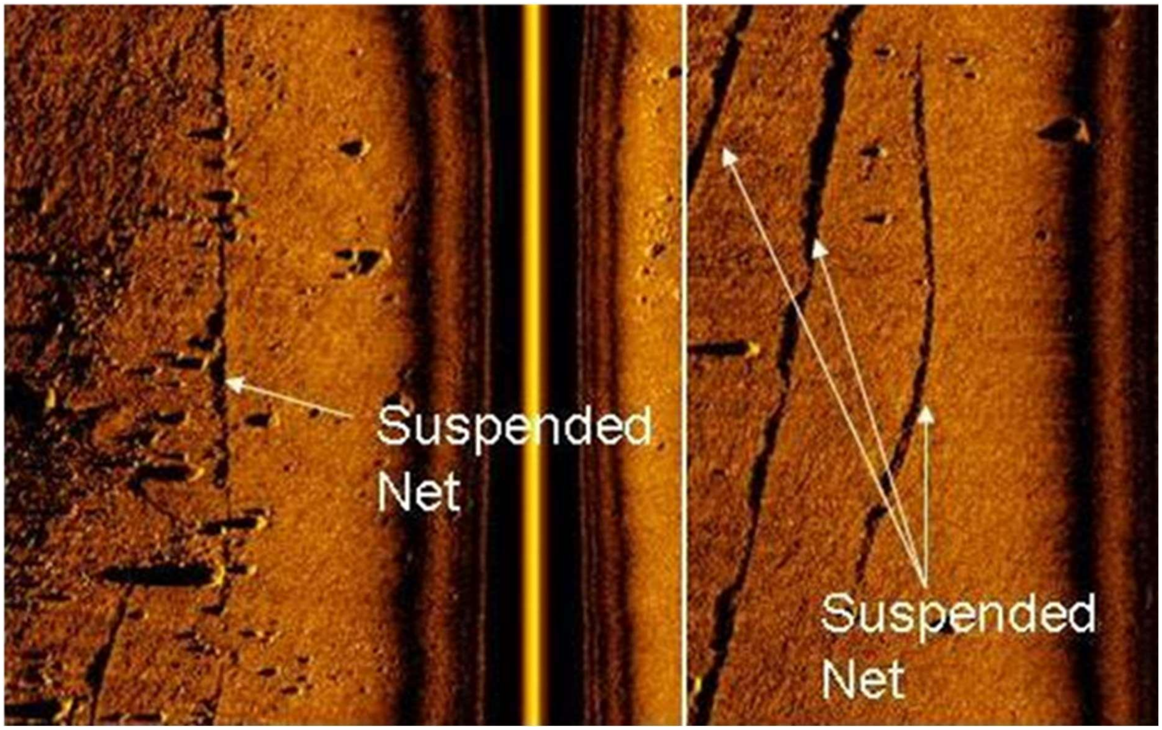

Figure 25. Sidescan sonar images of derelict nets located on Point Roberts Reef of the San Juan basin. Suspended nets have a larger acoustic shadow than nets flush with the bottom. Image used by permission of Natural Resource Consultants (NRC).

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 2020/21 fishing season compared to several years and decades ago (previous estimates of derelict nets were 16 to 42 annually (NRC 2010)). In 2018, an estimated eight nets became derelict, and six of them were recovered (James 2017). 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 2019/20 salmon fisheries. Based on this new information we estimate that a range of six to 20 gill nets may be lost in the 2020/21 fishing season, but up to 75%-80% 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 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. NMFS has incorporated analyses from the draft PFMC Salmon Fishery Management Plan Impacts to Southern Resident Killer Whales Final Draft Risk Assessment February 2020 (PFMC 2020) into this biological opinion where appropriate. NMFS has also incorporated analyses from WDFW (Cunningham 2020) and the NWIFC (Loomis 2020) regarding the 2020/2021 fisheries and SRKWs to assess the direct and indirect effects of the Puget Sound salmon fisheries on SRKWs.

Direct Effects: 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 in the inland waters and the distribution of the proposed fisheries. 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. First we describe the general predicted overlap of the whales and the 2020/2021 fisheries using historical seasonal SRKW sightings, then we describe the potential interactions (e.g., vessel strike, gear interaction, vessel or acoustic disturbance) and potential responses (e.g., mortality, serious injury, behavioral changes).

<u>Overlap of Puget Sound Salmon Fisheries and SRKWs</u>
As described in the Status section, Southern Residents occur in inland waters throughout the year (Table 27) and have typically spent a 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). This area has been identified as an important foraging area for Southern Residents in the summer months (Figure 27 and Figure 28) (Hanson et al. 2010; Shedd 2019). On average, the three pods have been observed in inland waters more often starting in May and June and would spend a considerable amount of time in inland waters through September (Table 27). 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). As discussed in the Status section, the whales' seasonal movements are only somewhat predictable because there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall. For example, K pod has had variable occurrence in June ranging from 0 days of occurrence in inland waters to over 25 days (Figure 15). In 2019, there were no observed sightings of SRKWs in the inland waters between April and July. Late arrivals and fewer days present in inland waters have been observed in recent years (Hanson and Emmons (2010); The Whale Museum unpubl. data). On average, encounters with J pod in inland waters occur more often than encounters with K and L pods (Table 27).

Table 27. Monthly pod occurrence in inland waters (Olson 2017). J-Pod= yellow, K-Pod= dark blue, J & K-Pod= light blue, J & L-Pod= dark green, and J, K & L-Pods=light green, (p)=partial, and ?=no positive identification on the sightings.

<table>
<tr><th>Year</th><th>JAN</th><th>FEB</th><th>MAR</th><th>APR</th><th>MAY</th><th>JUN</th><th>JUL</th><th>AUG</th><th>SEP</th><th>OCT</th><th>NOV</th><th>DEC</th></tr>
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<tr><td>2008</td><td>J, K & L</td><td>J & L</td><td colspan="3">J</td><td colspan="6">J, K & L</td><td>J, K & L (p)</td></tr>
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Updated: 4/1/2017 (JKO)

[Compiled by TWM staff from records maintained by Orca Survey, C.W.R. (1976-82), The Whale Museum's Hotline (1978-present), the Marine Mammal Research Group's Hotline (1985-2003), Bob Otis' Lime Kilm 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)]

Table 28. 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

MONTH	AVERAGE OBSERVED DAYS			MAXIMUM OBSERVED DAYS		
	J	K	L	J	K	L
OCT	16	14	13	22	21	22
NOV	12	9	6	16	16	12
DEC	10	10	5	18	18	10

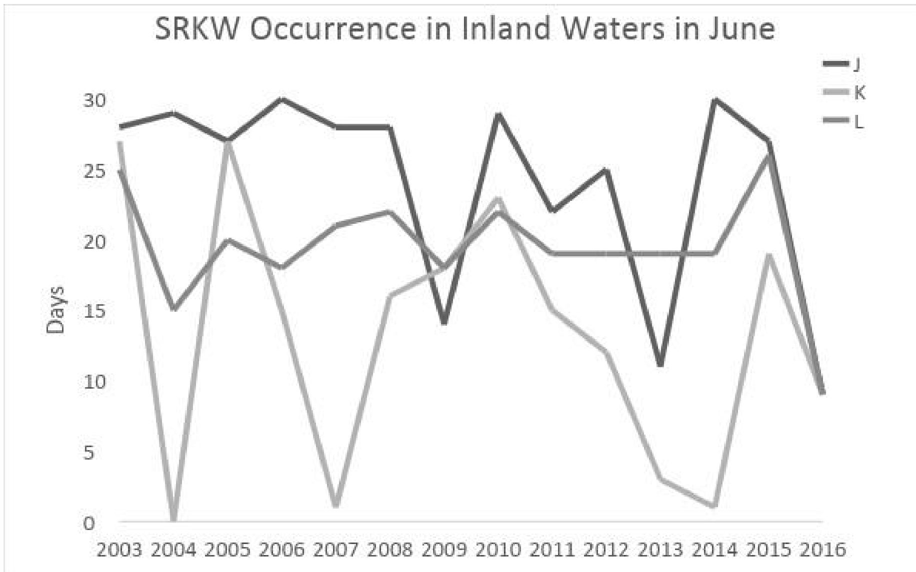


Figure 26. Number of days of SRKW occurrence in inland waters number in June for each year from 2003 to 2016 (data from The Whale Museum).

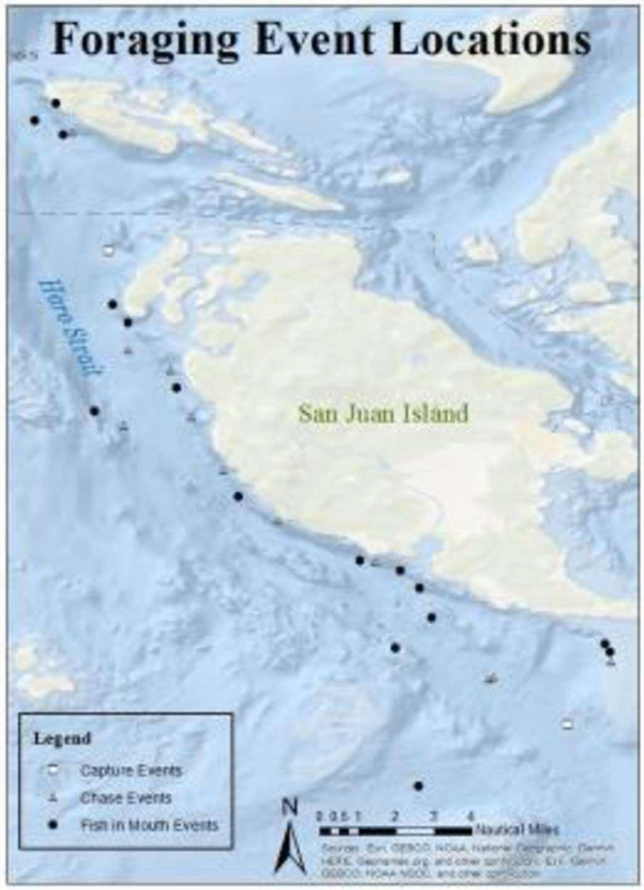


Figure 27. Foraging events observed in the Salish Sea in September 2017 (Shedd 2019).

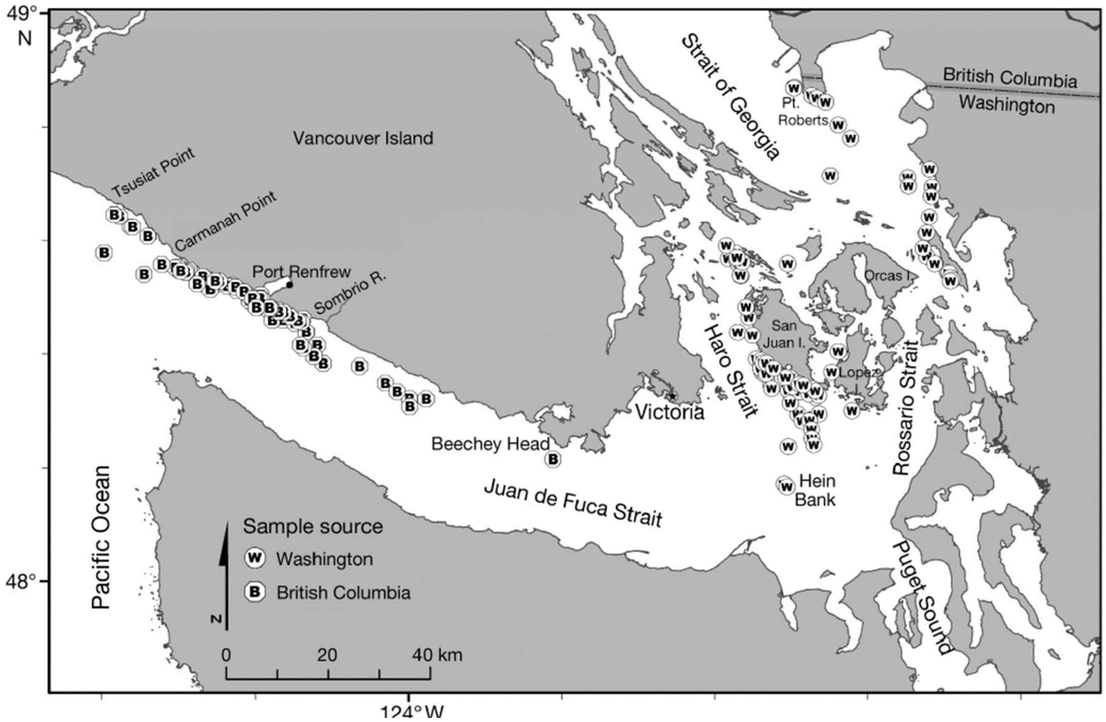


Figure 28. Foraging events observed in the Salish Sea from May to September 2004 to 2008 (Hanson et al. 2010).

The vessels associated with the Puget Sound salmon fisheries overlap with the whales, particularly in the San Juan Island area, or Washington Catch Area 7 (WCA 7) (Figure 29) in July through September (as described in previous Puget Sound fishery biological opinions, e.g. NMFS (2019c)). In 2020, the recreational Chinook salmon mark-selective fishery (MSF) in WCA 7 will occur from July 1, 2020 through July 31 and August 16-31 (Table 29). Anglers will be allowed a daily limit of up to two hatchery Chinook salmon. The WCA 7 recreational fishery will be non-retention August 1-15 and September 1-30. This area is a key foraging area for the whales during summer months and the non-retention requirements in the recreational fishery are anticipated to reduce impacts from vessels slightly (we anticipate lower vessel effort in non-retention fisheries) and to reduce impacts to prey available (as discussed below) to Southern Residents in the times and areas of high importance. Puget Sound recreational fishery closures in 2020/2021 also occur in the winter time period (Oct.-Apr.) and include the complete winter closure to Chinook fishing in Marine Areas 6, 7, 8, 9, 11, and 12 (Figure 29). These closures are substantial compared to recent fishing seasons and, recognizing that winter fisheries in Puget Sound are typically of a low magnitude (both effort and catch) relative to other Chinook-directed fisheries along the West Coast, may provide some small benefit to J pod given their occurrence in inland waters throughout the year (Cunningham 2020). Overall, the 2020/2021 recreational Chinook season in WCA 7 is reduced by 1.5 months relative to 2019 (Cunningham 2020).

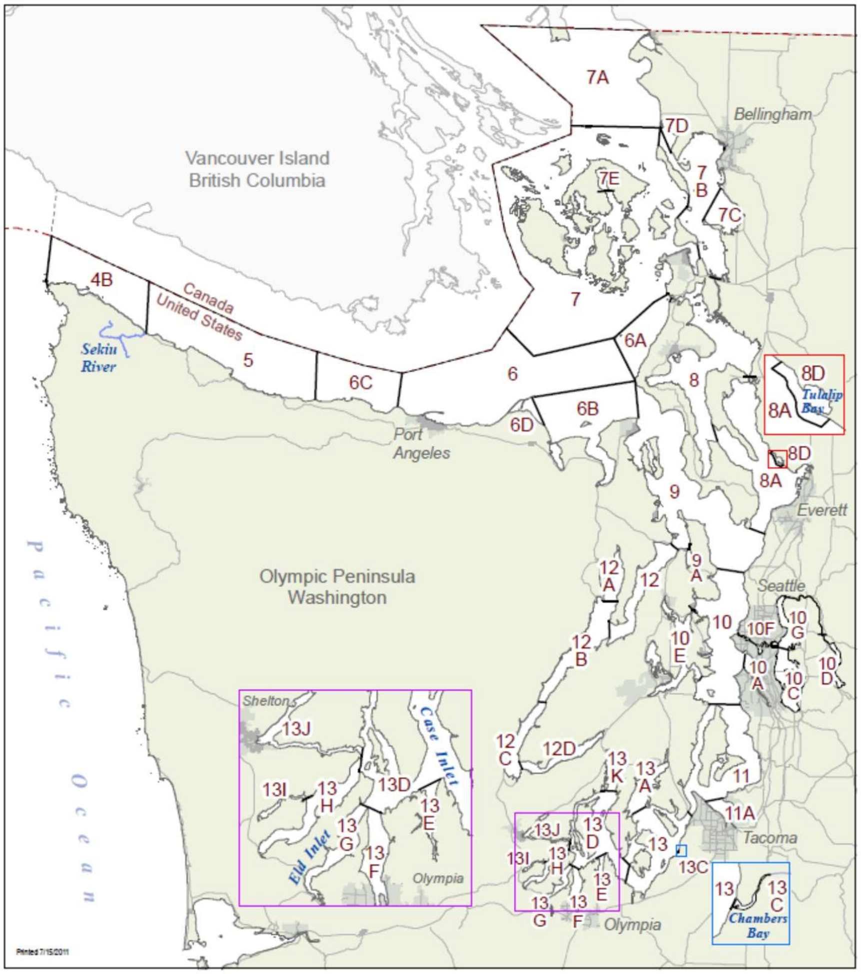


Figure 29. Puget Sound Fishing Zone Map and Catch Reporting Areas (reprinted from Cunningham (2020)).

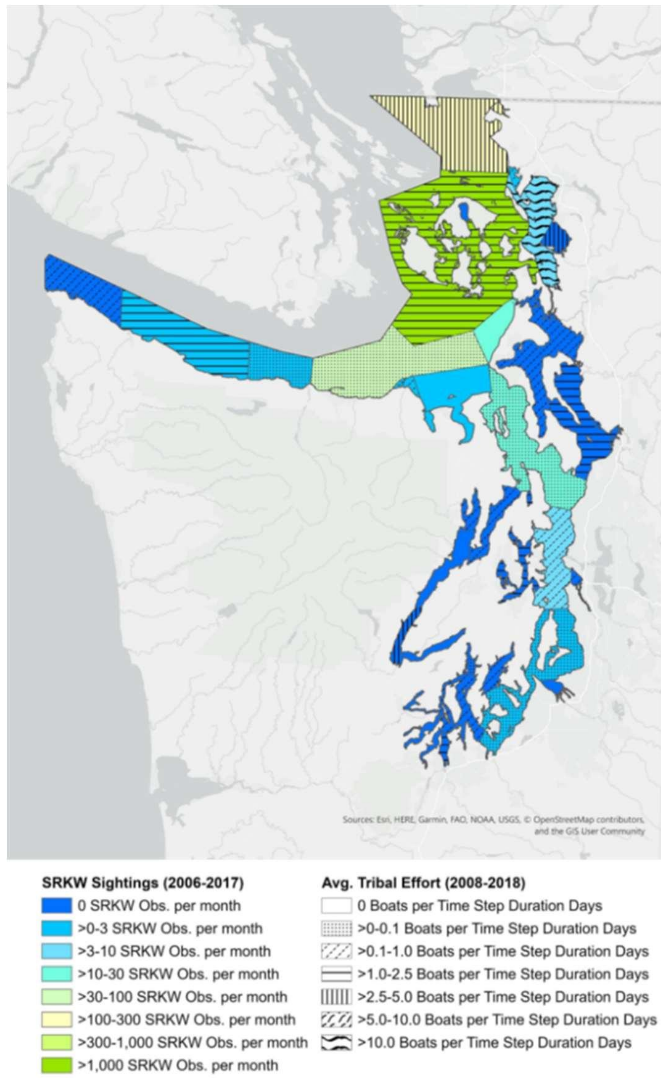
Table 29. Puget Sound Marine Pre-Season Recreational Chinook Seasons in Marine Area 7 (MA7) (2017 – 2020). MSF- Mark Selective Fishing; NS- Non-Selective; NR- Non Retention; Gray shaded cells indicate closed season. Months with split cells change management mid-month (e.g, NR/MSF means non-retention the 1st-15th of the month and mark selective fishing the 16th to the end of the month).

Year	May	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
2017			MSF	NS	NS				MSF	MSF	MSF	MSF
2018			MSF	NS	NR				MSF	MSF	MSF	MSF
2019			MSF		NR					MSF	MSF	MSF
2020			MSF	NR/ MSF	NR							

Commercial salmon fishing vessels licensed by WDFW also operate in WCA 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. In 2020, these vessels target sockeye returning to the Fraser River. During the Fraser fishery, Chinook salmon are required to be released by purse seines. The number of days fished in WDFW managed commercial purse seine and gillnet fisheries in WCA 7 and 7A (San Juan Islands and Point Roberts areas, respectively) during 2008, 2012, and 2016 averaged 7.3 days in August and early September Cunningham (2020). For 2020, these commercial fisheries in these areas targeting Fraser River sockeye are likely to be zero or dramatically reduced compared to these earlier years (based on the low Fraser River sockeye forecast with no harvestable surplus).

Tribal fishing in pre-terminal areas within Puget Sound is predominately directed at salmon species with Chinook salmon catch being incidental (Loomis 2020). The temporal and seasonal effort observed in recent years for tribal fisheries is not expected to change substantially over the duration of 2020/2021 (Loomis 2020). Therefore, to assess the potential spatial/temporal overlap of tribal vessels with SRKWs within the inland waters in 2020/2021, we considered the NWIFC analysis of tribal salmon fisheries effort (defined in terms of boat days as measured by unique fish tickets) in previous years overlapping with SRKW sightings (Loomis 2020). The recent 5-year average tribal fleet size (as defined by unique fish tickets) is 755 vessels. Assessing the potential for interaction utilizing the SRKW sightings and unique fish ticket data indicates that there is little overlap (Figure 30). This assessment indicates that the areas of highest use by the whales with the greatest interaction with tribal fisheries yields an average of 2.5 vessels per time step day.

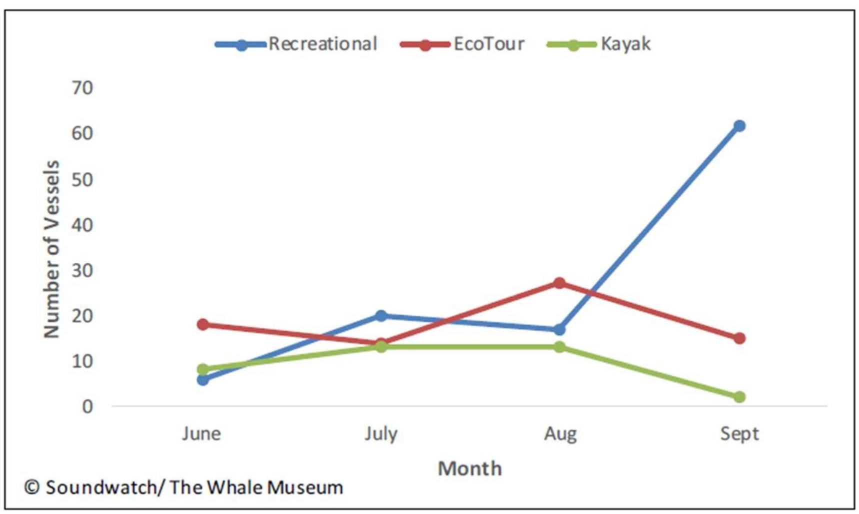
Figure 30. Average overlap of tribal fishing vessels (measured by unique fish tickets) and Southern Resident killer whale sightings in the summer months (FRAM timestep 3, July – September) (reprinted from Loomis (2020)).



To put the number of Puget Sound salmon fishing vessels in WCA 7 in the summer months in context, we use the Soundwatch Boater Education Program's long-term data set because it provides insight into annual trends of vessel activity near the whales. The Soundwatch Boater Education Program collects data on the number and types of vessels within ½ mile of the whales during the summer months in inland waters. Given the 2020/2021 recreational, commercial and tribal fisheries seasons are similar or reduced compared to recent years, we would expect a similar potential for overlap of the vessels with the whales observed in previous years (if we assume similar average SRKW seasonal movements).

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 32) (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 inconsistent with Be Whale Wise guidelines and the federal vessel regulations 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 (Shedd 2019).

In 2019, the annual maximum number of total vessels observed in a ½ mile radius of the whales was 29, which was the lowest maximum number of vessels recorded by Soundwatch (Shedd 2020). The majority of maximum vessel counts occur on the west side of San Juan Island in Haro Strait near Eagle Point (Shedd 2020). Of the vessels observed and contacted that were in proximity to SRKWs, 2% were engaged in fishing, 38% were transiting through the area, and 60% were actively engaged or intended to engage in whale watching activities (Shedd 2020). This decrease in maximum vessels may be attributed to the recent updates to the Pacific Whale Watchers Association (PWWA) guidelines, which limit the maximum number of commercial whale watching vessels around a single group of whales. This decrease could also be linked to increased dispersion by the whales, limited or closed fishing seasons, as well as other possibilities. In 2019, 72% of all incidents of vessel activities inconsistent with the Be Whale Wise Guidelines and non-compliant with federal regulations were committed by private/recreational motor vessels, 6% private sailing vessels, 7% commercial kayaks and 2% private kayaks, 5% Canadian commercial vessels, 5% U.S. commercial vessels (10% EcoTour) and 2% by commercial fishing vessels (Figure 32).



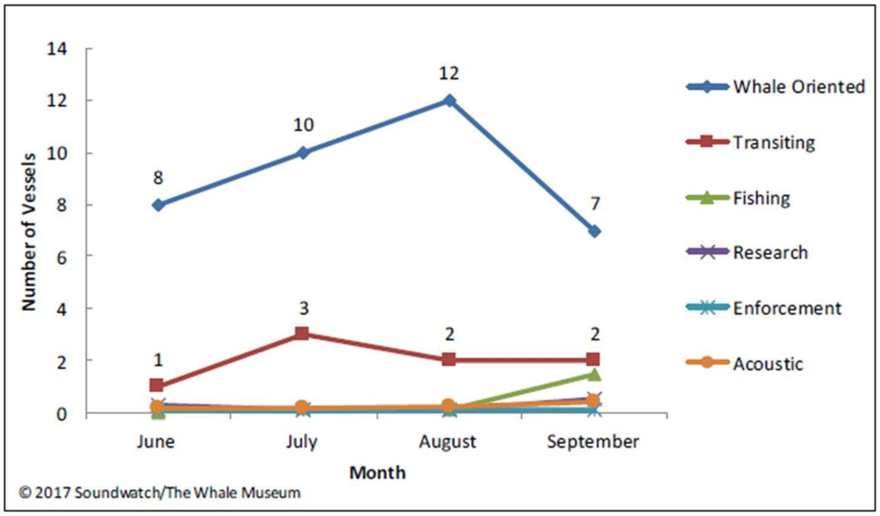
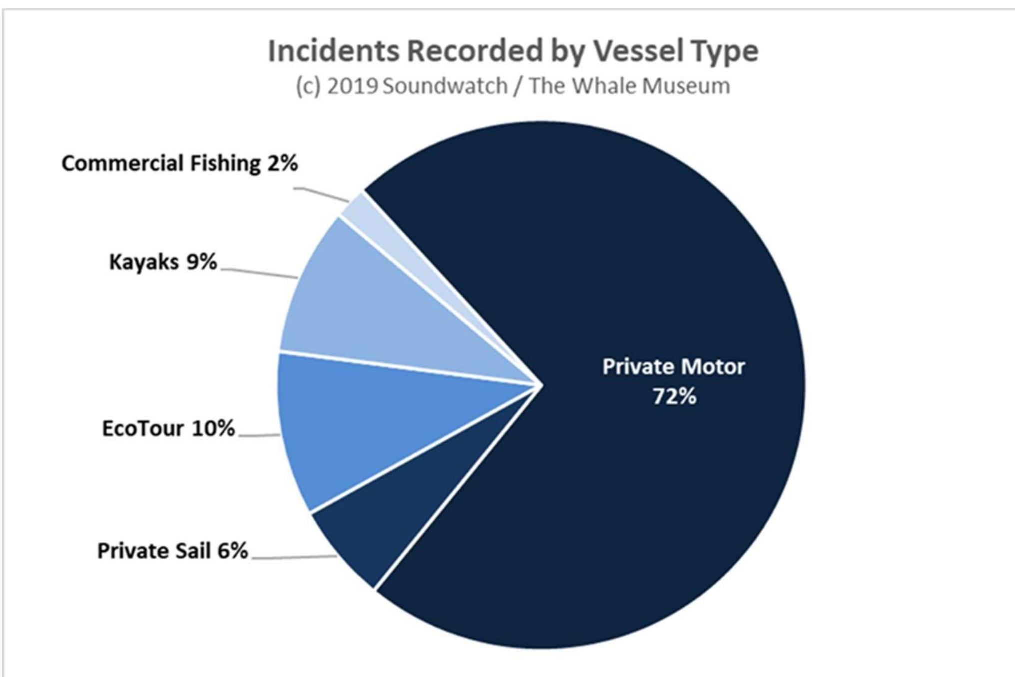


Figure 31. Monthly maximum (top) and average numbers (bottom) of vessels near Southern Resident killer whales by vessel type and activity in 2017 (Figures from Seely (2017)).

Figure 32. Incidents in 2019 recorded by vessel type (reprinted from Shedd 2020).



<u>Potential Interactions and Responses</u>

Interactions with Puget Sound fishing 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 in general have been observed (as described in the Environmental Baseline), entanglements are rare. NMFS, through its List of Fisheries (LOF), monitors and categorizes bycatch of marine mammals in all commercial fisheries according to relative risks of mortality and serious injury (M/SI)[45]. 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. 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. The List of Fisheries for 2019 classified the "WA Puget Sound Region salmon drift gillnet" fisheries (Treaty Indian fishing is excluded) as a Category II fishery (i.e., occasional interactions that result in M/SI) due to incidental takes of harbor porpoise, Dall's porpoise, and harbor seals (84 FR 22051, May 16, 2019). The overall take of marine mammals in this fishery is unlikely to have increased since the fishery was last observed in 1993, owing to reduction in the number of participating vessels and available fishing time since 1994. All other Puget Sound commercial fisheries are classified as Category III fisheries (i.e., remote likelihood of/no known interaction that would result in M/SI). Although vessel strikes and gear entanglement with SRKWs are unlikely, NMFS will evaluate the need for additional actions 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). Williams et al. (2006) reported lost foraging opportunities in Norther Resident killer whales in the presence of vessels and similar studies found 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

[45] Stocks as defined under the MMPA. These may not necessarily coincide with ESA-listed populations of marine mammals.

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.

Private vessels commonly come within a ½ mile of the whales in inland waters (Shedd 2019), and some private vessel users are likely to be recreational and commercial fishers associated with the proposed action. We have little information about the precise number of recreational and commercial fishers who would not engage in recreational boating if the proposed fishery were not authorized, and therefore 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 fisheries will result in more recreational and commercial fishing 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 in some areas of the action area such as WCR 7 in the summer months when the whales are present.

If fishing vessels were to co-occur with SRKWs, vessel and acoustic disturbances may cause behavioral changes, avoidance, or a decrease in foraging (e.g. vessel 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). Some of the disturbances may result in less efficient foraging by the whales than would occur in the absence of the vessel effects. However, 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. The greatest effects would be expected to occur in WCR 7 in the summer months where the potential for overlap of the whales and fisheries are the greatest. Two factors that influence the likelihood and extent of disturbance are the use of propulsion, sonar, and depth finders (acoustic effects) and vessel speed. The potential for acoustic effects from sonar and depth finders is limited by the fact that standard practice for tribal pre-terminal fishing does not generally include sonar and depth finders (Loomis 2019).

In addition, fishing vessels operate at slow speeds or in idle when actively fishing. When in transit, vessels would likely travel at faster speeds with potential to affect the whales' behavior; however, fishing vessels do not target whales, and any disturbance that may occur would likely be transitory.

WDFW also included additional measures as part of the proposed action to further reduce impacts from non-tribal fishing 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 WCR 7 for all recreational boats—fishing and non-fishing—and commercial fishing vessels (with the exception of the Fraser Panel

sockeye fisheries[46]) (Figure 33). 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 the San Juan County Marine Stewardship Area[47] extended in 2018 and the full protected area recognized by the Pacific Whale Watch Association[48] 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 No Go zone to be consistent with any outcomes of current marine spatial planning processes.

Figure 33. An approximation of the Voluntary "No-Go" Whale Protection Zone, from Mitchell Bay to Cattle Point (Shaw 2018).

3. Currently WDFW enforcement boats conduct coordinated patrols with the U.S. Coast Guard, NOAA Office of Law Enforcement, and San Juan County Sheriff's Office year-

[46] 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).
[47] https://www.sjcmrc.org/projects/southern-resident-killer-whales/
[48] https://www.pacificwhalewatchassociation.com/guidelines/

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 WCA 7 are specifically targeted to enforce regulations related to killer whales. These patrols will be increased in intensity at times SRKW calves are present. For comparison, in 2017, WDFW Police conducted 55 patrols; in 2018, they conducted 140 patrols; and in 2019 they conducted 105 patrols specific to WCA 7 during the summer (Cunningham 2020).

In summary, the proposed action is expected to result in Puget Sound fishing vessels occurring 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 and physical disturbance. Although vessel and acoustic disturbance are potential threats to SRKWs, fishing vessels operate at slow speeds or in idle when actively fishing. When in transit, vessels would likely travel at faster speeds with potential to affect the whales' behavior; however, fishing vessels do not target whales, no interactions of Puget Sound fishing vessels and SRKWs have been reported and any disturbance that may occur would likely be transitory. Fishing vessels also will be subject to new state regulations when transiting state waters that protect SRKWs, which includes vessel viewing distances 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 (see RCW 77.15.740), and otherwise subject to guidelines to avoid impacts to whales. There is a small number of tribal fishing vessels in the areas the whales spend the majority of their time in (e.g. 2.5 vessels per day in WCA 7) and sonar use and depth finders are not standard practice for pre-terminal tribal fisheries. In addition, with the current forecasts, there is no harvestable surplus for commercial salmon fishing vessels that target sockeye returning to the Fraser River, reducing vessel presence in important SRKW foraging areas. Lastly, the non-retention requirement in September and part of August is expected to slightly reduce recreational vessels, and a complete closure of the winter fisheries in WCAs 6, 7, 8, 9 and 11 are expected to minimize vessel impacts that may also benefit SRKWs, primarily J pod. Overall, the direct impacts from fishing vessels are expected to be relatively low in 2020/2021, similar to previous years, based on the reduced presence of fishing vessels in the key foraging areas (e.g. 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 enforcement. As a result, we expect that any fishing vessels in the vicinity of SRKWs are not likely to disrupt normal behavioral patterns nor have the potential to disturb by causing disruption of behavioral patterns. Ongoing monitoring of vessel activities near the whales will allow for tracking reductions in fishing vessel activity when whales are in key foraging areas.

Indirect Effects: Reduction of primary prey

We evaluated the potential indirect effects of the Puget Sound salmon fisheries on SRKWs based on the best scientific information about the whales' diet and distribution and the reduction in Chinook caused by the Puget Sound salmon fishing. 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. More recently, the PFMC formed the ad-hoc SRKW workgroup (Workgroup) to reassess the effects of PFMC-area ocean salmon fisheries on the Chinook salmon prey base of SRKW. In March 2020, the PFMC adopted the risk assessment as a final draft pending completion of an Executive Summary (PFMC 2020). A final risk assessment is expected at the June 2020 PFMC meeting. We relied on the PFMC SRKW Ad Hoc Workgroup report (PFMC 2020) where appropriate as well as the analyses described in Cunningham (2020) and Loomis (2020) that assess the impacts of recreational, commercial, and tribal fishing to SRKWs.

Similar to past biological opinions where we assessed the effects of fisheries (NMFS 2018c; 2019f) our analysis of Puget Sound salmon fisheries focuses on effects to Chinook salmon availability because the best available information indicates that Chinook salmon are the SRKWs primary prey (as described in the Status section) and this provides a conservative approach to assessing impacts from prey reductions. Focusing on Chinook salmon provides a conservative estimate of potential effects of the action on SRKWs because the total abundance of all salmon and other potential prey species is orders of magnitude larger than the total abundance of Chinook. This analysis considers whether effects of that prey reduction may impact the fitness of individual whales or affect survival and recovery.

First, we discuss the relationship between SRKWs and their primary prey, Chinook salmon. We then discuss our evaluation on the potential indirect effects of changes in prey availability from the Puget Sound salmon fisheries in 2020/2021 described further below. The analysis also 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.

Relationship between Southern Resident killer whales and Chinook salmon

Previous studies have found correlations between Chinook salmon indices and Southern Resident killer whale demographic rates (e.g. fecundity and mortality) (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 fecundity or survival). Another study found a significant relationship between the observed demographic patterns in the SRKW population with the biennial pattern in abundance of pink salmon (Ruggerone et al. 2019). The authors, however, provide no clear mechanistic explanation for this relationship but offer up a couple of hypotheses including that in high abundant pink salmon years (odd years), SRKW foraging efficiency declines thereby reducing the whales' nutritional status and affecting the survival in the subsequent year.

In recent years, the relationship between Chinook salmon abundance and SRKW demographic rates have weakened (e.g. SRKW status continues to decline with varying levels of Chinook abundance) and uncertainty remains. There are several challenges to quantitatively characterize the relationship between SRKWs and Chinook salmon. As described in PFMC (2020), the results of statistical models relating indices of Chinook salmon abundance to measures of SRKW demographic rates are sensitive to several factors. Attempts to compare the relative importance of any specific Chinook salmon stocks or stock groups using the strengths of 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. Different Chinook salmon populations are likely more important in different years. Large aggregations of modeled

Chinook salmon stocks that reflect abundance on a more coastwide scale appear to be equally or better correlated with SRKW 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 in diet samples as key sources of prey for SRKWs during certain times of the year in specific areas (Hilborn et al. 2012; Ward et al. 2013). There are also multiple interacting factors at play, and the strength of any one effect likely varies through time, leading to a situation known as "non-stationarity". These multiple threats affect SRKW's demographic performance through time, in addition to random chance, and these effects can confound the analysis of the effects of prey abundance.

Lacy et al. (2017) developed a PVA model that attempts to quantify and compare the three primary threats affecting the whales (e.g. prey availability, vessel noise and disturbance, and high levels of contaminants). The Lacy et al. (2017) model relies on published correlations using older data, assumes the correlations represent a causative relationship, and models SRKW demographic trajectories assuming that the relationship is constant over time. These assumptions (correlation represent causation, etc.) were previously criticized by a panel of experts and they cautioned against overreliance on correlative studies, particularly the prey relationships used in the Lacy et al. model, in evaluating reduced harvest impacts on the whales (Hilborn et al. 2012). Furthermore, the small population size may limit the ability to detect a relationship to input into a PVA and as the Workgroup risk assessment results suggest, these relationships are likely not constant over time. (PFMC 2020).

The Workgroup related past SRKW demographic performance with estimates of Chinook salmon abundances in specific time steps (October – April, May – June, and July – September) and areas (off the coasts of Washington, Oregon, California and in the Salish Sea and off SWVCI) (PFMC 2020). However, similar to past efforts, they also found predicting the relationship between SRKWs and Chinook salmon to be challenging. Although one of the fitted regressions met the criterion of statistical significance ($p \leq 0.05$) (winter Chinook abundance North of Falcon and SRKW survival with one year time lag) and several regressions had $p \leq 0.10$ in times and areas where whale presence is known to be most likely (Salish Sea abundance and SRKW survival with one year time lag in Oct – Apr had $p=0.0707$; May-June $p=0.0717$; July-Sep 0.0872) caution should be used when interpreting these results. One limitation to the regression analysis is the difference in distribution between J pod and K and L pods. For example, in the winter, J pod appears to remain much more within the Salish Sea relative to K and L pods that spend more time in coastal waters, thus it is likely that they would have differential responses to changes in the abundance of particular aggregates of Chinook stocks compared to K and L. However, considerable statistical power is lost when analyzing one pod at a time due to lower sample sizes. As a result the Workgroup examined all three pods together. Based on the new available information on the whales' distribution and diet and supported by the Workgroup's regression analysis, they found Chinook salmon abundance in North of Falcon[49] coastal areas to likely be most consistently important to the whales. Chinook salmon abundance in the Salish Sea, and Southwest Coast Vancouver Island are likely important as well (PFMC 2020).

As discussed in the Status section, nutritional stress as a chronic condition can lead to reduced body size and condition of individuals (e.g., Trites and Donnelly 2003). In general, killer whales

[49] The North of Cape Falcon (NOF) management area encompasses the Washington coast and northern Oregon (the coastal waters from U.S./Canadian border to Cape Falcon, OR).

physically mature at age 20 and the body stops growing (Noren 2011). Reduced body condition and body size has been observed in Southern and Northern Resident killer whale populations. For example, Groskreutz et al. (2019) used aerial photogrammetry to measure growth and length in adult Northern Resident killer whales, which prey on similar runs of Chinook salmon, from 2014 to 2017 and found adult whales that were 20 – 40 years old have significantly shorter body lengths than those older than 40 years of age, suggesting the younger mature adults had experienced inhibited growth. Similarly, adult Southern Residents that were under 30 years of age that were measured in 2008 by the same photogrammetric technique were also shorter on average than older individuals also suggesting reduced growth (Fearnbach et al. 2011).

What appears to be constrained growth in both resident killer whale populations occurred in the 1990s - during a time when range-wide abundance of Chinook salmon in multiple subsequent years fell below the 1979 – 2003 average (Figure 34) (Ford et al. 2010). The low Chinook salmon abundance and smaller growth in body size in whales was concurrent with an almost 20 percent decline from 1995 to 2001 (from 98 whales to 81 whales) in the SRKW population (NMFS 2008g). During this period of decline, multiple deaths occurred in all three pods of the SRKW population and relatively poor survival occurred in nearly all age classes and in both males and females. The Northern Resident killer whales also experienced population declines during the late 1990s and early 2000s. Hilborn et al. (2012) stated that periods of decline across killer whale populations “suggest a likely common causal factor influencing their population demographics” (Hilborn et al. 2012).

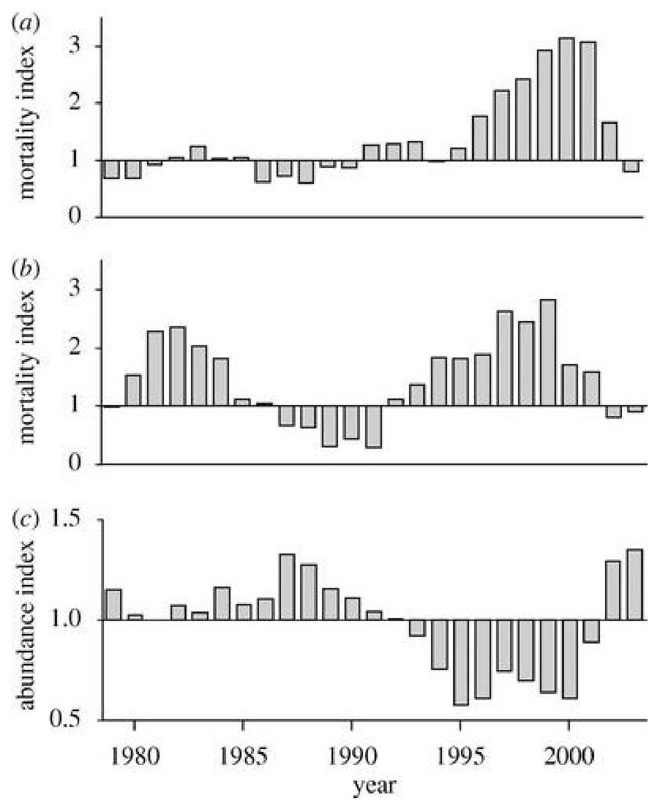


Figure 34. Annual mortality indices for a) Northern Resident and b) Southern Resident killer whales and c) abundance index of Chinook salmon from 1979 to 2003 (reprinted from Ford et al.

(2010)).

During this same general period of time of low Chinook abundance, declining body size in whales, and declining resident killer whale populations, all three SRKW pods experienced substantially low social cohesion (Parsons et al. 2009). This temporal shift in SRKW social cohesion may reflect a response to changes in prey. Although both intrinsic and extrinsic factors can affect social cohesion, it has been generally recognized the most important extrinsic factors for medium and larger terrestrial carnivores are the distribution and abundance of prey (Parsons et al. 2009). In social animals, once optimal group size occurs (that is based on intrinsic an extrinsic factors), the response to reduced prey abundance for example could include "group fissioning". However, this may not always be the case, especially if the benefit of "cooperative care" or food sharing outweighs the cost of the large group size. The authors note that smaller divisions within the pod's matrilines may temporarily occur in SRKWs as opposed to true fission but this warrants further investigation. Good fitness and body condition coupled with stable group cohesion and reproductive opportunities are important for reproductive success.

Intuitively, at some low Chinook abundance level, the prey available to the whales will not be sufficient to allow for successful foraging leading to adverse effects (such as reduced body condition and growth and/or poor reproductive success). This could affect SRKW survival and fecundity. Although there is currently no quantitative model that identifies a low abundance threshold that will cause adverse effects, there is evidence SRKW and other killer whale populations that are known to consume Chinook salmon may have experienced adverse effects from low prey availability in the late 1990s likely due to common factors affecting changes in the populations (NMFS 2008g; Towers et al. 2015).

To assess coastal salmon fisheries in 2020, NMFS identified a low abundance threshold for Chinook salmon abundance in waters north of Cape Falcon (the average abundance of the years 1994 - 1996, 1998 - 2000, and 2007 NOF) and recommended that if the NOF abundance was equal to or less than the threshold, the PFMC should implement precautionary conservation measures for PFMC salmon fisheries that affect the abundance in NOF waters (this includes salmon fisheries in Washington, Oregon, and California waters) to benefit SRKW (NMFS 2020a; 2020b). We acknowledge there is uncertainty in developing a low abundance threshold. The relationships between modeled Chinook salmon abundance and SRKW demographics examined by the SRKW Workgroup appear to be weaker than those from prior analyses as mentioned above (Ford et al. 2005; Ford 2009; Ward et al. 2009; Ward et al. 2013). There is uncertainty on what the whales' status would be below the low abundance threshold. It may be that multiple consecutive years of low abundance as that observed in the late 1990s are important to consider rather than a single low year. Despite the uncertainty, NMFS believes the low abundance threshold is the best available approach given that declining body size in whales, declining resident killer whale populations, and substantially low social cohesion in all three SRKW pods occurred during a period of time that had low Chinook abundance at or below the abundance threshold.

Populations with healthy individuals may be less affected by changes to prey abundance than SRKW (i.e., there may be a spectrum of risk based on the status of the whale population). Because SRKW are already stressed due to the cumulative effects of multiple stressors that could be additive or synergistic, reductions in Chinook salmon abundance likely have a greater physiological effect, which may have negative implications for SRKW vital rates and population viability (NAS 2017). For example, food scarcity could cause whales to draw on fat stores, mobilizing the relatively high levels of contaminants stored in their fat and potentially affecting reproduction and immune function (Mongillo et al. 2016). Increasing time spent foraging during reduced prey availability may also decrease the time spent socializing and reduces reproductive opportunities.

Effects of Prey Reduction Caused by the Proposed Action

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 2020/2021 (e.g. percent reduction in overall abundances from the fisheries). Second, we considered information to help put the reduction in context including 1) translating the reductions of Chinook salmon from the proposed fishing into biological context by relating it to the whales' energy requirements, 2) 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 3) 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.

In order to estimate how prey reduction from Puget Sound fisheries affects Southern Residents, we refer to methodology developed by the PFMC Workgroup (PFMC 2020) and adapted for Puget Sound fisheries as described in Cunningham (2020) and Loomis (2020). The analysis of the effects of Puget Sound fishing on salmon availability for 2020/2021 uses a different methodology than the previous Puget Sound fisheries biological opinions (e.g. NMFS 2019, NMFS 2018); therefore we caution that percent reductions and abundance in this biological opinion are not comparable to previous Puget Sound fisheries opinions. It should be noted that NOAA, the Puget Sound treaty tribes, and WDFW are exploring potential improvements to this analysis and its specific application to Puget Sound.

To assess reductions in prey availability from the Puget Sound fisheries, the FRAM stocks were combined into coarser aggregate stocks using the state-space model developed by Shelton et al. 2019. Table 30 provides abundances that represent starting SALISH region (aggregated Puget Sound, San Juan Islands, Juan de Fuca, and Georgia Strait) abundance in October and the annual and percent reductions of Chinook salmon from the Puget Sound fisheries throughout the entire management year. The estimated starting abundance (prior to natural or fishing mortality) of Chinook (age 3-5 years) in 2020 in the "SALISH" region in October is approximately 628,000 Chinook. This is slightly above the recent 10-year post-season average of approximately 612,000 total abundance (2007 through 2016; Table 30). A portion of that abundance is made up of Puget Sound Chinook (43% in 2020 compared to 1992-2016 average of 35%). Reductions to Salish Sea Chinook abundances caused by pre-terminal fisheries have decreased over time (see Table 30). In fact, the 2020 predicted return of adult Puget Sound Chinook salmon that will escape pre-terminal fisheries is approximately a 10% increase over the most recent ten-year average and a 15% increase over the available data series 1975-2018[50] (Cunningham 2020). The slightly higher annual starting abundance of Chinook salmon in 2020 and the predicted increase in escapement

[50] Historic data (1975-2018) comes from the Puget Sound Chinook run reconstruction.

from pre-terminal Puget Sound fisheries suggests slightly better conditions of prey availability for SRKWs in the action area in 2020 compared to the average conditions over this last decade. Percent reductions in prey in 2020/2021 are expected to be similar to the average annual reductions in the most recent decade (relatively low compared to decades prior as described the Environmental Baseline) and are estimated to be 3.33% relative to the starting abundance (Cunningham 2020).

Table 30. Estimated starting abundance (beginning of FRAM timestep 1; October) of age 3-5 Chinook in the "SALISH" Shelton et al. model (Shelton et al. 2019). 2007-2016 represent estimates from post-season FRAM runs (validation round 6.2). The annual abundance reduction and percent reduction are the difference between post-fishing (pre-terminal) September Chinook abundance from the validation runs and Chinook FRAM validation runs with no Puget Sound fishing (Cunningham 2020). Average values indicated in bold font.

Year	October Abundance	Annual Abundance Reduction	Percent Reduction of Total
2007	546,292	25,696	4.7%
2008	599,589	21,566	3.6%
2009	441,117	16,476	3.7%
2010	823,667	19,880	2.4%
2011	607,614	22,089	3.6%
2012	521,929	21,077	4.0%
2013	740,847	25,240	3.4%
2014	634,667	16,798	2.6%
2015	639,575	16,558	2.6%
2016	568,810	15,601	2.7%
07-16 Avg.	**614,411**	**20,098**	**3.33%**

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, impacts of Puget Sound tribal fisheries on Chinook salmon have been higher in terminal areas compared to pre-terminal areas (tribal pre-terminal fisheries primarily target sockeye, pink or chum salmon). The NWIFC estimated that average annual impact on Chinook salmon is split approximately 77/23 between terminal and pre-terminal tribal fisheries.

In addition to considering the overlap because of the location of some fisheries, the timing of fisheries is also important in evaluating effects on the whales. Evidence suggests that there is a higher likelihood of SRKWs having reduced body condition in winter months. In addition to Chinook biology, which suggests fish are more concentrated in the summer than the winter, and SRKW dietary studies, which suggest greater diet diversification during the winter, recent photogrammetry data has recorded J pod body condition declining over the winter period (as described in the Status section). Unlike K and L pods, which typically distribute along the West

Coast in the winter, J pod primarily remains in the Salish Sea during the winter. Puget Sound fishery closures in 2020/2021 focus on the winter time period (Oct.-Apr.) and include the complete winter closure to recreational Chinook fishing in Marine Areas 6, 7, 8, 9, 11, and 12 (Table 29). Although the winter fisheries in Puget Sound are typically of a low magnitude (both effort and catch) relative to other Chinook-directed fisheries along the West Coast, may provide some small benefit to J pod.

It is helpful to consider the magnitude of prey reductions in the context of the timing, location, and also the energetic needs of the whales. To consider the prey reduction from Puget Sound fisheries in context of the energetic needs of the whales, in previous biological opinions we have estimated the ratio of Chinook food energy available to the whales compared to their needs. As described above, the analysis in this year's opinion has been updated and is different than past years. Using Noren (2011) estimates of daily prey energy requirements and the demographics of the SRKW population, using the Shelton et al. model and FRAM to estimate Chinook abundance, and using a different range of estimated kcal per fish (see below) than what was used in our previous consultations (previously the average caloric density of Chinook was assumed to be 16,386 kcal/fish), the NWIFC (Loomis 2020) estimated the energetic needs of the whales. Their analysis shows that the entire population of whales requires between 11.31 million kcal (lower bound) and 13.57 million kcal (upper bound) per day. Those daily estimates were expanded by the number of months in each FRAM time step to estimate the population need: time step 1 (7 months, lower bound: 2.41 billion kcal, upper bound: 2.89 billion kcal), time step 2 (2 months, lower bound: 687.97 million kcal, upper bound: 825.66 million kcal) and time step 3 (3 months, lower bound: 1.03 billion kcal, upper bound: 1.24 billion kcal).

The NWIFC (Loomis 2019) estimated available kilocalories available to the whales using the following method. Fork lengths calculated by FRAM were transformed into kcal according to the formula kcal = 0.000011 * (fork length ^ 3.122) (O'Neill et al. 2014, formula 15). Adult Chinook in this analysis have on average between 3,944 kcal/fish and 10,944 kcal/fish depending on the area (O'Neill et al. 2014). Based on their analysis abundances in kcals for time step 1 have varied from a low of 2.96 billion kcal of Chinook in Puget Sound in 1995 to a high of 5.23 billion kcal in 2003. That can be compared to removals in time step 1 that have ranged from a low of 1.04 million kcal in 2016 to a high of 86.16 million kcal in 1992.

The NWIFC (Loomis 2020) estimated in some years, Chinook availability in the Salish Sea would have been less than the estimated caloric needs of SRKW in the winter (FRAM time step 1). This was the case in 1994 – 1996, 2000, 2007 – 2009, 2012, and 2018, or nine out of the 25 years. However, not all three pods are present in the Salish Sea every day in the winter and SRKWs consume other prey including coho and chum that add to the available calories for SRKW. During years or seasons when the ratio of Chinook prey available to meet the whales' needs is relatively low (i.e. similar to winter in 1994 – 1996, 2000, 2007 – 2009, 2012, and 2018), any additional measurable reduction can be a concern. Given the 2020/2021 Chinook abundance in October is estimated to be slightly above average, we anticipate the prey available in 2020/2021 will be relatively average (i.e. not relatively low and above the estimated caloric needs of the whales in the winter). Furthermore, with closures of recreational fishing in winter months for 2020/2021, and low tribal effort throughout Puget Sound (less than 10 boats per day per marine area; (Loomis 2020)) there would be a minor effect from the Puget Sound fisheries in the time period NWIFC found to have the lowest ratios.

The proposed fishing would reduce the available prey primarily in the summer months; however, we are unable to quantify how a small change in prey availability from fishing in the summer months for 2020/2021 (3.3% prey reduction) compared to the whales' caloric needs would affect foraging efficiency of the whales. 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, e.g. Chasco et al. (2017)).

Another context to consider for prey reductions from fisheries is the potential for 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, 2018 and 2019 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 3.3% 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, the current Chinook abundance models are not able to analyze prey reductions at a finer scale.

We can also look at the proposed fisheries in 2020/2021 and compare to previous years to evaluate potential for more localized depletion. As described above, the 2020/2021 fishery includes some changes in recreational fishing to reduce impacts to Chinook salmon including reduced impacts in WCA 7. For example, recreational salmon fisheries in Puget Sound which directly overlap in time and space with SRKW foraging activity have been curtailed in recent years (e.g. 2019 and 2020/2021) including changes from non-selective fishing to closure, non-retention, or mark selective fishing to address conservation needs for various stocks of ESA-listed Puget Sound Chinook. Similarly, commercial fishing is also expected to be relatively low compared to previous years, as discussed above. 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. (e.g. 2017 and 2018, see Table 30).

In summary, the proposed actions are expected to cause a 3.3% reduction in abundance of age 3-5 Chinook salmon in inland waters in 2020/2021 which is relatively low, similar to the average of this last decade, and estimated to have an increase in pre-terminal escapement. The starting Chinook abundance in 2020/2021 is also estimated to be slightly higher than the most recent 10-year average and higher than the years that had winter abundances below the estimated caloric needs of SRKW in the winter (e.g., 1994 – 1996, 2000, 2007 – 2009, 2012, and 2018). 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. Not all of the fish caught in the fishery would have been intercepted and consumed by the whales. This is also a period when forage ratios are higher than in winter (based on the new methods used in this opinion). Although some of the prey reduction occurs in an area known for its high use and is considered a foraging hotspot (e.g. WCA 7), recreational fishery restrictions in the summer (mark selective and non-retention) and winter (closure), likely very limited commercial fishing due to no harvestable surplus in Fraser River sockeye, and minor tribal fishing (approximately 2.5 boats per day), will likely reduce the impacts in this hotspot. Because SRKW are already stressed due to the cumulative effects of multiple stressors that could be additive or synergistic, small percent reductions can lead to reduced fitness, increased foraging effort, and less energy acquired. We anticipate small reductions in prey in 2020/2021 similar to recent years, in part because of reduction in fishing to protect vulnerable salmon populations (as described in the Chinook salmon Effects section) and the additional measures WDFW proposed to further reduce impacts from vessels that may also reduce impacts to prey availability. However, we do not expect these changes to persist or be so large that they result in more than a minor change to the overall health of any individual whale. 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.

Limitations and uncertainties

Here we briefly describe some limitations and uncertainties of the Workgroup analysis that we relied upon for estimated Chinook abundances and impacts on the SRKWs prey base from the fisheries (these uncertainties are described in more detail in PFMC (2020)).

Historically, Chinook salmon stocks were far more abundant than they currently are. However, the analysis is limited to Chinook salmon abundances for the years 1992-2016. There are uncertainties in these retrospective Chinook abundance estimates (as well as in abundance forecasts). These abundances rely on harvest and escapement estimates, which contain their own uncertainties, and also depend on assumptions such as constant adult natural mortality rates across years (although natural mortality likely varies across years). Chinook abundance estimates also rely on mortality associated with fish caught but released, drop-off mortality, and bycatch mortality in other fisheries that are not accounted for in the management models. There is also uncertainty in the estimated fishing mortalities. The fishing mortality estimates by stock, age, fishery and FRAM time step is based on coded wire tag recoveries from fishing years 2007–

2013. If stock distributions differ considerably from what occurred during this period of time, or if tagged and untagged fish have different distributions, these fishery mortality estimates would be less realistic and prey availability for Southern Residents could be over- or under-estimated.

There is also uncertainty in Chinook stock distributions, particularly on Chinook salmon distributions during the winter, and there is limited information for most spring-run stocks (PFMC 2020). As described above, the Workgroup used the Shelton et al. (2019) distribution model to estimate Chinook abundance in particular time and areas, but the model is subject to uncertainty due to sampling error in harvest data, assumptions about how catch per unit effort scales with local abundance, and similar assumptions as that discussed above (e.g. natural mortality, similar distributions between tagged and untagged fish, etc.). Additionally, the time steps in Shelton et al. (2019) are offset by a month relative to the FRAM model. Finally, the spatial model ignores changes in Chinook salmon spatial distribution within each timestep, and assumes that the effects on Chinook salmon abundance from fishery removals are distributed across space in proportion to Chinook salmon abundance, rather than based on where fishery removals actually occur and how quickly fish redistribute themselves across space.

The models described in PFMC (2020) assume that the effect of Chinook salmon abundance in a particular season and area is the same every year (i.e. assume stationarity), and the same for all pods, regardless of where SRKW actually spent the most time that year, and do not account for any variation at finer spatial or temporal scales than those defined by the model. The logistic regressions used for survival and fecundity assume that all whales of the same age (fecundity) or sex/stage (survival) have identical probabilities of giving birth or dying in a given year, ignoring individual variability (aside from excluding whales who gave birth the prior year from the fecundity analysis). Among the conclusions by Hilborn et al. (2012) were that "considerable caution is warranted in interpreting the correlative results as confirming a linear causal relationship between Chinook salmon abundance and SRKW vital rates". These relationships are likely non-linear, the relationships may be influenced by small sample sizes of killer whale births and deaths, and the relationships may arise from uncertainties in the indices of Chinook abundance used for fisheries management.

Much of the knowledge of SRKW distribution is based on sightings reported in the inland waters of the Salish Sea, especially in summer months (Hauser et al. 2006; Olson et al. 2018). The distribution of SRKW year to year can be characterized as variable, and possibly subject to short term trends. Over the last several years, for example, many social groups of the SRKW population have not spent much time in inland waters during the summer relative to their historical occurrence (Olson et al. 2018). For non-summer months, sighting data is generally limited. Several satellite tags have been deployed on SRKWs and acoustic recorders have been deployed primarily in Washington waters, but also off Oregon and California, to characterize coastal distribution. Data from these deployments suggest differences in distributions between J pod and K/L pods (J pod appears to remain much more within the Salish Sea relative to K and L pods that spend more time in coastal waters) (Hanson et al. 2018). Thus it is likely that they would have differential responses to changes in the abundance of particular Chinook stocks. However, considerable statistical power is lost when analyzing one pod at a time due to lower sample sizes. As a result all three pods were examined together.

The degree to which killer whales are able to or willing to switch to non-preferred prey sources (*i.e.*, prey other than Chinook salmon) is also largely unknown, and likely variable depending on the time and location. We took a conservative approach to assessing impacts from prey reductions by assuming whales consume solely Chinook salmon and do not account for varying abundance and availability of alternative prey sources in these analyses. Previous genetics work has suggested that SRKWs switch from Chinook to other salmon in fall months (particularly coho and chum salmon; (Ford et al. 2016)). Given Chinook salmon are consumed throughout the whales' range and prey samples indicate they are consumed the majority of the time, we assume the whales prey switch if their primary prey, i.e. Chinook salmon, are not available.

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.

The proposed fishing is expected to reduce prey quantity and availability in critical habitat as a result of 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 estimate for starting abundance (i.e., in October and does not include natural mortality or mortality from harvest) of age 3-5 Chinook in designated critical habitat is approximately 628,000, slightly above the recent 10-year average of approximately 612,000 (2007 through 2016) and the proposed action is likely to result in reductions in prey quantity and availability by 3.33% (similar to average impacts in this last decade). 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, the NWIFC (Loomis 2020) 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. This year's prey availability is not expected to be lower than the whales' energy needs as was the case in 1994-1996, 2000, 2007-2009, 2012, and 2018. Overall, the Puget Sound fisheries would reduce the available prey and slightly lower the ratio of prey available compared to the needs of the whales. 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, the proposed action is expected to cause a 3.3% reduction in abundance of age 3-5 Chinook salmon designated critical habitat in 2020/2021 which is relatively low, similar to the average of this last decade, and estimated to have an increase in pre-terminal escapement. The starting Chinook abundance in 2020/2021 is also estimated to be slightly higher than the most recent 10-year average and higher than the years that had winter abundances below the estimated caloric needs of SRKW in the winter (e.g., 1994 – 1996, 2000, 2007 – 2009, 2012, and 2018). 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. This is also a period when forage ratios in critical habitat are higher than in winter (based on the new methods used in this opinion). Although some of the reduction occurs in a core area known for its high use and is considered a foraging hotspot (e.g. WCA 7), recreational fishery restrictions in the summer (mark selective and non-retention) and winter (closure), likely very limited commercial fishing due to no harvestable surplus in Fraser River sockeye, and minor tribal fishing (approximately 2.5 boats per day), will likely reduce the impacts in this hotspot. We anticipate small reductions in prey in 2020/2021 in critical habitat similar to recent years, in part because of reduction in fishing and the additional measures WDFW proposed to further reduce impacts from vessels that may also reduce impacts to prey availability.

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, the amount of disturbance caused by the fishing vessels may 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 may 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 compared to the most recent 10-years based on the reduction in overlap of fisheries and whales in the summer core area (e.g. zero or dramatically reduced commercial fisheries, non-retention and mark selective recreational fisheries in August and non-retention in September, and small tribal fisheries (2.5 boats in the summer months) in WCA 7, which includes the summer core area, and winter closures in recreational fisheries in multiple areas as described above), 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 WCA 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 2008 and 2019, there have been two recorded vessel strikes to humpback whales that occurred off of Clallam County, WA, one vessel strike near Neah Bay in 2018, and a vessel strike in 2019 off of Bainbridge (NMFS WCR Strandings database, 2019). However, we have no recorded evidence of a collision between a salmon fishing vessel and humpback whales in the action area. Fishing vessels do not target marine mammals, operate at relatively slow speeds, remain in idle, or the engine is off when actively fishing. While the fishing vessels do produce noise, the amount of additional noise produced within the action area is unlikely to cause harm to the humpback whales. Vessels would have a short-term presence in any specific location and any disturbance from vessels and noise would be minimal. Therefore, we consider the potential for effects relating to vessel strikes to be discountable and the disturbance from vessels and noise to be insignificant.

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; Saez et al. 2020). 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. This analysis will therefore focus on the interactions between Puget Sound salmon fisheries gear and ESA-listed humpback whales. We first summarize available information on interactions that have occurred in the past, then we assess the likelihood of future interactions based on the co-occurrence of ESA-listed populations of humpback whales with Puget Sound salmon fisheries. Finally, we consider and describe the potential extent of impacts that may occur for ESA-listed populations of humpback whales based on the available information on the extent of Puget Sound salmon fisheries.

Previous Interactions of Humpback Whales with Puget Sound Salmon Fisheries

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[51] by NMFS through the LOF as required by the MMPA. The LOF lists U.S. commercial fisheries (not including tribal fisheries occurring under this plan) 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. In order to accomplish this task, NMFS often relies upon data provided by the use of fisheries observers.

The LOF for 2019 classified the Washington salmon purse seine, WA salmon reef net, and CA/OR/WA salmon troll fisheries all as a category III (i.e., remote likelihood of/no known incidental mortality or serious injury of marine mammals) (84 FR 22051, May 16, 2019). The prediction of future interactions between humpback whales and these gear types occurring when there has never been a documented interaction to have occurred before, 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, salmon reef net, and troll gear and humpback whales, 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. Therefore, we consider the potential for effects relating to these gear types to be discountable.

From 2007 to 2018, gillnet entanglements along the West Coast, predominately in Southern California but including four Washington gillnets, represent 6 percent of all reported humpback whale entanglements along the West Coast of the US, with the most gillnet entanglements occurring in 2018.

In 2019, the Puget Sound region salmon drift gillnet fishery (defined in LOF 2019 as that which includes all inland waters south of US-Canada border and eastward of the Bonilla-Tatoosh line-Treaty Indian fishing is excluded) 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 are not one of the species currently driving this classification[52]. In 1993, observers were placed onboard vessels in the Puget Sound region drift gillnet fisheries as part of a pilot program to monitor sea turtle and marine mammal interactions. No incidental takes of humpback whales were documented. This fishery has not been observed since 1994.

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 (Carretta et al. 2019a; Muto et al. 2019) and a Serious Injury and Mortality Report published annually (Carretta et al. 2019c). 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

[51] Stocks as defined under the MMPA. These may not necessarily coincide with ESA-listed populations of marine mammals.

[52] Harbor porpoise inland WA is driving the current classification.

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 (not just those that lead to M/SI) that can be found in the most current drafts of these reports and NMFS's entanglement response database. We acknowledge uncertainty of the severity of injury and the impacts to the humpback population around the most recent data because they have not yet gone through the serious injury determination process.

From 2007 to 2016, there were no documented humpback whale entanglements in gear that was known to or may have been associated with salmon fishing gear in Puget Sound (Carretta et al. 2019c). In 2017, there was one humpback whale reported entangled in gillnet gear of unknown origin off of San Juan Island. Although the whale was resighted with no gear, the gear was not recovered and therefore was not identified. In 2018, three humpback whales were reported entangled in gillnet gear that was part of the Puget Sound salmon fishery in the in inland Washington waters, in the Strait of Juan de Fuca (NMFS WCR entanglement database, 2019). One additional entangled humpback whale was reported off the coast of Port Angeles, WA that was also confirmed to have a gillnet entanglement, but the specific fishery of origin is unknown. Of the three gillnet entanglements in 2018, one resulted in the death of the whale, and the status of the other two are unknown. While there have been occurrences of entanglements of humpback whales in Washington gillnet fisheries, these have been infrequent (Carretta et al. 2019c). There were three reports of humpback whale entanglements in inland waters of WA in 2019 with unidentified gear (Fisheries 2019).

Likelihood of Interactions in 2020

This review focuses on the degree of overlap of humpback whales with gillnet fisheries based on the interactions with this gear type discussed above. While there have been interactions with reef net fisheries in other areas, these have been infrequent and have not happened in the Salish Sea. To determine the likelihood of interactions of humpback whales with Puget Sound pre-terminal (open marine waters) gillnet salmon fisheries in 2020 that are part of this action, we assessed the overlap of humpback whale sightings in the last two years and active pre-terminal gillnet fisheries. We assume that the areas with greater overlap will also have a greater likelihood for potential interactions. Specifically, we examined citizen sighting reports of humpback whales to Orca Network, a non-profit organization dedicated to raising awareness of whales of the Pacific Northwest, during each time period within Washington Catch Areas (WCA) (Figure 35) that were open in 2018 and 2019. A total of 915 unique sightings[53] were reported over the two year period[54]. The number of humpback whale sightings reported within the Salish Sea do not reflect the total number of whales in the Salish Sea due to the opportunistic nature of citizen sighting reports. The location of the sightings were then compared with the LOAF[55] for the 2018-2019 and 2019-2020 seasons. In Table 31, we provide the number of humpback whale sightings in

[53] 'Unique sightings' in this context mean a sighting of a humpback whale in a specific area of the Salish Sea at a specific time. Sightings within two hours of each other within the same area were considered the same sighting and only one was recorded. The reported sightings here likely include multiple sightings of the same whale on the same day in the same area. As such the number of sightings does not equate to the number of individual whales in the Salish Sea at a given time. These represent rough estimates and do not consider movement of whales between the Marine Areas.

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

[55] Fisheries often do not occur as often as provided for in the LOAF.

2018 and 2019 in each WCA where net fisheries occurred. The LOAFs group some WCAs together (i.e. 4B, 5, 6C). To be consistent with this grouping, our analysis similarly grouped sightings within these areas. Other areas were grouped to better reflect the movement of the whales through those portions of the Salish Sea. Humpback whale sightings within Canadian waters that run the length of the international boundary between Washington State and British Columbia were included in the estimates of humpback whale sightings.

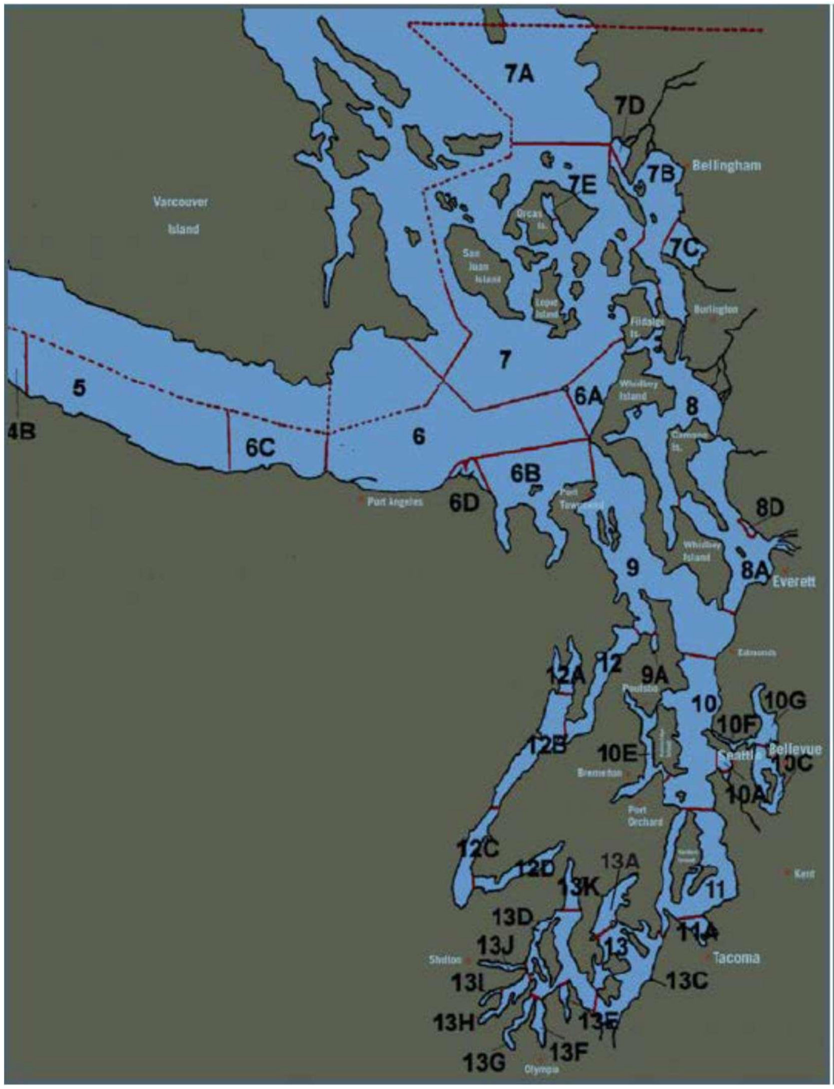


Figure 35. Puget Sound Fishing Zone Map and Catch Reporting Areas (Source: 2006 WDFW commercial salmon regulations, Prepared by Preston Gates & Ellis LLP).

Table 31. Number of humpback whale sightings and overlap with active fisheries, including test fisheries. Within each month is the number of "unique" whale sightings reported to Orca Network. Cells are shaded

if the sightings overlapped with an open gillnet fishery for all or a portion of the month. WCAs open for a short portion of a month were considered open for the full month. WCAs were grouped consistent with the LOAFs. Areas 10, 10A, and 10E along with 13 A-H were grouped to better reflect the movement through these areas. Fraser River Panel Control was assumed to allow gillnet fishing.

Marine Fishing Areas	June		July		August		September		October		November	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
4B,5,6C	5	4	46	120	99	191	221	88	30	18	13	6
6, 7, 7A	22	18	23	44	14	31	11	41	23	19	9	18
9	10	9	15	42	7	23	22	48	41	25	12	
10,10A,10E	9	5	5	23		7	4	8	2		4	
11	7	2	2	18			1	1	32		33	1
11A	3						1				1	
13A-H	3		7			1					1	

The Puget Sound salmon gillnet fisheries are generally open for a period of time between June and December, depending on the WCA. While many of the WCA showed overlap, the largest degree of overlap between open gillnet fisheries and the number of humpback whales unique sightings occurred in the Strait of Juan de Fuca pre-terminal areas (WCAs 4B, 5, and 6C). This was also the location of the three humpback whale entanglements in gillnet gear that occurred in 2018. However, the pre-season estimate of Fraser River sockeye forecasted run size for 2020 is low and contains no foreseeable harvestable surplus. Because of this, the 2020 sockeye test fishery in this area will be much smaller than the same test fishery in 2018. Additionally, there is no pink salmon in 2020, resulting in further reduced anticipated fishing efforts. Therefore we expect limited fishing effort in these northern WCAs in the upcoming season, which could potentially reduce the likelihood of entanglements in gillnet gear. Although WCA 9 had a relatively high number of humpback whale sightings throughout the year (

Table *31*), there was a relatively small overlap with the fisheries. The degree of overlap in some of the WCAs may be less than reflected here since they were open for a small portion of a month.

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. For example, the potential for overlap between fisheries and humpback whales seen along the West Coast likely increases during periods of 'habitat compression'. When sea surface temperatures increase, associated with compression of upwelling to nearshore areas, humpback whales may move closer to shore or to inland waters and switch to different prey (Santora et al. 2020). 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. It is not clear yet what the oceanographic conditions will be like in the Salish Sea in 2020.

Humpback whales are expected to overlap with WCAs again in 2020 (e.g., WCAs in the Strait of Juan de Fuca and surrounding the San Juan Islands) based on their return to the Salish Sea in increasing numbers in recent years (Calambokidis et al. 2017) However, because we expect limited gillnet fishing in the areas that overlapped with humpback whales in 2018 and 2019 and, we anticipate fewer than the three interactions observed in 2018. While we can't quantify the reduction in fishing effort or absolute risk, we find it is reasonable to conclude that the risk will be less in 2020/2021 compared to 2018, and as a result we assume entanglements would be less than 2018. We therefore estimate that no more than 2 interactions with these fisheries would be expected in the 2020-2021 fishing season. Based on the past range in severity of entanglements, the 2 interactions could include non-serious, serious injury or mortality.

Humpback Whale Population-Level Effects

For any individual entanglement, it is likely that the humpback whale would be from either the unlisted Hawaii DPS or the threatened Mexico DPS. The 2 interactions would most likely be from the unlisted Hawaii DPS, as they likely have the highest abundance in Washington waters, followed by the threatened Mexico DPS and a very small chance of interactions for Central America DPS whales. 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: 8.7% estimated from the Central America DPS and 27.9% to be from the Mexico DPS. The remaining 63.5% are considered to be from the unlisted Hawaii DPS. The 2 interactions estimated for the 2020-2021 fishing season would likely involve an individual from the Hawaii DPS and may include no more than 1 interaction with individuals from the threatened Mexico DPS. The likelihood of an interaction with individuals from the endangered Central America DPS is very low. These estimates represent very small proportions of the entire populations of each DPS and only a portion of those interactions would be expected to result in serious injury or mortality. The likelihood of a gillnet interaction resulting in serious injury/mortality is 0.25 (Carretta et al. 2019c) meaning that the estimated 2 interactions is unlikely to result in a severe impact on the individual whale if they do occur.

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. The estimated 2 interactions with Puget Sound salmon gillnet fisheries would account for less than approximately 5 percent of estimated mortality and serious injury related to commercial fisheries interactions for the stock. Any potential interaction would most likely involve an individual from the unlisted Hawaii DPS or the threatened Mexico DPS. If there was one interaction with an individual from the Mexico DPS or the Central America DPS that resulted in SI/M, this interaction would represent less than 1 percent of either DPS population and would not put the larger population at risk, even conservatively assuming the minimum population estimates from Wade 2017 that likely underestimate the current abundances of these two ESA-listed DPSs to some degree.

In summary, NMFS finds impacts from prey reduction, noise and vessel collisions to be very minor or discountable, while the proposed action may result in 2 interactions between fishing gear and humpback whales within the action area with a reasonable expectation that one of those could be from a listed DPS and could potentially be a serious injury or mortality. The continually increasing presence of humpback whales in inland WA waters, especially during periods of overlap with Puget Sound fisheries, may cause similar levels of interactions in 2020 when compared to what occurred over the last two years. However, fishing effort in 2020 is expected to be reduced in response to lower salmon abundance forecasts, particularly for sockeye salmon. Less fishing effort could reduce the overlap and risk of interactions between fishing gear and humpback whales. Because of this, we anticipate fewer interactions than the maximum of three entanglements witnessed in 2018. Based on the proportions of the DPSs in the inland waters, these interactions would most likely impact either the unlisted Hawaii DPS or the threatened Mexico DPS, and any impacts to the Central America, which are very unlikely, or Mexico DPSs would be extremely small when compared to the population of the 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. The proposed fishery related research projects are designed and planned to contribute no more than 1% of ER to any one of the Puget Sound Chinook management unit's conservation objective form 2020, as a provision provided in the 2010-2014 Puget Sound Chinook harvest RMP.

PSC Fall Chum Salmon Study

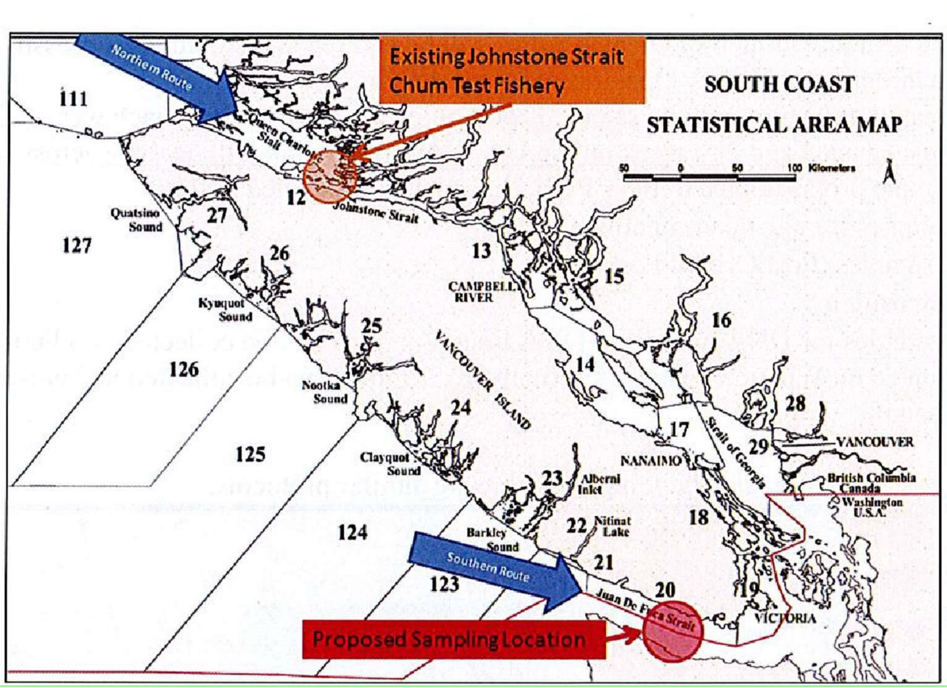


Figure 36. Location of proposed sampling site for PSC chum genetic sampling study.

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 2020. The fall chum research proposal is included in BIA's proposed action for 2020 and is summarized here (Mercier 2020). This is the fourth year of the study and follows the same methodology as in previous years. The proposed study will use one purse seine vessel four days per week for five weeks during October and early November in Area 5 (U.S. territory) (Figure 36). 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 (Mercier 2020).

There is the potential to encounter small numbers of non-listed and ESA-listed Puget Sound natural and hatchery steelhead during implementation of the study. 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. The PSC reached these estimates of potential encounters based on encounter rates in fisheries in the same general location and gear type and the application of a conservative buffer. 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 2016-19 resulted in only 1 encounter with a potentially ESA-listed steelhead (Mercier 2020).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 in the action area and provides some useful perspective about the likely impact of this marine area research study. Ten steelhead encounters would represent 0.04% of the total Puget Sound steelhead assuming all encountered steelhead were from the Puget Sound DPS. This research impact is therefore considered to have a negligible effect on natural-origin steelhead abundance, productivity, spatial structure, and diversity and is unlikely to impede the Puget Sound Steelhead DPS from reaching viability.

The study is also expected to encounter no more than 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 levels 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 (Mercier 2020). 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 unit 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 2019a; Mercier 2020). Based on the results of the 2016-2019 studies in which few unmarked Chinook were encountered (30 avg immature Chinook (range 2-69), 3 adult Chinook, only in 2017), we expect the impacts from this research to have a minimal effect on natural-origin Chinook abundance, productivity, spatial structure, and diversity.

Lake Washington/Lake Sammamish Invasive Species Research and Removal Efforts: Muckleshoot Indian Tribe (MIT) and WDFW predator removal test fisheries, MIT Pilot small-scale predator removal commercial effort, and MIT invasive species population size research

Several research activities are proposed to occur within the Lake Washington area. These studies are all designed to remove warm water fish species that prey on salmon and steelhead in the Lake Washington watershed, or to further inform the development of warm water fish predator removal fisheries. These proposals are summarized here and incorporated by reference (Mercier 2020).

MIT Warm-water Species Test Fishery

The Muckleshoot Indian Tribe (MIT) proposes to continue implementation of 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. This work has occurred, in this form, for the last three years. The 2020 test fishery will take place from early May and June 12th, 2020 and from January 1-April 30, 2021. Over the past three years, the MIT has developed a warm water test fishing study area which is divided into eight zones (Figure 37). The test fishery timing and locations will minimize encounters with ESA-listed species, including steelhead, and will use gear designed to avoid these species as well (Mercier 2020). The test fisheries proposed for 2020-2021 will occur in Lake WA zones 1-4 (Figure 31). During the first three years of the study, 2017, 2018 and 2019, no steelhead were encountered in the test fisheries (Warner 2019). There we a small number of rainbow trout captured in the test fisheries (1 in 2017, 11 in 2018, 0 in 2019) but these were determined by size, mark status, physical appearance, to not be steelhead. Over the three prior years of this work there have been zero Chinook adults caught in these fisheries. There have been several immature, lake-residual Chinook (blackmouth) caught in the test fisheries—11 total in the three years and 446 total net nights of testing (Mercier 2020). Only a couple of these have been unmarked fish (personal com., Jason Schafler, MIT, April 2020).

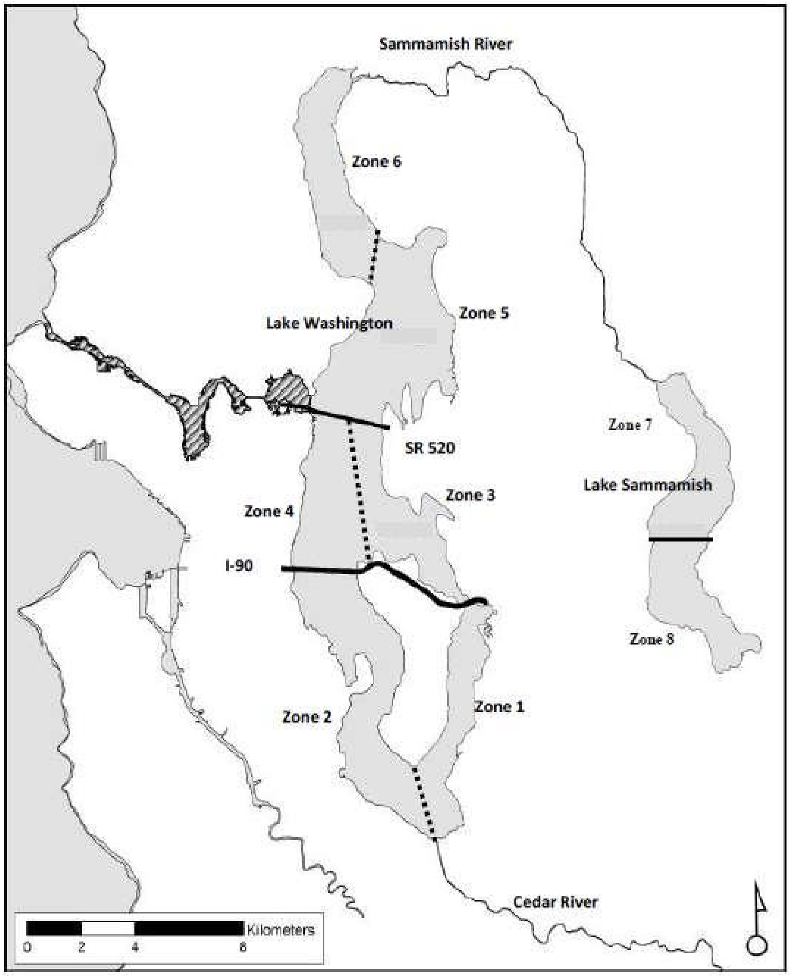


Figure 37. Muckleshoot Indian Tribe proposed warm water test fishery zones (1-8) and exclusion areas (cross-hatched) that will not be fished in order to minimize the potential for adult steelhead encounters (Mercier 2020).

MIT Warm-water Pilot Net Fishery

In addition to the continued test fishery described above, the MIT have proposed to conduct a small-scale pilot commercial fishery, targeting non-native warm water species, and based on the findings of the prior years' testing. This initial, small-scale commercial effort is planned for March 1-April 30, 2021 and would occur in warm water test fishery zones 5 and 6 (Figure 31) in North Lake WA. The small-scale effort is designed to allow for thorough monitoring of the fisheries as a transition to potential larger scale warm water fisheries in the future. The proposed locations and timing of the fisheries is also designed to reduce potential encounters of listed adult Chinook salmon or steelhead, due to the seasonal run-timing of the extant Chinook and coho being summer/fall and winter, respectively, and the North Lake WA tributaries having observed no adult steelhead spawning in the area for the last several years (Table 33). Additionally, the proposal limits the gear used in the fishery to the gears used in previous years' test fisheries and limits the number of nets per fishery.

MIT Warm-water Lake Sammamish Electrofishing

One of the underlying pieces of missing information, with regard to development of a potential management plan for warm water fisheries in Lake WA, is an estimate of the overall abundance of these non-native fish in the system. To date, the MIT test fisheries have focused on the efficacy of gear types and development of locations with adequate catch numbers to foster interest and participation. To get at the overall viability of a fishery, in terms of time horizon for effective overall removal of these species, an assessment of the scale of the populations in Lake WA and Lake Sammamish is being proposed to begin in 2020. The MIT have proposed to conduct an electrofishing survey and mark-recapture tagging program in Lake Sammamish. Lake Sammamish was chosen due to its smaller size, the presumed smaller population of the target fish species, and for the lower likelihood of encounters with ESA-listed species utilizing seasonal migratory corridors (Mercier 2020). These fisheries are proposed for a fall and spring period. The fall period for 2020 would be utilized for equipment training and testing and would only be employed for a couple of days and after Chinook adults have cleared the lake (Late Oct-Nov). The spring 2021 Sammamish electrofishing work is proposed for the March 1-June 30 period (personal com., Jason Schafler, MIT, April 2020). MIT proposes to employ best practices in conducting this electrofishing work, utilizing the protocols developed for electrofishing for warm water species (Bonar et al. 2000), including areas were listed non-target species of fish exist (Mercier 2020).

The potential for take of listed Chinook salmon and steelhead, as well as the life-history of the fish that could be impacted varies between the three components of the overall MIT warm water fisheries proposed above. The continued test fishery in the South Lake WA and the small-scale pilot commercial fishery in the North Lake WA are not likely to encounter juvenile Chinook or steelhead, due to the size of the gill nets utilized (larger than these fish) and the results of the prior years' work, however, they can impact these species at sub-adult or adult sizes. The timing and location of the fisheries, during the late spring and early summer (May 1-June 12) will likely reduce the potential for interaction with adult Chinook and steelhead, given the fall run-timing of the Chinook and the winter run-timing of potential steelhead encountered.

Unlike the net fisheries involve with the test and pilot commercial efforts, the electrofishing gear effect any species and life history that it comes into contact with, including juvenile listed Chinook and steelhead. The choice of Lake Sammamish and the period of March 1-June 30 should reduce the likelihood of encounters with adult Chinook salmon, while the extremely low observed numbers of adult steelhead in the Lake WA system in general and the North Lake WA tributaries specifically (Mercier 2020), reduce the likelihood of encountering adult steelhead significantly. As such, the MIT has proposed the following levels of expected take, in the form mortalities, for each component of the proposal in Table 32.

Table 32. Expected maximum levels of incidental mortality of ESA-listed Lake WA Chinook and steelhead, by life stage, associated with the 2020-2021 MIT Warm water predator-removal

studies.

<table>
<tr><th>MIT Warm Water predator removal component</th><th>unmarked Chinook juveniles</th><th>Unmarked Chinook sub-adults</th><th>Unmarked Chinook adults</th><th>Unmarked Steelhead juveniles</th><th>Unmarked Steelhead Adults</th></tr>
<tr><td>Lake WA test fishery cont.</td><td>0</td><td>5</td><td rowspan="2">5</td><td>0</td><td rowspan="2">3</td></tr>
<tr><td>Pilot Commercial fishery</td><td>0</td><td>8</td><td>0</td></tr>
<tr><td>Sammamish Electrofishing</td><td>7</td><td>0</td><td>0</td><td>3</td><td>0</td></tr>
<tr><td>Total</td><td>7</td><td>13</td><td>5</td><td>3</td><td>3</td></tr>
</table>

((Mercier 2020); pers. com. Jason Schafler, MIT, April 2020)

The MIT proposals also state that there would be monthly reporting on status of work, in general, and immediate reporting of NOR Chinook and steelhead encountered in these proposed fisheries.

WDFW Abundance and Diet of Piscivorous Fishes in Lake Washington Shipping Canal

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) assess the stomach contents of piscivorous fishes inhabiting different sectors of the LWSC and (3) identify sectors of the LWSC where predation on juvenile salmonids is greatest during the out-migration period. Gill netting would occur from early-May to late-June 2020, during the salmon smolt out-migration period, and would consist of multiple sampling days (Mercier 2020). 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 USFWS (Roger Tabor). Nets will be deployed at selected stations within the study area (Figure 38).

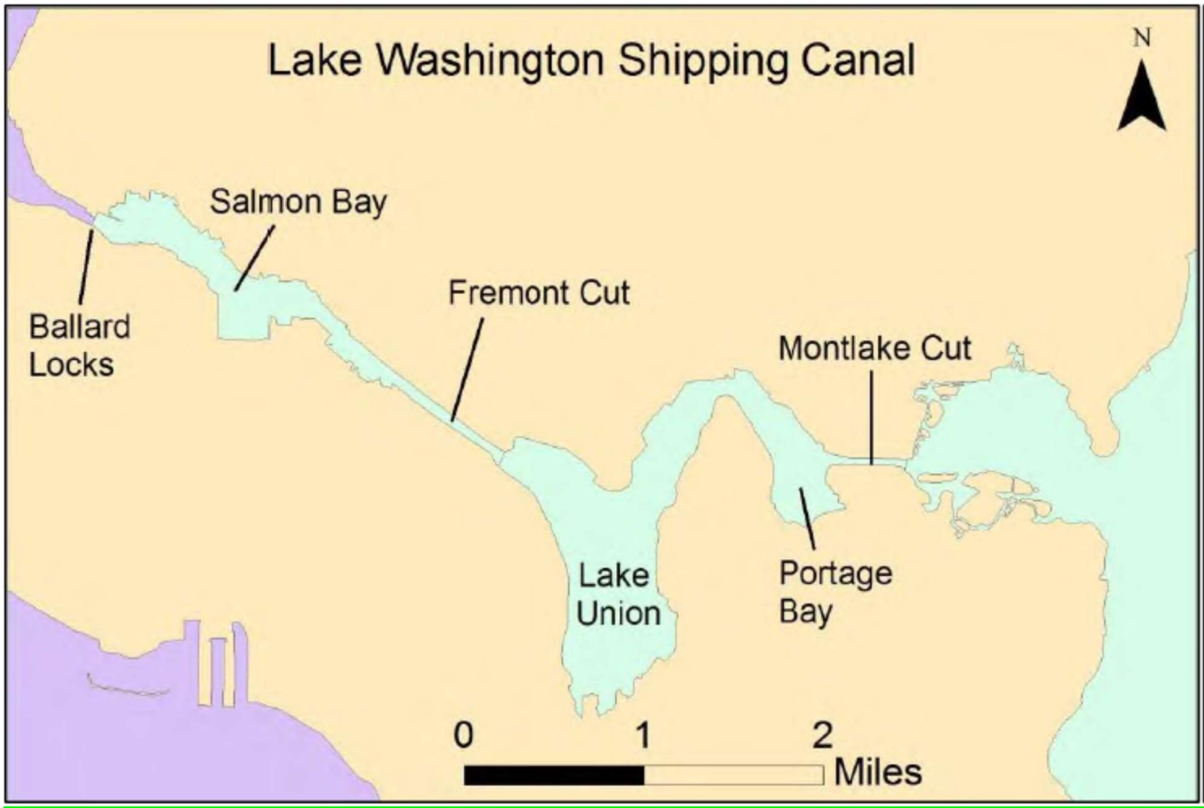


Figure 38. Proposed WDFW study area—Lake Washington Ship Canal (Mercier 2020).

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 the three previous years of this work (2017-2019) (Mercier 2020).

Chinook adults typically begin migrating through the LWSC in mid-June with the peak migration period occurring in mid to late August (Mercier 2020). 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 toward the middle of the canal 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 2017-2019) in the LWSC. Due to the early timing of the proposed sampling, the lack of encounters in previous studies and the off-channel areas where sampling will occur, the number of adult Chinook encountering sampling gear would likely be small if any. A total 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 2017-2019) in the LWSC. The take is estimated as zero juvenile Chinook.

As outlined above the proposed fishery-related research activities in the Lake Washington system would not expect take of Chinook to exceed a level equivalent to 1% of the estimated annual abundance (i.e. 1% ER). The total expected take of Lake WA Chinook salmon, from both the MIT and WDFW warm water predator removal work would be up to 10 adults, which would represent 0.24% of the Lake WA terminal run size based on the 2020 pre-season forecast for terminal run size of 4,594. Potential, additional impacts based on the sub-adult and juvenile estimates of take—up to 13 and 7, respectively, across both MIT and WDFW projects, will not add substantively to this impact level given the low survival rates of juvenile and immature Chinook to adult.

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. The report indicates a larger decrease in abundance for the Cedar River winter-run DIP between the 2005-2009 and 2010-2104 time periods (Table 33).

Table 33. 5-year geometric mean of raw natural steelhead 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 juvenile and three adult Puget Sound steelhead for the MIT test fishery and zero 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 . The conclusion is supported by the lack of steelhead encounters during the 2017-2019 MIT test fisheries.

After considering the above factors, take from the test fishery proposals if they were to occur are largely negative on the population level for steelhead, but encounters with steelhead are considered rare and unlikely to occur. The studies will reduce predator populations that could be a substantial mortality factor on salmonids thereby providing a benefit to the populations. The studies could also provide future evidence to resolve questions regarding the presence of ESA-listed steelhead in Lake Washington.

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 July. Few data currently exist on holding area preferences or Nooksack River-specific thermal preferences of South Fork Nooksack River Chinook salmon, 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 South Fork Nooksack River Chinook salmon by affecting entry of the fish to the South Fork Nooksack River which, in turn, may delay spawn timing and induce temperature related pre-spawn mortality.

A tangle net (5" 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 South Fork Nooksack River hatchery Chinook salmon (CWT only), and some hatchery origin North Fork Nooksack Chinook salmon (identified with a adipose mark) will be tagged with radio transmitters and tracked using ground and aerial surveys on a weekly basis. Any of the tagging work done during the on-going C&S fishery could retain a portion of the marked hatchery-origin fish for C&S use. During tagging activities that take place outside of the C&S fishery (location or time), fishers would only retain fish that are seriously injured or mortalities—all other fish would either be tagged and released or simply released after sampling. A secondary benefit of this project may be the ability to validate or inform Nooksack-specific release mortality rates for the selective fishery and demonstrate that removal of surplus Nooksack Chinook HORs, during the spring selective drift fishery, can be done in balance with Chinook recovery efforts in the Nooksack basin (Mercier 2020).

Up to 80 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 2020, this radio tag study will be limited to no more than 15 natural origin encounters. Applying the co-manager agreed 30% release mortality to these 15 encounters results in 5 natural-origin mortalities. These 5 mortalities result in a 0.82 ER on natural-origin Nooksack spring Chinook (Mercier 2020). Based on the 2019 study design (Norton 2019a), NMFS expects that up to five steelhead could also 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. Recent year average steelhead abundance estimates for the Nooksack basin are 1,850 fish. The one estimated potential steelhead mortality from this study will not negatively impact the current status of the Nooksack winter or South Fork Nooksack summer steelhead populations.

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 poor water quality in the freshwater and marine environments of Puget Sound. 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. These effects may occur at somewhat higher or lower levels than those described in the Baseline.

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 2011b) 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 2008c), Washington State Department of Transportation Preservation, Improvement, and Maintenance Activities (NMFS 2013a), the National Flood Insurance Program (NMFS 2008d), the Elwha River Fish Restoration Plan (Ward et al. 2008), and the Howard Hansen Dam Operations and Maintenance (NMFS 2019e). 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). NMFS recently adopted a recovery plan for Puget Sound Steelhead on December 20, 2019. A Recovery Plan for Puget Sound/Georgia Basin Yelloweye Rockfish and Bocaccio was completed in 2017 (NMFS 2017f) 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 2008g). Rules on vessel traffic to protect Southern Residents from vessel effects were adopted in 2011 (76 FR 20870). Outreach and enforcement of these regulations will reduce the vessel effects (as described in 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 expanded this area in 2018 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[56]. In 2019, a new state law was signed that increases vessel viewing distances 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. 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, which is expected to decrease the effects of vessel activities to whales in state waters. NMFS initiated scoping in 2019 to evaluate the need to revise existing federal regulations.

On November 8, 2019, the task force released its Year 2 report[57] that assessed progress made on

[56] Available here: https://www.governor.wa.gov/sites/default/files/OrcaTaskForce_reportandrecommendations_11.16.18.pdf
[57] Available here: https://www.governor.wa.gov/sites/default/files/OrcaTaskForce_FinalReportandRecommendations_11.07.19.pdf

implementing Year 1 recommendations, identified outstanding needs and emerging threats, and developed new recommendations. Some of the progress included increased hatchery production to increase prey availability. In response to recommendations of the Washington State Southern Resident Killer Whale Task Force, the Washington State Legislature provided approximately $13 million in funding "prioritized to increase prey abundance for southern resident orcas" (Engrossed Substitute House Bill 1109) for the 2019-2021 biennium (July 2019 through June 2021). Hatcheries are in the midst of enumerating the spring 2020 releases, but the planned production associated with this legislative action is a release of an additional 13.5 million Chinook salmon (approximately 6.4 million from Puget Sound facilities, approximately 5.6 million from Washington coastal facilities, and approximately 1.5 million from Columbia River facilities). A similar level of Chinook production funded by this legislative action is anticipated in the spring of 2021. The released smolts would return as adults and be part of the prey base 3 – 5 years later.

The state passed House Bill 1579 that addresses habitat protection of shorelines and waterways (Chapter 290, Laws of 2019 (2SHB 1579)), and funding was included for salmon habitat restoration programs and to increase technical assistance and enforcement of state water quality, water quantity, and habitat protection laws. Although these measures won't improve prey availability in 2020/2021, they are designed to improve conditions in the long term.

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. 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. 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. In 2019, Canada implemented some of these actions, including interim sanctuary zones, as part of an interim order to protect the whales and they are currently reviewing measures to protect the whales in 2020[58].

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.

[58] https://www.tc.gc.ca/eng/mediaroom/interim-order-protection-killer-whales-waters-southern-british-columbia.html

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 as well as larger-scale marine survival conditions and fishery management imprecision. The derivation of the RERs also makes assumptions about the effects of the actions discussed in the Cumulative Effects such as Puget Sound environmental conditions affected by continuing human impacts. By considering the RERs, status, and trend information in the discussion of effects of the proposed actions, the effects of the activities in the Environmental Baseline and Cumulative Effects sections of the biological opinion, as well as broader environmental conditions, 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 Puget Sound harvest (proposed action) 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 populations 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 difference the proposed fisheries would make in terms of returning spawners, 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 34 which may help navigate the complexities of the narrative.

For 2020 the Chinook populations in the Georgia Basin Region are forecasted to have escapements below, for the North Fork Nooksack Chinook population, and slightly above critical status for the South Fork Nooksack Chinook population. The long-term average natural-origin escapement abundances have been near (NF) and below (SF) critical thresholds (Table 3) which is cause for concern given their role in recovery of the ESU. Productivity estimates for the North Fork continue below replacement, while the South Fork population has risen above replacement in recent years (Table 3). Impacts from the proposed actions in Puget Sound fisheries are low (<8%), and our analysis indicates that further harvest reductions in 2020 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 trends and growth rates 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. As described in section 2.4.1, Environmental Baseline, the two Nooksack conservation hatchery programs are part of the Critical Stocks Program, with ongoing funded through the PST, as a measure to bolster the status of populations that are impacted in PST fisheries. 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 Puget Sound fishery actions in 2020 will meet the recovery plan guidance of not impeding achievement of viability for two to four population 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 five of these are below their RERs with five of the ten exceeding the RERs (Upper Skagit, Lower Skagit, Skykomish, and Snoqualmie, South Fork Stillaguamish). Of these four populations, three exceed their RERs by two percent or less. 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 2020 for the two Skagit fall populations, the Skykomish, South Fork Stillaguamish and Snoqualmie fall 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 23).Exploitation rates in 2020 Puget Sound fisheries are expected to be relatively low across the four management units (5%-23%) (Table 23). If the proposed actions were not to occur in 2019, we estimate that an additional 3 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 two Stillaguamish populations (Table 4). This indicates that fisheries may provide some stabilizing influence to abundance and productivity thereby reducing demographic risks.

For the Central/South Sound Region, implementation of the proposed 2020 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 34). However, harvest impacts on all but one population are anticipated to exceed their RERs in 2020.

The additional risks associated with exceeding the RER in the 2020 fishing year should not impede achievement of viability by the Nisqually, Puyallup or Green, Sammamish, and Cedar River populations. The White and Nisqually populations are in Tier 1 watersheds and essential to recovery of the ESU. While the proposed 2020 actions present a low risk to the White River, they could present a risk to the Nisqually (Table 34). For the Nisqually population, the risk presented by the 2020 proposed fisheries on the viability of the population is balanced by four additional 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 2020 exceeds the critical threshold, and (4) the implementation of a new long-term transitional strategy for the population, which began in 2018 and will continue in 2020. 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 2020 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 natural-origin escapement for the Cedar River population is above its rebuilding escapement threshold and escapement in 2020 is also expected to be above its rebuilding threshold. Trends for escapement (total and NOR) and growth rate are increasing. Average natural origin escapement for the Puyallup population is higher than its rebuilding threshold. Escapement in 2020 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 fisheries may provide some stabilizing influence to abundance and productivity thereby 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 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 2020 should not impede achievement of viability of five (White, Cedar, Duwamish-Green, Puyallup, and Nisqually) of the six populations in the Region in 2020; including the two populations that are essential to the recovery of the Puget Sound Chinook ESU (White River and Nisqually). Therefore, implementation of the proposed 2020 fisheries is consistent with the recovery plan guidance that two[59] to four populations representing the range of life histories displayed by the populations in that region 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 2020, while below the critical threshold, is higher than in most recent years, and the co-managers have proposed additional 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 2019a). 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 22). 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 2020, the fisheries put forward by the co-managers are again expected to result in a total exploitation rate near 48%

[59] The Central/South Sound Region contains two life history patters—spring run and fall run timing. There is only one spring run populations, the White River.

(Table 23). 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. Progress of the long-term transitional strategies in the Skokomish basin should be closely watched given the status of the Skokomish fall Chinook 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 population. 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 2020 should not impede the long-term persistence of the Skokomish Chinook population.

The Mid-Hood Canal Rivers Chinook population is considered essential for recovery of the Puget Sound Chinook ESU. The historically small abundances and developing trend in recent years of even lower abundance is concerning. The total escapement for 2020 is expected to be well below the critical abundance threshold. However, the available information indicates further constraints on 2020 Puget Sound fisheries would not measurably affect the risks to viability for the population, amounting to less than two additional spawners that would return to the Mid-Hood Canal Rivers population. In addition, 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 Chinook salmon population. In this context, the proposed 2020 Puget Sound fisheries will have a negligible effect to the survival or recovery of the spawning aggregations within the Mid-Hood Canal population.

In the Strait of Juan de Fuca Region, the Dungeness and the Elwha populations are both expected to be below the critical threshold for natural-origin spawners in 2020. Total fishery impacts on both are expected to exceed their RERs in 2020. Impacts from the proposed actions in Puget Sound fisheries are very low (<3%) and analysis suggests further harvest reductions in 2020 Puget Sound fisheries would not measurably affect the risks to viability for either population. When hatchery-origin spawners from the two conservation programs are taken into account, anticipated escapement in the Dungeness is more than three 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.

Additionally, we have evaluated fishery-related research effects to Puget Sound Chinook in Section 2.5.6, describing and assessing the anticipated levels of take associated with each of these studies. This assessment found that the research-related effects with not increase risk to the status of any of the individual populations encountered. These effects are quite small, particularly to adult Chinook, and do not meaningfully add to the effects of the fisheries.

In summary, under the proposed action, the combined ocean and Puget Sound exploitation rates for the 2020 fishing year for one of the 14 management units (Skagit early) and 6 of 22 total populations (Lower Sauk, Upper Sauk, Upper Cascade, Suiattle, NF Stillaguamish, and White) are expected to be under their RER or RER surrogates (Table 34). The Snohomish, Snoqualmie and South Fork Stillaguamish Chinook salmon populations are each expected to exceed their respective RERS by 2.1% or less. NMFS considers the proposed action to present a low risk to populations that do not exceed their RERs (NMFS 2004b). For the remaining populations above their RERs or RER surrogates:

(1) current and anticipated population status in 2020 and stable or positive trends in escapement and growth rate alleviated concerns about additional risk (Lower Skagit Upper Skagit, Cedar, Green, and Puyallup);

(2) anticipated impacts from the proposed 2020 Puget Sound fisheries are low and the effect on the population is negligible (North Fork Nooksack, South Fork Nooksack, Mid-Hood Canal Rivers, Dungeness, Elwha);

(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 (Sammamish).

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 34). Eight populations are expected to be below their critical thresholds (North Fork Nooksack, North and South Fork Stillaguamish, Sammamish, Mid-Hood Canal, Skokomish, Dungeness, and Elwha). For the latter populations, the fisheries resulting from implementing the proposed actions in 2020 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 34. 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	Red	Yellow	Red	Green	Green	Green	Green		**1**
	S.F. Nooksack early	Red	Red	Yellow	Yellow	Yellow	Red	Green		**1**
Whidbey/Main Basin	Upper Skagit moderately early	Red	Green	Green	Yellow	Yellow	Green	Yellow		1
	Lower Skagit late	Red	Yellow	Yellow	Yellow	Red	Green	Yellow		1
	Lower Sauk moderately early	Green	Green	Green	Yellow	Red	Yellow	Yellow		1
	Upper Sauk early	Green	Green	Green	Green	Green	Green	Yellow		1
	Suiattle very early	Green	Green	Green	Yellow	Green	Yellow	Yellow		1
	Upper Cascade moderately early	Green	Green	Green	Yellow	Green	Green	Yellow		1
	N.F. Stillaguamish early	Green	Yellow	Red	Yellow	Red	Yellow	Green		2
	S.F. Stillaguamish moderately early	Red	Red	Red	Red	Red	Red	Green		2
	Skykomish late	Yellow	Green	Green	Yellow	Yellow	Yellow	Yellow		2
	Snoqualmie late	Yellow	Green	Green	Yellow	Red	Red	Yellow		3
South Sound	Sammamish	Red	Yellow	Red	Yellow	Green	Green	Yellow		3
	Cedar	Red	Green	Green	Green	Green	Green	Yellow		3
	Duwamish-Green	Red	Yellow	Yellow	Yellow	Red	Red	Red		2
	White	Green	Green	Green	Green	Green	Green	Yellow		1
	Puyallup	Red	Green	Green	Red	Red	Red	Red		3
	Nisqually	Red	Yellow	Yellow	Green	Red	Yellow	Red	Green	1
Hood Canal	Mid-Hood Canal	Red	Red	Red	Yellow	Red	Yellow	Green		1
	Skokomish	Red	Red	Red	Yellow	Red	Yellow	Red	Green	1
Strait of Juan de Fuca	Dungeness	Red	Red	Red	Green	Green	Green	Green		1
	Elwha	Red	Red	Red	Green	Red	Red	Green		1

[1] Table 19. NMFS considers fisheries to present a low risk to populations where estimated total fishery impacts 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

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 minimized 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 2020-2021 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 2020-21 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 16**.

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 14).

We anticipate low 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 6 potential adult mortalities (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 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 was completed in 2019, worked to 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 (Walters and Parma 1996; PFMC 2000), 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.

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 35).

Table 35. 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	0.02 to 1.7
Yelloweye rockfish	2 to 66	143,086	0.001 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 36).

Table 36. 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 38 fish, and 21 mortalities in 2020 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 associated with the action 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 2020/21 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.

The SRKW DPS, composed of J, K, and L pods, was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). The limiting factors affecting this population include reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008g). Oil spills and disease as well as the small population size are also risk factors. It is likely that multiple threats are acting together to impact SRKWs.

In the early 1970s following live-captures for aquaria display, the SRKW population was at its lowest known abundance (68 whales). The highest recorded abundance since the 1970s was in 1995 (98 whales), though the population declined to 81 whales by 2001. The population experience a growth between 2001 and 2006, but has been generally declining since then. However, in 2014 and 2015, the SRKW population increased from 78 to 81 as a result of multiple successful pregnancies that occurred in 2013 and 2014. At present, the SRKW population has declined to near historically low levels Figure 11. As of April 2020, the population is 72 whales (one whale is missing and presumed dead since the 2019 summer census).

The NWFSC has updated the population viability analysis and the results now suggest a downward trend in population size projected over the next 50 years (although there is increased uncertainty around the estimates the further out the model projects). The downward trend is in part due to the changing age and sex structure of the population. If the population of SRKW experiences demographic rates (e.g. fecundity and mortality) that are more similar to 2016 than the recent 5-year average (2011-2016), the population will decline faster as shown in Figure 12 (NMFS 2016j).

SRKWs 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 (Figure 13). During the spring, summer, and fall months, the whales have typically spent 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. Although seasonal movements are somewhat 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 inland waters in recent years (Hanson and Emmons (2010); The Whale Museum unpubl. data). 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).

Harvest outside and inside of the action area affect prey availability in the action area (e.g. Southeast Alaska, British Columbia, PFMC salmon fisheries, and the proposed action). These fisheries are subject to management under provisions to the Pacific Salmon Treaty. The 2019 PST Agreement includes reductions to harvest impacts in all Chinook salmon fisheries within its scope. These reductions will result in larger proportions of annual salmon abundance returning to the southerly U.S. Pacific Coast Region than under previous PST Agreements, including Puget Sound. Additional hatchery production of Chinook funded through the programmatic PST-related funding initiative is designed to conserve Puget Sound critical populations and increase hatchery production to provide additional prey for SRKW. The SRKW prey production component of the funding initiative, consulted on at a programmatic level in NMFS 2019c, is expected to result in a 4-5% increase in available prey throughout inland and coastal waters frequented by SRKW's range and affected by fisheries managed under the PST in the next 3 – 5 years. To accomplish this percent increase in prey availability would require the release of 20 million additional smolts from hatcheries located in Puget Sound, the Columbia River, and coastal Washington areas. WDFW is contributing toward the goal of producing additional Chinook as prey for SRKW, planning for annual release of an additional 13.5 million Chinook salmon. Hatcheries in Washington State are in the midst of enumerating the spring 2020 release and a similar level of Chinook production funded by legislative action is anticipated in the spring of 2021.

In addition to increased hatchery production, the PST-related funding initiative is expected to fund projects to improve habitat conditions for specified populations of Puget Sound Chinook salmon, which we anticipate would increase Puget Sound Chinook abundance, also benefiting SRKW. Furthermore, the Washington State passed House Bill 1579 that included addressing habitat protection of shorelines and waterways, and funding was included for salmon habitat restoration programs and to increase technical assistance and enforcement of state water quality, water quantity, and habitat protection laws, along with other actions. By improving conditions for these populations, we anticipate abundance would increase, also benefiting SRKW. However, the benefits of these actions for SRKW will not occur in 2020-21, thus we don't expect them to mitigate the short-term effects of the 2020-21 salmon fisheries in Puget Sound.

Puget Sound salmon fisheries will affect SRKWs and their designated critical habitat through direct effects of vessel activities, and through indirect effects from reduction in prey availability. We have analyzed the effects of the 2020/2021 Puget Sound salmon fisheries on prey of SRKWs and these form the basis for the analysis of the effects to their critical habitat through reduction in available prey.

Vessel disturbance is part of the environmental baseline, which includes the near-constant presence of the whale watching fleet and other private vessels in inland waters in summer months, although there may be reductions in whale watching associated with COVID-19 orders. 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. 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 inconsistent with guidelines and out of compliance with 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 2020 and enforcement presence in 2020 is expected to improve compliance by vessel operators and reduce overall vessel impacts that may impact foraging or passage.

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. Although there is some potential for direct interaction between SRKWs and salmon fishing vessels and gear in the action area, particularly in WCA 7 in the summer months, because of the potential spatial and temporal overlap between the whales' distribution and the distribution of the Puget Sound salmon fisheries, vessel strikes or reports of entanglement in general are rare and have not been observed in association with Puget Sound salmon fisheries and are therefore unlikely. The proposed action 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 WCA 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 may result in less efficient foraging by the whales than their foraging efforts would be in the absence of vessel effects.

We compared the direct impacts from fishing vessels from the proposed action analyzed in this opinion to such impacts in previous years. Impacts are expected to be lower than the previous 10 year average in 2020 based on the reduced presence of fishing vessels in the key foraging areas. This reduction in fishing vessel impacts is expected because of the closure of recreational fishing in WCA 7 in winter months and continued restrictions in summer months (including Southern Resident killer whale foraging hotspots along the west side of San Juan Island) and the reduced commercial fishing based on the low Fraser River sockeye forecast with no harvestable surplus. Tribal fisheries are also not expected to be higher in 2020/2021 compared to the previous decade and is expected to have a small number of vessels in summer months in WCA 7 (2.5 boats per day). 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. Vessel and acoustic disturbances may cause short-term behavioral changes, avoidance, or a decrease in foraging. However, based on the operation of fishing vessels we expect that any transitory small amount of disturbance caused by the fishing vessels is not likely to disrupt normal behavioral patterns, nor have the potential to disturb by causing disruption of behavioral patterns, nor impair the prey (i.e., availability) and passage features of their existing and proposed critical habitat.

As described in the Effects Section, we focused our analysis on SRKW's primary prey, Chinook salmon, and impacts in inland waters in summer months where the fisheries overlap with foraging areas. 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 2020 proposed fisheries and Chinook abundance to the recent 10 year average. Using updated FRAM models, the pre-season estimates for abundance of age 3-5 Chinook in inland waters will be approximately 628,000, which is slightly above the recent 10 year post-season average of 612,000, and estimated to have an increase in pre-terminal escapement. The starting Chinook abundance in 2020/2021 is also estimated to be higher than years that had winter abundances below the estimated caloric needs of SRKW in the winter (e.g., 1994 – 1996, 2000, 2007 – 2009, 2012, and 2018).

The proposed fishing is expected to reduce the annual abundance of prey in inland waters by 3.3% which is similar to the average reductions over the recent 10 years (approximately 21,000 fish). 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 because it is extremely unlikely that the whales would have consumed all the 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.

There are several limitations and uncertainties of the analysis including uncertainty in Chinook stock abundances and distributions, effects of changes in Chinook salmon size and age structure, uncertainty in SRKW distribution and the factors that drive changes in distribution, differential responses to changes in Chinook abundance among pods, ability of SRKW to switch to alternative prey, and patterns of temporal variation in competing threats (refer to PFMC (2020) for more details on these uncertainties). In past years, we and the NWIFC 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 forage 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. 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.

While the benefits of the programmatic funding initiative related to U.S. domestic actions associated with the new PST Agreement, as described in the Environmental Baseline, in improving habitat and increasing hatchery production won't be realized during the 2020/2021 season, there are other ongoing measures intended to support SRKW recovery efforts as described in the Cumulative Effects section. We cannot quantify the direct benefits of these actions in offsetting reductions from Puget Sound fisheries at this time and will continue to develop ways to evaluate the effectiveness of protective measures.

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. While the fishing proposed in 2020/2021 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 2020, a 10-15% increase in pre-terminal escapement compared to an average of the previous decade, and starting abundance levels above the whales' energetic needs. In addition, a number of conservation measures identified by WDFW as part of the action are expected to reduce the impact 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 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, relatively low fishing effort and protective measures in 2020 conditions are anticipated to be improved for the whales compared to average conditions in the last decade. 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.

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. On September 19, 2019 NMFS proposed to revise the critical habitat designation for the SRKW DPS under the ESA by designating six new areas along the U.S. West Coast (84 FR 49214). Specific new areas proposed along the U.S. West Coast include 15,626.6 square miles (mi2) (40,472.7 square kilometers (km2)) of marine waters between the 6.1-meter (m) depth contour and the 200-m depth contour from the U.S. international border with Canada south to

Point Sur, California (Figure 22). This action has the potential to affect prey quantity and availability and passage in designated critical habitat, which are also impacted by a variety of other threats to Chinook salmon and from vessel activity. We do not expect the proposed fisheries to impact water quality.

As described above the abundance of prey is projected to be above average in 2020 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.

In conclusion, there appears to be a declining trend with the status of the whales likely due to a combination of the three top limiting factors: prey availability, vessel noise and disturbance, and toxic contaminants. Chinook salmon are likely the predominant prey species and there is likely a linkage between Chinook abundance and the whales' status. There is likely a spectrum of risk and at some low level of Chinook abundance there is higher risk to adversely affect the whales' status. Although this level is uncertain, abundance levels below whale energetic needs (e.g. winter Chinook abundance levels in the Salish Sea in 1994 – 1996, 2000, 2007 – 2009, 2012, and 2018) would create a higher risk to the status of the whales. While past studies found a relationship between Chinook abundance and whale health and status, that relationship has become less clear with more recent data and studies. Earlier biological opinions relied heavily on this relationship, but the best available science and data does not support such heavy reliance. The environmental baseline and cumulative effects show a continuation of effects of human activities in the action area that contribute to the top three limiting factors for the whales' status, but there are improvements in recent years that are expected to continue, such as reductions in northern fishery impacts under the new PST Agreement, the beginnings of additional hatchery production to provide increased prey for the whales, increased restrictions on vessel traffic near the whales, and state efforts to improve salmon habitat conditions in Washington.

This proposed action adds one year of limited fisheries to this backdrop. It is possible that there is a measurable effect to the whales' behavior in terms of possible additional foraging effort given that small prey reductions will occur in a year with moderate Chinook abundance. For purposes of this opinion, we assume there is a measurable effect on additional foraging effort. However, we do not expect these changes to persist or be so large that they result in more than a minor change to the overall health of any individual whale, or that they change the status of the population. Thus, even assuming a measurable effect, this would not rise to the level of an appreciable reduction in the likelihood of survival of any individual whale or the population.

Similarly, we do not expect the 2020 fisheries to affect the whales' likelihood of recovery. Efforts are underway to produce additional hatchery fish to increase prey availability for the whales, and to offset to some extent the effects of the salmon fisheries in future years. In recent years, Canada and Washington State have increased vessel measures to reduce sound and disturbance to the whales and NMFS initiated scoping in 2019 to evaluate the need to revise existing federal regulations. These efforts along with voluntary measures are underway to reduce impacts of vessels on foraging. In light of these ongoing efforts addressing the three primary limiting factors and projecting into the future beyond 2020 with reasonably certain assumptions, we do not expect that the 2020 fisheries will impede the recovery of the whales. With these efforts to ensure that recovery progresses, we find that the 2020 fisheries do not appreciably reduce the likelihood of survival and recovery of SRKW or adversely modify its designated critical habitat over the long run.

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 along the coast from northern Washington and southern British Columbia to Southeast Alaska. 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. Approximately 8.7% of humpback whales found off of Washington and British Columbia are considered to be from the endangered Central America DPS, while 27.9% are considered to be from the threatened Mexico DPS, with the majority 63.5% from the unlisted Hawaii DPS (Wade 2017). It is currently unknown which DPSs spend time in the inland waters, 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 been proposed but not designated for humpback whales.

Humpback whales face many 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 and disturbance from vessels and noise 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. Analysis of citizen sighting reports of humpback whales in 2018 and 2019 showed a relatively large degree of overlap of whales in the more northern WCAs (e.g., in the Strait of Juan de Fuca and the San Juan Islands) with active gillnet fisheries. There were three 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. 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 low fishing effort within the action area in 2020, humpback whales have been returning to the Salish Sea in increasing numbers in recent years, meaning we expect continued overlap. Even with growing humpback whale sightings, with less gear in the water we expect a lower number of interactions this year when compared to 2018, the year with the highest number of interactions. The proposed action may result in 2 interactions within the action area, which may range from minor (not serious injury) to mortality with an expectation that one of the interactions could be an ESA-listed whale, most likely from the Mexico DPS. Whales from the Hawaii DPS, which is not listed under the ESA, are likely the most common humpbacks in the area, so an estimate of 1 interaction out of 2 being assigned to the Mexico DPS is conservative. One interaction represents a very small proportion of the entire populations of either listed DPS and further 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 risk of an interaction is extremely low and 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 in the action area; 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 the endangered or threatened humpback whale DPSs.

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, 2020 through April 30, 2021 through contact with fishing gear. NMFS anticipates Puget Sound salmon fisheries occurring in 2020 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 23 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 23. 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 15 adult, 73 immature, and 7 juvenile Chinook incidental mortalities will occur in the research studies discussed in this opinion from May 1, 2020 through April 30, 2021.

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, 2020 through April 30, 2021 through contact with fishing gear.

NMFS anticipates that a maximum of 325 steelhead will be incidentally 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% (**Table 16**) (James 2018d; Shaw 2018; WDFW and PSIT 2018; Norton 2019a; WDFW and PSTIT 2019; Mercier 2020). This 4.2% will be calculated as an average across the Puget Sound winter steelhead index populations (i.e., Snohomish, Green, Puyallup and Nisqually). This rate 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 6 adult and 3 juvenile steelhead mortalities will occur in the research test fisheries discussed in this opinion (PSC chum test fishery, Lake Washington predator removal and assessment, and Nooksack telemetry study) from May 1, 2020 through April 30, 2021.

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 2020/21 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 action is likely to result in some level of harm constituting take to SRKW by reducing prey availability, 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). There are no data available to help NMFS 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. 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 action 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 2020/2021 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 23 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 3.3% annual reduction in the abundance of large (age 3-5) Chinook in the action area as estimated by FRAM. This 3.3% 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 23. Because those exploitation rates are actually used to manage the fisheries, are the best measure of fishing effort including prey reduction, 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 net fisheries, most likely to occur in Northern Puget Sound. 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 2 interactions of humpback whales with the Puget Sound fisheries for 2020-2021, ranging from minor (not serious injury) to mortality, with potential for 1 take from a listed DPS. These interactions would most likely be with whales from the unlisted Hawaii DPS, as they likely have the highest abundance in Washington waters, but 1 could be from the Mexico DPS and are unlikely to be from the Central America DPS. 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.

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. Reports from NMFS' entanglement database, which also includes stranded animals, were used to assess risk of entanglement. We will use these in-season mandatory reports and stranding information, 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 2 humpback whales reported (likely reported as unknown DPS origin) interacting in the Puget Sound fisheries resulting in entanglement during the 2020-2021 fishing season.

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. Although the federal agencies are responsible for carrying out this reasonable and prudent measure, in practical terms, it is the states and tribes that monitor catch impacts and regulate fisheries:

(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:

(1) NMFS, in consultation with the co-managers, will estimate the observed abundance of Chinook after fishery removals, using postseason information as it becomes available.
(2) Harvest impacts on Southern Resident killer whales shall be monitored using the best available measures.
(3) 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:

(4) 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

(5) Derelict gear impacts on listed rockfish shall be reported using best available measures.
(6) 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:

For Chinook salmon and steelhead

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. 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.[60]

1c. 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 2000a).

1d. The co-managers and NMFS will meet by phone to discuss the initial results of the Green River inseason run size 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 2020 List of Agreed to Fisheries.

1e. For the Green River Chinook 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.

1f. 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.

1g. 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.

1h. Work with the Nisqually Indian Tribe to finalize and approve the 2020 Nisqually River selective gear study, prior to initiating the study in 2020.

2. 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 or using suitable alternatives if sampling access is limited. The effectiveness of the management measures should be assessed in the postseason report.

3. 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 to the extent access to the fish for sampling is possible, 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

[60] 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.

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.

4a. Work with the affected tribes and WDFW to provide post season reports for the 2020-2021 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.

4b. Work with the affected treaty tribes and WDFW, to provide postseason reports for the 2020-2021 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, 2020 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.

5. 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.

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 or using suitable alternative methods. 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 to explore improvements to the framework including analytic methods for assessing fishery effects to SRKW through prey removal, and providing a method for managing these effects. The framework should:

- be responsive to the status of SRKWs and Chinook salmon, and
- identify the need for thresholds for Chinook salmon abundance in the Salish Sea 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 humpback whales, although it is unlikely they will be identified as Central America or 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. <u>Derelict Gear Reporting</u>. Requiring all derelict gear to be reported to appropriate authorities within 24 hours of its loss.

b. <u>Derelict Gear Accounting and Location</u>. Recording the total number and approximate locations of nets lost (and subsequently recovered) on an annual basis.

c. <u>Derelict Gear Prevention</u>. 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) 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

(8) 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

Green sturgeon (*Acipenser medirostris*) are long-lived, anadromous fish that occur along the west coast of North America from Mexico to the Bering Sea. Green sturgeon consist of two DPSs that co-occur throughout much of their range, but use different river systems for spawning. The Southern DPS consists of all naturally-spawned populations of green sturgeon originating from coastal watersheds south of the Eel River (Humboldt County), California, whereas the Northern DPS consists of populations originating from coastal watersheds north of and including the Eel River. On April 7, 2006, NMFS listed the Southern DPS green sturgeon as a threatened species and maintained the Northern DPS as a NMFS Species of Concern (71 FR 17757). On October 9, 2009, NMFS designated critical habitat for Southern DPS green sturgeon (74 FR 52300).

Individuals of the Southern DPS green sturgeon are unlikely to be caught in Puget Sound salmon fisheries. First, green sturgeon do not appear to use Puget Sound very extensively. Observations of green sturgeon in Puget Sound are much less common compared to the other estuaries in Washington, and monitoring data for tagged green sturgeon show few detections in Puget Sound (NMFS 2009a). In addition, 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, making any such effects discountable.

Designated critical habitat for Southern DPS green sturgeon does not include Puget Sound, but does include the Strait of Juan de Fuca (74 FR 52300). The designated critical habitat within the Strait of Juan de Fuca contains all three essential habitat features for green sturgeon: food resources, water quality, and a migratory corridor. However, we do not expect the proposed Puget Sound salmon fisheries to have a measurable effect on these essential features. First, the proposed fisheries are not expected to catch or affect prey species for green sturgeon (i.e., benthic invertebrates and fish such as shrimp, clams, crabs, anchovies, sand lances) (Moyle et al. 1995; Erickson et al. 2002; Moser and Lindley 2007; Dumbauld et al. 2008). Second, the proposed fisheries are not expected to affect dissolved oxygen or contaminant levels in the designated critical habitat areas. Finally, the proposed fisheries are not likely to reduce the quality of the migratory corridor for green sturgeon, because the proposed salmon fisheries use hook-and-line gear that is fished near the surface or mid-water, or net gear that is fished at the surface, with limited contact with bottom habitat. Based on the nature and location of the proposed salmon fisheries, NMFS would not expect any measurable effects on the essential features of designated critical habitat, making any such effects discountable.

The proposed salmon fisheries therefore are not likely to adversely affect Southern DPS 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 2020/21 fishing season compared to several years and decades ago (previous estimates of derelict nets were 16 to 42 annually (NRC 2010)). In 2018, an estimated eight nets became derelict, and six of them were recovered (James 2019). 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 2019/20 salmon fisheries. Based on this new information we estimate that a range of six to 20 gill nets may be lost in the 2020/21 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[61]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[62]5 and a moderate to high likelihood that a majority of populations would achieve their

[61]4 Also referred to in previous opinions as the Upper Escapement Threshold.

[62]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,[63]6 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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[63]6 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:

$R = (aS\mathrm{e}^{-bS})(M^{c}\mathrm{e}^{dF})$ [Ricker]

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

$R = (\min[aS, b])(M^{c}\mathrm{e}^{dF})$ [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.[64]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

[64]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.

Appendix B

Table B.1. List of Chinook salmon stocks in Fishery Regulation Assessment Model (FRAM).

1. UnMarked Nooksack/Samish Fall
2. Marked Nooksack/Samish Fall
3. UnMarked North Fork Nooksack Spr
4. Marked North Fork Nooksack Spr
5. UnMarked South Fork Nooksack Spr
6. Marked South Fork Nooksack Spr
7. UnMarked Skagit Summer/Fall Fing
8. Marked Skagit Summer/Fall Fing
9. UnMarked Skagit Summer/Fall Year
10. Marked Skagit Summer/Fall Year
11. UnMarked Skagit Spring Year
12. Marked Skagit Spring Year
13. UnMarked Snohomish Fall Fing
14. Marked Snohomish Fall Fing
15. UnMarked Snohomish Fall Year
16. Marked Snohomish Fall Year
17. UnMarked Stillaguamish Fall Fing
18. Marked Stillaguamish Fall Fing
19. UnMarked Tulalip Fall Fing
20. Marked Tulalip Fall Fing
21. UnMarked Mid Puget Sound Fall Fing
22. Marked Mid Puget Sound Fall Fing
23. UnMarked UW Accelerated
24. Marked UW Accelerated
25. UnMarked South Puget Sound Fall Fing
26. Marked South Puget Sound Fall Fing
27. UnMarked South Puget Sound Fall Year
28. Marked South Puget Sound Fall Year
29. UnMarked White River Spring Fing

30. Marked White River Spring Fing
31. UnMarked Hood Canal Fall Fing
32. Marked Hood Canal Fall Fing
33. UnMarked Hood Canal Fall Year
34. Marked Hood Canal Fall Year
35. UnMarked Juan de Fuca Tribs. Fall
36. Marked Juan de Fuca Tribs. Fall
37. UnMarked Columbia River Oregon Hatchery Tule
38. Marked Columbia River Oregon Hatchery Tule
39. UnMarked Columbia River Washington Hatchery Tule
40. Marked Columbia River Washington Hatchery Tule
41. UnMarked Lower Columbia River Wild
42. Marked Lower Columbia River Wild
43. UnMarked Columbia River Bonneville Pool Hatchery
44. Marked Columbia River Bonneville Pool Hatchery
45. UnMarked Columbia River Upriver Summer
46. Marked Columbia River Upriver Summer
47. UnMarked Columbia River Upriver Bright
48. Marked Columbia River Upriver Bright
49. UnMarked Cowlitz River Spring
50. Marked Cowlitz River Spring
51. UnMarked Willamette River Spring
52. Marked Willamette River Spring
53. UnMarked Snake River Fall
54. Marked Snake River Fall
55. UnMarked Oregon North Coast Fall
56. Marked Oregon North Coast Fall
57. UnMarked West Coast Vancouver Island Total Fall
58. Marked West Coast Vancouver Island Total Fall
59. UnMarked Fraser River Late
60. Marked Fraser River Late

61. UnMarked Fraser River Early
62. Marked Fraser River Early
63. UnMarked Lower Georgia Strait
64. Marked Lower Georgia Strait
65. UnMarked White River Spring Year
66. Marked White River Spring Year
67. UnMarked Lower Columbia Naturals
68. Marked Lower Columbia Naturals
69. UnMarked Central Valley Fall
70. Marked Central Valley Fall
71. UnMarked WA North Coast Fall
72. Marked WA North Coast Fall
73. UnMarked Willapa Bay
74. Marked Willapa Bay
75. UnMarked Hoko River
76. Marked Hoko River
77. UnMarked Mid Oregon Coast Fall
78. Marked Mid Oregon Coast Fall